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Effect of Micro-Osteoperforations on Orthodontic Tooth Movement with Clear Aligner Treatment.

DoBin Choi

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Effect of Micro-Osteoperforations on Orthodontic Tooth Movement with Clear Aligner Treatment

DoBin Choi, D.D.S.

Thesis submitted
to the School of Dentistry
at West Virginia University

in partial fulfillment of the requirements for the degree of

**Master of Science in
Orthodontics**

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2017

Keywords: Accelerated orthodontics, Micro-osteoperforation, Orthodontic tooth movement,
Clear aligner treatment

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ABSTRACT

Effect of Micro-Osteoperforations on Orthodontic Tooth Movement with Clear Aligner Treatment

DoBin Choi, D.D.S.

Background and Objectives: Micro-osteoperforation (MOP) is a relatively non-invasive procedure to expedite the rate of orthodontic tooth movement (OTM) by enhancing naturally occurring inflammatory response. This procedure is often combined with clear aligner treatment (CAT) in order to shorten the duration of aligner wear. However, the question yet remained whether the accuracy of OTM was maintained if the patients switched the aligners more frequently than recommended. The objectives of the study were to investigate the effect of MOPs on the accuracy of anterior OTM and to evaluate the differential effect of MOPs on gender, age, severity of the mal-alignment, and the likelihood of refinement treatment.

Experimental Design and Methods: A de-identified sample of 105 patients who completed CAT and met the inclusion criteria was obtained from the private practice of Thomas Shipley (Peoria, AZ). The experimental group consisted of 46 CAT cases with MOPs and 3-day aligner change, and the control group consisted of 59 CAT cases with 14-day aligner change. For data collection, CloudCompare software was used to superimpose the post-treatment and prediction scans to the pre-treatment scans and to measure the actual and predicted amount of displacement of each anterior tooth of both arches. Using the transformation matrices from tooth-by-tooth alignment, the amount of linear and angular displacement in 3 different planes was obtained and used to calculate the linear discrepancy and the relative errors for the angular discrepancy. The difference of these values between the control and the experimental samples was analyzed using ANOVA, student's t-test, Wilcoxon/Kruskal-Wallis rank sums test, and contingency analysis.

Results: Statistical analyses showed no significant difference between the groups for the accuracy of anterior tooth movement in general, and the type of movement was unaffected by MOPs. No clinically significant difference was found between the predicted and the actual outcomes for varying gender, age, and severity of mal-alignment. On the other hand, a greater percentage of the experimental samples required refinement treatment. **Conclusions:** Compare to the 14-day aligner wear, the 3-day aligner wear with MOPs did not affect the accuracy of OTM. MOP had a negligible effect on the types of tooth movement, gender, age, and the severity of mal-alignment. The frequency of refinement treatment was higher for the 3-day aligner wear with MOPs possibly due to more severe mal-alignment and greater number of prescribed aligners of the experimental samples. In general, MOP can be a viable procedure to reduce the length of CAT without compromising the quality of the clinical outcome.

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CHAPTER 1: INTRODUCTION

Background

Prolonged orthodontic treatments are associated with a higher risk of several adverse effects, such as enamel decalcification, external root resorption, gingival inflammation, decrease in patient compliance, and poorer quality of treatment outcome as a result.^{2, 13-16} Hence, the current trend in orthodontics is incorporation of methods to expedite the treatment while achieving a satisfactory outcome by increasing the rate of orthodontic tooth movement as well as increasing treatment efficiency. In an attempt to accelerate the rate of orthodontic tooth movement, many studies have investigated the biological mechanism of orthodontic tooth movement and how to manipulate the physiology.

Orthodontic tooth movement is an inflammatory phenomenon. A mechanical force applied to a target tooth creates a pressure side and a tension side of the tooth root, which stimulates the production and activation of various inflammatory mediators. These inflammatory factors in turn activate bone-remodeling cells, including osteoblasts and osteoclasts in the periodontal ligament (PDL) space.⁸ This idea that orthodontic tooth movement is an inflammatory phenomenon is empirically supported by a higher level of an inflammatory mediator, PGE₂, found in gingival crevicular fluid of patients undergoing orthodontic treatment.¹⁰ Also, Bartzela et al. reported in the systematic review that experimental administration of inflammatory mediators, such as leukotriene, prostaglandin, and prostacyclin, significantly increased the rate of orthodontic tooth movement in non-human subjects.¹¹ On the other hand, substances that inhibit the activities of bone remodeling cells, such as bisphosphonates, are capable of inhibiting the orthodontic tooth movement, and anti-

inflammatory substances have been shown to decrease the rate of tooth movement.^{11, 12} These results suggest that enhanced inflammatory response in the periodontal ligament space may promote bone resorption and bone deposition, encouraging rapid tooth movement within alveolus.

Induction of inflammation to increase the tooth movement is not a novel concept. In 1983, Frost first used a term “regional acceleratory phenomenon” to describe a tissue reaction to noxious stimuli by increasing the production of inflammatory mediators.²⁵ Noxious stimuli can be any chemical or mechanical agents that can cause “trauma” to the periodontal ligament, thus increasing the production of inflammatory factors within the PDL space. These factors in turn will activate and recruit osteoblasts and osteoclasts involved in remodeling of the bone around the tooth. Increased bone remodeling during orthodontic treatment will result in an increased tooth movement. Other dental procedures, such as tooth extraction, periodontal surgery, or even orthognathic surgery, are considered noxious stimuli, and a faster tooth movement and shortened treatment duration can be observed following invasive dental procedures.

Inspired by the regional acceleratory phenomenon, researchers have made numerous efforts to utilize this phenomenon to deliberately increase the rate of orthodontic tooth movement and shorten the treatment duration. Studies have evaluated various surgical and non-surgical interventions to induce inflammation to increase the rate of orthodontic tooth movement. These efforts range from low-level laser therapy and pulsed electromagnetic fields to corticotomy and distraction osteogenesis.¹⁷⁻²³ Nevertheless, only a few of these procedures are found to be effective. Surgical procedures, such as full-thickness flap elevation with extensive decortications, corticotomies, piezopunctures, and periodontal and dento-alveolar distractions, are shown to increase the rate of orthodontic tooth movement by activating inflammatory mediators, thus

increasing the osteoclastic and osteoblastic activities in the alveolar bone.^{1, 3-6, 9} However, the most notable drawbacks of these methods lie in their invasive nature, possibility of surgery-related morbidity, and impracticality of a routine application.

Micro-osteoperforation (MOP) is a newly introduced technique that can easily be performed in an office setting with minimal patient discomfort to increase the rate of orthodontic tooth movement. MOP is a shallow intentional puncture wound through soft tissue into the cortical plate around a target tooth using a stainless steel mini-screw of a 2-mm diameter and 7-mm length. According to Alikhani et al., a resultant localized inflammatory response seems to recruit and stimulate surrounding bone remodeling cells to increase the rate of bone resorption and deposition, thus increasing the rate of tooth movement and shortening the treatment duration.⁷ Unlike the aforementioned surgical techniques, MOPs can be applied under topical anesthesia, minimizing patient discomfort and surgery-related morbidities. Moreover, a simple, cost-effective protocol may allow a more frequent application in comprehensive treatment with fixed appliances as well as clear aligner treatment (CAT).²⁴

An aesthetic alternative to the traditional fixed appliance treatment, CAT is a series of removable vacuum-formed polyurethane appliances that are designed to apply a point pressure to move teeth to a desired position in small increments. This is not a new treatment concept; in fact, many practitioners have used this technique to achieve a minor tooth movement. In 2001, Align Technology incorporated computer-aided designing/computer aided manufacturing (CAD/CAM) stereolithographic technology to CAT, which allowed CAT to be an aesthetic treatment option for more complex cases. However, many studies revealed that the efficiency of orthodontic tooth movement via CAT is less than ideal with the average accuracy of tooth movement between 29 to 57 percent.²⁶⁻²⁸ In addition, many clinicians have incorporated accelerated tooth movement

into CAT, claiming that the duration of clear aligner treatment can be shortened by half or even a third of the usual treatment duration (3-day aligner wear versus 14-day aligner wear) while maintaining the quality of the outcome.

Statement of the Problem

Attempts have been made to increase the accuracy of the tooth movement as well as the rate of the tooth movement with clear aligner treatment. With the emergence of new techniques to accelerate the rate of tooth movement, clinicians and researchers are investigating the effects of MOP in clear aligner treatments. Until present, there have been no organized studies that systematically investigated the effect of MOPs in clear aligner therapy.

Significance of the Study

A relatively non-invasive method, MOP has been shown to increase the rate of tooth movement and reduce the duration of orthodontic treatment. Understanding the effectiveness and efficiency of this procedure on clear aligner therapy may provide orthodontists an added armamentarium to reduce the duration of orthodontic treatment with the same or similar accuracy in orthodontic tooth movement. The present study will shed light on whether the use of MOP can reduce the length of time in changing from one aligner to the next and the ability of the aligners to track the tooth movement accurately in three planes of space.

Primary Research Questions

1. Can the addition of the MOP procedure help in reducing the length of time changing from one aligner to the next?
2. How close can the aligners track the tooth movement in the experimental group treated with the addition of the MOP procedure compared to the control group?
3. Is there a difference in the aligner's ability to track different types of tooth movement (tipping, rotation, and torque movements) in either the experimental or the control group?
4. Is there a difference in the effect of MOP for different gender, age, or the severity of mal-alignment?
5. Is there a difference in the frequency of refinement treatment at the completion of the prescribed aligner treatment with or without the use of MOP?

Null Hypotheses

Compared to the conventional clear aligner therapy alone, the fast-tracked clear aligner therapy with micro-osteoperforation will show:

1. No significant difference in tooth movements of the anterior teeth predicted by the ClinCheck compared to the actual treatment between the experimental and control groups.
2. No significant difference in the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome among different types of tooth

- movement (i.e. linear displacement and angular displacement in mesiodistal, faciolingual, and occlusogingival directions).
3. No significant difference in the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome between genders.
 4. No significant difference in the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome among different age groups.
 5. No significant difference in the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome for varying severity of anterior malalignment.
 6. No significant difference in the frequency of refinement treatments at the completion of the prescribed aligner treatment.

Assumptions

The following were assumed for the purpose of the study:

1. Same algorithm developed by Align Technology is used for treatment planning of all cases.
2. Each aligner is designed to move the tooth at a fixed increment in distance and rotation.
3. All MOPs are completed equally to perforate the full thickness of the buccal cortical plate around the anterior teeth.
4. The effect of interarch elastics on anterior alignment is insignificant.

5. Landmarks are accurately identified for necessary measurements and superimposition of the intraoral scans.

Limitations

1. Samples are limited to the subject database provided by one of the co-investigators Dr. Thomas Shipley (Peoria, AZ).
2. There is no sample of patients with CAT with 3-day aligner wear without MOPs.
3. There is patient-related variability – demographics, bone physiology, types of malocclusion, amount of crowding, and the level of compliance.
4. There is treatment-related variability – types and amount of required tooth movement, amount of interproximal reduction, and the use of auxiliary devices.
5. Measurements are affected by intra-operator variability and margin of error.

Delimitations

1. Control samples that were treated in the same time period (January 2013 to July 2016) as the experimental samples were selected to eliminate any variables in treatment planning algorithm or treatment philosophy.

2. Samples were selected to include a similar distribution of patient-related variability, such as age range, race, gender distribution, types of malocclusion, and high compliance level, for both groups.
3. Samples were selected to include a similar distribution of treatment-related variability, such as types and amount of required tooth movement, amount of interproximal reduction, and the use of auxiliary devices, for both groups.
4. Ten samples in each group were randomly selected for intra-operator reliability test to calculate the margin of error and the reliability of the measurements.

CHAPTER 2: REVIEW OF THE LITERATURE

Theories of Orthodontic Tooth Movement

Discoveries of the evidence of orthodontic tooth movement in ancient Egyptian mummies suggest the long history of practice of orthodontics. However, the physiology of orthodontic tooth movement is a topic of relatively recent studies. These studies introduce several theories of orthodontic tooth movement.

1. Bone Bending/Piezoelectric Theory (Farrar)

In 1888, Farrar first introduced Piezoelectric Theory, also known as Bone Bending Theory, to describe the mechanism of orthodontic tooth movement.³⁶ Piezoelectricity is an electric charge that occurs due to a mechanical deformation of a crystalline object, such as mucopolysaccharide, collagen, hydroxyapatite, or collagen-hydroxyapatite interface in bone. The piezoelectricity will create micro-currents throughout the object, stimulating the bone remodeling cells, such as osteoblastic and osteoclastic activities.³⁷ The theory explains that any mechanical stress that causes bending of any of these crystalline structures will generate electric signals, increasing the cellular activities in the matrix. Yasuda et al. found differential charges on different surfaces of the deformed bone. When a pressure was applied on a femur, they detected a callus formation in the periosteum and endosteum as well as negative piezoelectric charges on the compression side and positive piezoelectric charges on the tension side.³⁸ The negative charge is generally associated with an increased osteoclastic activity, and the positive charge is associated with an increased osteoblastic activity.

Studies also suggest that increasing the amount of bone deflection may cause an increase

in piezoelectricity.^{39, 43} The inverse of this phenomenon was also shown to be true when an increased osteogenic activity and an accelerated bone repair were observed in animals with an application of an electric current.^{40, 41} This concept can be applied to the tooth movement where a force to a tooth causes bending of the alveolar bone surrounding the tooth and creates differential piezoelectric currents within the PDL space. These currents will stimulate osteoclasts and osteoblasts necessary for bone remodeling and in turn, orthodontic tooth movement. Shapiro and his colleagues noted a sustained tooth movement when a pulsed electric current was applied to a maxillary molar of a female patient.⁴²

One of the main drawbacks to this theory to explain the physiology of orthodontic tooth movement is the quick decay rate of piezoelectricity. When a force is applied to a tooth, a piezoelectric current is created; however, the electric signal quickly dissipates to zero even with a sustained force application. Moreover, another unusual characteristic of piezoelectricity is that once the force is released, an equal and opposite piezoelectric signal is created.⁴⁴ Thus, this may imply that after the force is released, the resorptive area shows bone deposition and vice versa. Also, studies indicate that the piezoelectricity is responsible for bone remodeling due to stress-generated electric signals. Yet, this phenomenon does not fully explain the physiology of tooth movement when the orthodontic force application is maintained, which frequently occurs in orthodontic treatments with fixed appliances. Nevertheless, studies suggest that a pulsed force application with a careful removal of force may stimulate a unidirectional orthodontic tooth movement.

2. Pressure-Tension Theory

Pressure-tension theory is based on the concept that orthodontic tooth movement is an

inflammatory process. When orthodontic force is applied to a tooth in a certain direction, a catabolic-pressure side and an anabolic-tension side are created in the PDL space. Depending on the side of the tooth, cellular activities are distinctly different. On the pressure side, histochemical findings indicate that compressive force within the PDL space significantly increases the expression of cyclooxygenase (COX).⁸ COX is derived from arachidonic acid, one of the components of cell membrane phospholipids. COX enzyme is responsible for the production of prostaglandins (PG), especially PGE₁ and PGE₂. Studies have indicated the bone resorptive effect of PGE₁ and PGE₂ via their effect on other molecules.^{45, 46} These factors activate receptor activator of nuclear factor kappa B ligand (RANKL), whose action is to aid in differentiation, function, and survival of bone-resorbing osteoclasts. These PGs are also involved in initiating the cyclic adenosine monophosphate (cAMP) pathway.⁴⁷ This pathway eventually leads to an increased production of cellular components necessary to sustain an increased cellular activity of bone remodeling cells.

At the same time, PGs lower the osteoprotegerin (OPG) level, altering the ratio of RANKL/OPG to favor the formation of functional osteoclasts.^{30, 31} Compressive force also increases the expression of interleukin (IL)-17, whose action is to activate bone-forming osteoblasts.²⁹ In addition, there is a differential expression of various inflammatory cytokines, such as IL-1, IL-6, tissue necrosis factor (TNF)- α , and interferon- γ , which are also associated with osteoblast and osteoclast activation. The combined actions of these inflammatory factors and the cells they stimulate on the pressure side will aid in bone remodeling and bone modeling necessary for the tooth to move into the newly created space.

On the tension side, similar molecules and cells are involved but at a different level of activity, thus producing a different phenomenon. The major factor associated with the anabolic

side is transforming-growth factor (TGF)- β 1. TGF- β 1 is a chemotactic molecule involved in proliferation, differentiation, survival, and function of osteoblasts, which are the cells responsible for bone formation. Osteoblasts will deposit bone on the tension side of the socket once the tooth is moved away from the original position.^{32, 33} Studies indicate an increased level of TGF- β 1 in the PDL space upon application of tensile force, increasing the osteoblastic activity.³⁴ In addition, upon the force application, there is an increased level of vascular endothelial growth factor (VEGF). This is another factor that is associated with the enhanced survival and activity of osteoblasts.³⁵ Also, as mentioned earlier, the ratio of RANKL/OPG affects the osteoclast formation. With a tensile force, OPG level is increased, lowering the RANKL/OPG ratio and decreasing the production of functional osteoclasts.³² Overall there is an increased osteoblastic activity and a decreased osteoclastic activity, thus increasing the rate of bone deposition in the tension side of the PDL space. The Pressure-Tension Theory explains the biologic mechanism of orthodontic tooth movement by presenting the evidence of altered level of inflammatory mediators caused by orthodontic force application to a tooth.

Figure 1. A schematic of Pressure-Tension Theory of orthodontic tooth movement.⁷⁴

Regional Acceleratory Phenomenon

First described by Frost in 1983, the regional acceleratory phenomenon (RAP) is used to describe a tissue response to a noxious stimulus that results in an increased cellular activity.²⁵ It is understood as a necessary reaction of the affected tissue to counter the disturbance and increase the healing capacity. Without the RAP reaction, healing capacity is compromised, and the tissue becomes more prone to infection.⁵² This phenomenon of accelerated healing occurs not just in soft tissue, but also in hard tissue, such as bone and cartilage.⁴⁸ According to Verna, the extent of the elicited response is directly proportional to the magnitude and the nature of the noxious stimuli, which can include a variety of external factors, both chemical and mechanical. For example, soft or hard tissue infection, any type of fractures, surgical procedures, and inflammatory processes are all capable of inducing the RAP.⁵¹

Verna explains that the RAP affects the variety of cellular activities, such as the differentiation of precursor cells and the metabolism of the already differentiated cells within the bone multicellular unit (BMU). The BMU consists of the cells depositing, resorbing, and maintaining the bone in a cyclical sequence. The sequence of bone remodeling during the RAP is activation, resorption, reversal, and formation. First, activation phase is initiated by binding of RANKL to its receptors present on the surface of preosteoblasts. This reaction results in the emergence and differentiation of preosteoclasts from the bone marrow into osteoclasts. The mature osteoclasts will begin the second phase, bone resorption. After the second phase, osteoclasts undergo apoptosis, and the further resorption is carried out and completed by mononucleated phagocytes. At the same time, during the reversal phase, preosteoblasts are differentiated into mature osteoblasts, which secrete OPG to discourage the differentiation and activities of osteoclasts. During the last phase of bone formation, mature osteoblasts deposit

osteoids, which eventually complete mineralization in three to four months.⁵¹ The bone modeling/remodeling sequence is a normal process of bone turnover, but becomes heightened during the state of injury via the RAP.

Histologic studies have supported the above process that in an injured bone tissue, the RAP is characterized by augmented osteoblastic and osteoclastic activities that lead to an increased formation of unorganized woven bone, which subsequently becomes organized into lamellar bone.⁴⁹⁻⁵¹ As a result, the rate of bone modeling and remodeling is increased, eventually leading to bone healing. Dental pathologies that can cause the RAP include fractures of the bone and periodontal diseases, and dental procedures that can cause this phenomenon include tooth extraction, orthognathic surgery, implant placement, and orthodontic tooth movement. Experimental results suggest that the RAP in general lasts between four and eight months, but the scope of the tissue response depends on the severity of the dental disease processes or the extent of the dental procedures.⁵¹ In orthodontic tooth movement, since the RAP stimulates both the osteoblastic and the osteoclastic activities, it can be assumed that this phenomenon occurs on both the tension and the pressure sides.

Interventions for Accelerated Orthodontics

Once the connection between the orthodontic tooth movement and the RAP has been established, numerous studies have been conducted to develop methods to accelerate the rate of orthodontic tooth movement. The main idea is to induce the regional inflammatory response around the target tooth to increase the RAP, thus increasing the rate of tooth movement.

Researchers have investigated various methods to utilize and enhance the RAP, both surgical and

non-surgical, and several systematic reviews that analyzed these studies are available.

Long and his colleagues reviewed five procedures discussed in nine studies that met their inclusion criteria in their systematic review.¹ Among the five procedures were low-level laser therapy (LLLT), corticotomy, electrical current, pulsed electromagnetic fields (PEMF), dentoalveolar and periodontal distraction. First, from the two qualifying studies, the authors concluded that corticotomy could reliably accelerate orthodontic tooth movement. The authors noted a report of transiently compromised gingival health in the corticotomy samples, possibly due to the difficulty maintaining an adequate oral hygiene following the surgery. Nevertheless, the authors agreed that corticotomy is a relatively safe and effective method of increasing the rate of orthodontic tooth movement.

Another study included in this systematic review was by Kharkar et al. that investigated the effectiveness of dentoalveolar and periodontal distractions.⁹ This study reported a faster rate of orthodontic tooth movement with dentoalveolar distraction compared to periodontal distraction. Despite the limitations of the experimental design of this study, the authors suggested that dentoalveolar distraction was a safe, promising procedure in clinical practice. The last three procedures, LLLT, electrical current, and pulsed electromagnetic fields, were also investigated for their efficacy. However, the authors were unable to find any definitive evidence that these procedures were effective in accelerating orthodontic tooth movement.

A more recent systematic review by Hooegeveen et al. reviewed eighteen studies that evaluated corticotomy, periodontal ligament distraction, and dentoalveolar distraction.⁵³ Unlike the previous study, Hooegeveen et al. found the evidence of the efficacy of both distraction methods. They concluded that all three procedures, corticotomy, PDL distraction, and dentoalveolar distraction were methods that can temporarily, but reliably increase the orthodontic

tooth movement with minimal risks of periodontal damage, root resorption, and pulp devitalization. However, the authors noted that the level of evidence to support this claim is limited due to the moderate to high level of bias of evidence currently available.

Another systematic review by Gkantidis and his associates reviewed eighteen articles that evaluated the efficacy of five surgical and non-surgical interventions, namely corticotomy, interseptal bone reduction, photobiomodulation, LLLT, and PEMF.⁵⁴ The authors concluded that corticotomy was the only procedure that reliably increased the rate of orthodontic tooth movement without any significant adverse effect. They found no evidence to support the efficacy of interseptal bone reduction, photobiomodulation, and PEMF. On the other hand, several studies included in this review indicated some evidence of effectiveness of LLLT. However, a careful interpretation of the data concerning LLLT was recommended since the effectiveness of the procedure was indicated only in the studies with a moderate risk of bias, whereas the studies with a low risk of bias failed to show the effectiveness. Along with the aforementioned reviews, other systematic reviews and comparison studies have also concluded that corticotomy is a reliable and safe method of elevating the rate of orthodontic tooth movement, whereas other procedures lack evidence to support the efficacy.^{4, 19, 20, 55}

Micro-Osteoperforation

Inspired by findings of the RAP in orthodontic tooth movement, Micro-Osteoperforation (MOP) is a technique recently incorporated in orthodontics to accelerate the rate of orthodontic tooth movement. MOPs are done by creating shallow perforations using a mini-implant-like device or a small round bur and a hand-piece through the gingiva into the

buccal cortical plate of a target tooth.⁵⁵ The idea is to induce regional inflammatory response via intentional bone injuries to increase the bone remodeling activities, thus accelerating the rate of orthodontic tooth movement. The perforation process is similar to that of corticotomy, which is one of few procedures that are shown to be effective in accelerating the rate of orthodontic tooth movement. However, corticotomy involves an extensive gingival flap procedure, which may increase the healing time and patient discomfort level and negatively impact the patient acceptance rate. On the other hand, MOPs do not require laying a gingival flap. Instead, the small perforations are completed directly through the soft tissue.

The animal study conducted by Teixeira and her associates reported a significantly higher rate of orthodontic tooth movement in rats with orthodontic force and MOPs (0.62mm), compared to the rats with orthodontic force only (0.29mm). Also, histochemical studies indicated that on the MOP side, the authors observed a 1.6- to 2.8-fold increase in the level of cytokines and chemokines as well as a 3-fold increase in the number of osteoclasts in the experimental side.⁵⁵ The results indicate that in rats, the injury caused by MOPs illicit a regional inflammatory response, leading to an accelerated rate of orthodontic tooth movement through the RAP.

Similarly, another animal study by Tsai et al. investigated the effect of MOPs and corticision on the rate of tooth movement in rats.⁵⁶ They concluded that compared to the control samples that received orthodontic force only, both experimental samples (MOPs and corticision) experienced an increased rate of tooth movement and the difference between the two experimental groups was insignificant. Histologic studies indicated that the bone density was significantly lower around the tooth with the MOPs. In addition, the number of osteoclasts present around the target tooth was significantly higher in both experimental samples. The authors concluded that these minimally invasive procedures resulted in an induction of a

localized inflammatory process and an increase in the rate of orthodontic tooth movement in rats.

Lastly, Alikhani et al. investigated the effect of MOPs on the rate of canine retraction in human subjects.⁷ All of the subjects underwent maxillary first premolar extraction and canine retraction, and the subjects in the experimental group received MOPs with a mini-implant-like device. The results indicated an increased rate of tooth retraction by 2.3-fold in the subjects who received MOPs, compared to the control samples. Moreover, the gingival crevicular fluid study indicated a significantly increased level of cytokine expression in the experimental samples. The authors explained that MOPs were capable of inducing a localized inflammatory response, thus recruiting and stimulating the surrounding bone remodeling cells to increase the rate of bone resorption and deposition to aid in the accelerated tooth movement.

Figure 2. Different designs of the devices specifically designed for Micro-osteoperforation by PROPEL Orthodontics (Ossining, NY)⁷⁵

Clear Aligner Therapy

1. Overview

Clear aligner therapy (CAT) is an aesthetic treatment alternative to conventional orthodontic treatment with fixed appliances. The treatment is rendered through a series of clear removable vacuum-formed polyurethane aligners to accomplish minor tooth movement as each aligner moves the teeth by fixed distances.⁵⁶ First introduced by Kesling in 1945 as a flexible tooth-positioning device, CAT is not a new concept. Traditionally, the aligners were fabricated by manually altering the tooth position in small increments on a stone model, thus limiting the scope of CAT to only minor tooth movement, such as mild rotations and mal-alignment of anterior teeth up to 2mm.⁵⁷ If more dental movement was desired, additional stone models with the altered tooth position had to be manually fabricated.

Recent development of Invisalign® (Align Technology, Santa Clara, CA) incorporated the CAD/CAM technology into CAT, which dramatically changed the ability of the clear aligners to treat more complex malocclusion. Instead of fabricating each dental cast by hand, the practitioners can simply submit polyvinyl siloxane impressions or 3-dimensional digital intraoral scans, which are used to virtually design a desired treatment outcome.⁵⁷ Computer program then develops a sequence of tooth movements that will be achieved by each aligner to reach the desired outcome. Thus, each stage of the treatment can be visualized and modified before ever starting the treatment.⁵⁶ Moreover, the traditional method of producing the physical models is replaced by stereolithography, a method to print a solid three-dimensional object, in this case a dental model, from liquid plastic. This method allows a mass production of dental casts so that the sequential models and corresponding clear aligners can be easily manufactured.⁵⁷ The incorporation of CAD/CAM technology allows the CAT to be a viable, aesthetic treatment

option for more complex malocclusion.

2. Factors Affecting the Tooth Movement with Clear Aligner Treatment

Orthodontic tooth movement with CAT depends on several external and internal factors, including the physical properties of thermoplastic materials and the characteristics of attachments. Materials used in CAT differ according to manufacturers and stages of the treatment.⁵⁸ Depending on the physical property of the polymers or the fabrication method of the aligners, the force level and the activation rate may differ significantly.⁵⁹ According to Ercoli et al., an aligner system that uses poly-vinyl chloride (PVC) material with pronounced elastics characteristics when subjected to a moderate load may require less optimal wear time due to the characteristic force that the PVC material can apply to the tooth. On the other hand, an aligner system that uses polyethylene terephthalate glycol may be more resistant to time and wear and allow more gradual tooth movement.⁶⁰ Another study by Simon and the colleagues investigated the forces and moments generated by Invisalign's proprietary aligner material. They observed the exponential force decay during the aligner wear. Their results indicated that the force systems varied throughout the aligner treatment despite a treatment plan with a constant tooth movement. Also, the authors recommended using attachments to maximize the moment transfer.⁵⁹ Likewise, different materials exert different effects on tooth, which may translate into varying efficiency of orthodontic tooth movement.

Another factor that can affect the efficiency of tooth movement is the activation time, or aligner-wear time. An *in-vivo* study by Clements et al. evaluated the effect of varying activation time on the quality of the outcome determined by peer assessment rating and incisor irregularity index.⁵⁶ Among the four protocols with differing types of material and aligner wear time (1-week

activation with soft material, 1-week activation with hard material, 2-week activation with soft material, and 2-week activation with hard material), the authors did not find any statistically significant difference among the 4 protocols in the rate of space closure or anterior alignment. However, they noted a general trend with a 2-week activation having a higher rate of extraction space closure and anterior alignment, compared to the 1-week activation. Similarly, Drake and his colleagues investigated the effect of a duplicate aligner for the second week of aligner wear, compared to the conventional protocol of 2-week aligner wear on the total amount of orthodontic tooth movement.⁶¹ The results showed no statistically significant difference between the two protocols, indicating that the material fatigue was not a major determinant of the amount of orthodontic tooth movement.

In addition to the treatment-related factors, Chisari et al. evaluated patient-related factors that may affect orthodontic tooth movement, such as age, sex, root length, bone levels, and bone quality. The results indicated a negative correlation between age and tooth movement as well as a significant negative correlation between locations of center of resistance, determined by root length and bone levels, and tooth movement. However, bone quality had little effect on orthodontic tooth movement. Sex of the patients, the authors reported, may have a complex contribution to orthodontic tooth movement.²⁷ Furthermore, tooth movement via clear aligner treatment is considerably affected by patient compliance. Therefore, controlling orthodontic tooth movement with clear aligners is a complex process, and the amount and rate of tooth movement is rather unpredictable.

3. Accuracy of Orthodontic Tooth Movement with Clear Aligner Treatment

Studies have shown that the efficiency of orthodontic tooth movement with CAT is

affected by patient-related factors as well as treatment-related factors.²⁶⁻²⁸ A recent systematic review evaluated current available literatures on the efficacy of clear aligners in controlling orthodontic tooth movement. Their search concluded that the efficacy of the treatment with clear aligners is comparable to that of the fixed appliances with straight-wire technique in general. However, the selected articles indicated certain differences in the efficacy of CAT compared to the straight-wire technique (SWT). Compared to SWT, CAT was more effective in leveling and aligning, anterior intrusion, controlling posterior buccolingual inclination, and upper molar distalization up to 1.5mm. On the other hand, this treatment modality was less effective in anterior extrusion, controlling anterior buccolingual inclination, and rotation of rounded teeth.⁶² Therefore, due to these deficiencies in the ability to control certain orthodontic tooth movement, CAT becomes less predictable than fixed appliance treatment with SWT.

The predictability of clear aligner treatment was tested using several different methods. Buschang et al. utilized the standardized grading system to objectively evaluate the quality of the actual outcome and compare to that of the prediction.²⁶ ClinCheck feature of Invisalign system, which allows the practitioners to visualize the predicted outcome, was used as the predicted outcome of each case. The authors graded the outcomes of selected CAT cases using the American Board of Orthodontics (ABO) Objective Grading System (OGS), and compared the scores of the predicted outcomes to those of the actual outcomes. The results showed that the OGS scores of the predicted outcomes were lower than those of the actual outcomes, indicating that the quality of the ClinCheck prediction was more acceptable than that of the actual outcome. The authors supported the idea that the ClinCheck prediction was not entirely an accurate representation of the actual outcome observed clinically. Their conclusion agreed with the aforementioned systematic review in that the discrepancy between the OGS scores of the actual

outcomes and those of the predicted was mainly due to deficiencies in the ability of CAT to control alignment, buccolingual inclinations, occlusal contacts, and occlusal relations.

Another method of evaluating the accuracy of orthodontic tooth movement with clear aligners is to compare the amount of tooth movement that actually occurred to the anticipated amount of tooth movement. Kravitz and his colleagues used Invisalign's proprietary software, ToothMeasure to answer the question, "How well does Invisalign work?". The authors evaluated the efficiency of seven different types of tooth movements of over 400 anterior teeth by superimposing the intraoral scans of the achieved outcome to the predicted outcome. The results indicated the mean accuracy of tooth movement was 41%, the most accurate movement being lingual constriction of maxillary incisors (47.1%) and the least being extrusion of maxillary incisors (18.3%). They also observed a significant loss of control of maxillary canine rotation greater than fifteen degrees.²⁸ These results are in general agreement with other studies that reported the lack of control of orthodontic tooth movement with clear aligners.

In 2011, Krieger and her colleagues utilized the same software to determine the accuracy of Invisalign treatments in the anterior region. They compared the prediction models to the final models by measuring the changes in overjet, overbite, and dental midline shift in upper and lower arches. The results revealed deviations in all parameters: overjet 0.4mm (SD±0.7), overbite 0.9mm (SD±0.9), and dental midline shift 0.4mm (SD±0.5).⁶³ Similarly, the same authors evaluated the efficiency of CAT in further details. Using ToothMeasure, the accuracy of Invisalign treatments was evaluated in terms of the change in anterior crowding, anterior arch length, intercanine distance, overjet, overbite, dental midline deviation, and Little's irregularity index. The authors found that the clear aligner treatment was effective in resolving anterior crowding by increasing the arch length and intercanine distance. The results were comparable to

their previous study where they observed slight discrepancies between the ClinCheck prediction and the actual outcome in all parameters. Although the change in overbite was the least effective ($-0.7\text{mm} \pm 0.87$), the authors concluded that the discrepancies were clinically insignificant.⁶⁴ The reported deviations between the predicted outcome and the actual outcome may necessitate the practitioners to incorporate overcorrection in their treatment plan to achieve the desired amount of tooth movement.

Methods of Analyzing Orthodontic Tooth Movement

As intraoral-scanning and mesh-analyzing technology advances, many studies have been done to analyze orthodontic tooth movement occurring during CAT. Some studies used a certain company's proprietary software to superimpose the intraoral scans and measure the discrepancies.^{28,63,64} Others used commercially available CAD software to reach a similar goal.⁶⁵⁻⁶⁸ With any type of software, the steps involve superimposing the scanned models and measuring the tooth movement in terms of translation and rotation in three planes (mesiodistal, buccolingual, and occlusogingival).

1. Superimposition of Intraoral Scans

3D models of the dentition can be obtained via either directly scanning the teeth using any commercially available intraoral scanner or laser scanning the stone models of teeth obtained from an alginate or polyvinyl siloxane (PVS) impression. These intraoral scans can be uploaded on any CAD software with an alignment function. In order to compare orthodontic tooth movement between two 3D models, the scans have to be superimposed using stable structures as

references. According to Jang et al., anatomic structures, such as palatal rugae, that are known to be stable throughout orthodontic treatment can be used as a reliable registration point.⁶⁹

Mandibular superimposition may involve superimposing on chin, which is a stable skeletal structure.⁶⁷ Implants can also be placed in areas that are not affected by tooth movement to be used as stable references for superimposition.⁷⁰ Others have utilized teeth that underwent no orthodontic movement.^{65,66} Whatever the structure is used, superimposition can be valid as long as the structures are stable between the two time points that the intraoral scans are obtained.

Once the stable registration points are identified, most CAD programs use iterative closest point (ICP) algorithm, where the distances between one point to its closest point on the two registered scans are calculated, using the least-squares method as shown in Equation 1.⁶⁸ Based on the unchanged structures found in both scans, software computes the optimal transformation to align one set of data points to the other set of data points by calculating the smallest possible differences of the two data sets.⁶⁷ As a result, the transformation matrix is obtained where the two scans can be best aligned.

$$f(M) = \frac{1}{N} \sum_i \|x_i - Mp_i\|^2$$

Equation 1. Cost function as the mean of the least-square distances from the vertices of one data set to the other (M is a rigid transformation matrix, N is the number of points, x_i is the vertex of the first data set, and p_i is the vertex of the second data set)

2. Measurement of Tooth Displacement

In order to measure the amount of tooth displacement through superimposing the pre-treatment and post-treatment scans, numerous methods can be used to measure the 3-dimensional

changes. Many studies utilize the 3-plane coordinate system to calculate the displacement in translation and rotation in x-, y-, and z-axes.⁶⁵⁻⁶⁸ Once two scans are aligned and oriented in a common coordinate system, each axis is defined to represent mesiobuccal, faciolingual, and occlusogingival planes. Depending on the goal of the study, some studies record the coordinates of the same anatomic structures, e.g. cusp tips, of the scans to calculate the linear displacement in three directions.^{65,66} This method does not include any rotational changes.

On the other hand, the ICP algorithm that was used to initially align the two scans can be used again to calculate the direction and the extent of tooth movement. After the scans are oriented in a common coordinate system, the tooth in question can be superimposed in three dimensions to the corresponding tooth in the other model, using the same method with a different transformation matrix that is unique to each tooth. This transformation matrix represents the movement by a translation vector and a rotation matrix.^{67,68} This method will provide a linear displacement as well as a rotational displacement.

Figure 3. Normalized 3-D view of the anterior teeth before and after treatment. Black: before treatment; gray: 2 months after treatment.⁶⁸

Figure 4. Coordinate system for analyzing tooth movement by automatic registration. (a) Before registration, (b) after registration. The coordinate systems (x', y', z') and (x, y, z) correspond to before and after tooth movement, respectively.⁶⁸

3. CloudCompare Software

CloudCompare (<http://www.danielgm.net/cc/>) is open source 3-dimensional point cloud and mesh processing software. Designed mainly to compare between two point clouds or meshes, the software can carry out advanced algorithms, including registration, resampling, statistics computation, sensor management, and segmentation.⁷¹ With these functions, CloudCompare can be applied to tasks that require high sensitivity and specificity in comparing two 3-dimensional objects. Manuel and his colleagues utilized CloudCompare to validate their comparison study of the steady state geometry of the finite element model of the nasal tip deformation. The comparison of the models was made by evaluating the distance between the subset of points. Their results indicated that there was a good agreement with the two undeformed models as well as a good overlap between the point cloud from 3D reconstruction and the finite element model from computed tomography image. Using CloudCompare, the authors

could validate the finite element models with a clinical significance.⁷²

Likewise, another study employed CloudCompare in identifying the unique anatomical features of frontal sinus. Beani and his colleagues obtained 3D configurations of frontal sinus of twenty subjects. Using CloudCompare, the authors calculated the difference between the two meshes and performed a qualitative comparison of the two. The results indicated that the accuracy of the comparison was up to 100%, and the study concluded that the 3D anatomy of frontal sinus can be used to identify different individuals.⁷³ Therefore, CloudCompare is used in a variety of researches that require a meticulous comparison of 3D point clouds and meshes. The software can perform advanced algorithms to derive a conclusion with reasonable reliability.

CHAPTER 3: EXPERIMENTAL DESIGN AND METHODS

Institutional Review Board Approval

In an effort to protect the participants' human right, the protocol was reviewed and approved by West Virginia University Institutional Review Board for human research protection (Protocol #1606156142). (See Appendix A)

Sample Collection

For this retrospective study, permission to use the patient records was obtained from one of the co-investigators, Thomas Shipley (Peoria, AZ), who provided the necessary patient data. (See Appendix B) The records of all patients who completed treatment with clear aligners between January 1, 2013 and July 1, 2016 were reviewed. Cases that did not have pre-treatment or post-treatment (or pre-refinement) scans were not included in the study. Among 426 clear aligner cases reviewed, a total of 105 cases met the following inclusion criteria and were included in the study.

Inclusion Criteria

- 1) Complete permanent dentition excluding third molars
- 2) Age between 13 and 80
- 3) Non-smoker
- 4) No gender or race predilection

- 5) ClinCheck treatment plan included a minimum of 10 aligners
- 6) Complete pre-treatment and post-treatment (or pre-refinement) records, including intraoral scans
- 7) No fixed appliances or auxiliary devices were used
- 8) Non-extraction treatment
- 9) Planned treatment involved minimal molar movement
- 10) All of the prescribed aligners were completed without refinement or alterations of the treatment plan

For the experimental group, a total of 46 consecutively treated clear aligner cases with MOPs were selected. These patients switched the aligners every 3 days after receiving MOPs in the anterior region for both arches. For the control group, a total of 59 consecutively treated clear aligner cases without MOPs were selected. These patients did not undergo MOPs and switched the aligners every 14 days. Each subject was given a random identification number, and all protected healthy information identifiers were removed for de-identification purposes.

Using OrthoCAD (<http://www.mycadent.com>), the pre-treatment as well as the post-treatment intraoral scans of the maxillary and mandibular arches of each patient were obtained in STL file format (Figure 5). The prediction models were also obtained in STL file format via ClinCheck Pro v.5.0 (<http://www.invisalign.com/us/support/pages/clincheckpro.aspx>) (Figure 6). For the study, tooth displacement of only the permanent maxillary and mandibular incisors and canines were considered.

Figure 5. An example of a composite of intraoral scans obtained from OrthoCAD

Figure 6. An example of a composite of prediction models obtained from ClinCheck Pro

Superimposition of Scans and Establishing Coordinate System

For each case, a pre-treatment scan and a post-treatment scan of the same arch were uploaded on the CloudCompare software. Using “Align/Point Pairs Picking” function of the software, 3 or more easily identifiable anatomical landmarks on unmoved posterior teeth, such as cusp tips and fossae of the molars, were selected on the post-treatment scan (i.e. “Reference”). The corresponding landmarks were also selected on the pre-treatment scan (i.e. “Align”) in the same order (Figure 7).

Figure 7. Initial alignment and registration of pre-treatment and post-treatment scans using “Align/Point Pairs Picking” function on CloudCompare

With the Root Mean Square (RMS) <10%, the pre-treatment scan was superimposed onto the post-treatment scan. The alignment was visually inspected to verify the correct positioning of the scans (Figure 8). The aligned scans were saved as a CloudCompare project.

Next, the same pre-treatment scan was uploaded; this time, it was aligned to the ClinCheck prediction model using the same method. This process was repeated for both upper and lower arches. For each sample, maxillary and mandibular pre-treatment, post-treatment, and prediction scans were aligned and saved separately as CloudCompare projects.

Figure 8. Visual verification of the initial alignment of pre-treatment and post-treatment scans

Analysis of Tooth Displacement

For the study, the amount of displacement of only the incisors and canines of each arch were considered. The previously saved project of the aligned arches was uploaded onto CloudCompare (Figure 9).

Using the “Align/Point-Pairs Picking” function with $RMS < 10\%$, the pre-treatment scan was selected as the “Align” point cloud, and either the post-treatment scan or the prediction model was selected as the “Reference” point cloud (Figure 10). The scans were re-aligned at one of the anterior teeth by selecting three or more easily recognizable anatomical structures on a particular tooth.

Figure 9. Aligned scans were uploaded on CloudCompare to analyze the displacement of each tooth

Figure 10. Tooth-to-tooth alignment using the “Align/Point Pair Picking” function

Unlike the initial alignment of the arches, the information of the direction and the magnitude of the transformation was important for the tooth-to-tooth alignment. Thus, after the alignment at the particular tooth was visually verified, the resultant transformation matrix was saved in a text format (Figure 11). The same process was repeated for all incisors and canines of both arches for all of the pre-treatment/post-treatment and pre-treatment/prediction projects.

Figure 11. Visual verification of the alignment of the tooth and the resultant transformation matrix

Calculation of Tooth Displacement

Each transformation matrix (Figure 12) was applied to a formula on Microsoft Excel spreadsheet to calculate the angular changes about the x-, y-, and z-axes as well as the linear changes in x-, y-, and z-planes.

Final RMS: 0.2377			

Transformation matrix			
0.992	0.128	0.000	2.997
-0.127	0.987	-0.097	2.221
-0.013	0.096	0.995	1.568
0.000	0.000	0.000	1.000

Scale: fixed (1.0)			

Figure 12. An example of a transformation matrix

From the transformation matrix, the magnitude of the linear and angular displacement of each tooth could be calculated using the components of the matrix. The transformation matrix is expressed as 4×4 matrix as:

Transformation Matrix

$$= \begin{bmatrix} \cos \beta \cos \gamma & -\cos \beta \sin \gamma & \sin \beta & dx \\ \cos \alpha \sin \gamma + \cos \gamma \sin \alpha \sin \beta & \cos \alpha \cos \gamma - \sin \alpha \sin \beta \sin \gamma & -\cos \beta \sin \alpha & dy \\ \sin \alpha \sin \gamma - \cos \alpha \cos \gamma \sin \beta & \cos \gamma \sin \alpha + \cos \alpha \sin \beta \sin \gamma & \cos \alpha \cos \beta & dz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

or

$$\text{Transformation Matrix} = \begin{bmatrix} R_{11} & R_{12} & R_{13} & dx \\ R_{21} & R_{22} & R_{23} & dy \\ R_{31} & R_{32} & R_{33} & dz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where, $\alpha = \tan^{-1} \left(-\frac{R_{23}}{R_{33}} \right)$; $\beta = \tan^{-1} \left(\frac{R_{13}}{\sqrt{R_{23}^2 + R_{33}^2}} \right)$; $\gamma = \tan^{-1} \left(-\frac{R_{12}}{R_{11}} \right)$.

From the transformation matrix, the rotation matrices about x-, y-, and z-axes are calculated, respectively:

$$Rot_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \alpha & -\sin \alpha \\ 0 & \sin \alpha & \cos \alpha \end{bmatrix}$$

$$Rot_y = \begin{bmatrix} \cos \beta & 0 & \sin \beta \\ 0 & 1 & 0 \\ -\sin \beta & 0 & \cos \beta \end{bmatrix}$$

$$Rot_z = \begin{bmatrix} \cos \gamma & -\sin \gamma & 0 \\ \sin \gamma & \cos \gamma & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

The translational vector t is:

$$\{t\} = \begin{Bmatrix} dx \\ dy \\ dz \end{Bmatrix}$$

Thus, the linear distance and the angular changes of each tooth in 3 planes were derived from the transformation matrices and recorded for every project. By the nature of the CloudCompare software, any linear change along the x-axis represents mesiodistal direction, y-axis represents faciolingual direction, and z-axis represents occlusogingival direction of the tooth movement. Also, any rotation about the x-axis represents faciolingual tipping, any rotation about the y-axis represents mesiodistal tipping, and any rotation about the z-axis represents rotation about the long axis of the tooth.

For the discrepancy in linear displacement, the difference in the magnitude of the vectors was calculated using the formula, where x_1 , y_1 , and z_1 denote the linear magnitude of an actual tooth displacement vector in 3 different planes, and x_2 , y_2 , and z_2 denote the linear magnitude of a predicted tooth displacement vector in 3 different planes:

$$\text{Linear discrepancy } (\Delta V) = \sqrt{((x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2)}$$

For the discrepancy in angular displacement, the relative error of the angular change in each direction was calculated using the formula:

$$\text{Relative Error for Angular Change } (\Delta x^\circ, \Delta y^\circ, \Delta z^\circ) = \left| 1 - \left(\frac{\text{Actual Value}}{\text{Predicted Value}} \right) \right|$$

The resultant relative errors have no unit. All of the values would approach zero as the actual tooth displacement approximated closer to the predicted amount of tooth displacement.

Statistical Analysis

Tooth movements for each tooth in all three directions were analyzed using analysis of variance, Student's t-test, Wilcoxon/Kruskal-Wallis rank sums test, and contingency analysis. Significance of results was determined as p-value < 0.05 (95% Confidence Interval). The intra-operator correlation test was performed to evaluate the intra-operator error.

CHAPTER 4: RESULTS

Reliability of Measurements

Intra-rater reliability test was performed to evaluate the operator's reliability with initial alignment of the scans, superimposition of the anterior teeth, and measurement of the tooth displacement. Twenty measurements were repeated seven days apart. The intra-rater reliability of the investigator was 98.8%.

Analysis of Tooth Displacement

1. Effect of MOP on Individual Tooth

The linear and angular discrepancies of the individual tooth were compared between the control samples and the experimental samples using one-way analysis of variance (ANOVA) supplemented by Wilcoxon/Kruskal-Wallis Rank Sums test. The mean values of all data were presented in Table 1. The average values for ΔV , Δx° , Δy° , and Δz° of individual tooth ranged from 1.9138 to 3.5393, from 1.0386 to 2.5315, from 0.8844 to 3.9326, and from 0.5938 to 1.8373, respectively. However, the standard deviations for all parameters ranged from 0.4470 to 14.6098, indicating a broad range of discrepancy values. The broad range of the values can be visually confirmed when these mean values were plotted in bar graphs according to teeth and parameters (ΔV , Δx° , Δy° , and Δz°).

The mean values showed a noticeable variability among teeth, parameters, or arches (Figures 13 and 14). The figures indicate no consistent pattern between the groups where no

mean value of a certain parameter is consistently higher in one group than the other. For example, the control group's mean relative error of the rotation about the y-axis (Δy°) for upper right central incisors (3.9326 ± 2.2639) was greater than twice the experimental group's value (1.9114 ± 2.8025). On the other hand, for the same parameter, the mean relative errors for lower right canines (#27) show an opposite pattern, where the experimental value (1.5885 ± 2.5676) is almost double the control value (0.8844 ± 2.2146). Likewise, the figures do not readily exhibit any tendency for other parameters of the rest of the anterior teeth.

Table 1. Mean values of the linear (ΔV) and angular discrepancies (Δx° , Δy° , Δz°) of all anterior teeth and the standard deviations for all parameters

		ΔV		Δx°		Δy°		Δz°	
		Mean	Std Dv	Mean	Std Dv	Mean	Std Dv	Mean	Std Dv
#6	Control	2.7242	0.9866	1.6015	1.6681	1.2881	2.2489	0.8774	3.5278
	MOP	3.5393	1.4669	1.0988	1.9814	1.5790	2.6037	0.9594	7.9788
#7	Control	2.7672	1.0244	1.9361	1.6694	2.0734	2.2613	0.9025	3.5645
	MOP	3.2902	1.5055	1.4042	1.9906	1.4716	2.6446	0.8104	8.0522
#8	Control	2.7395	1.0966	1.4863	1.6705	3.9326	2.2639	0.5938	3.7776
	MOP	3.4710	1.5105	2.5315	1.9931	1.9114	2.8025	0.7343	9.8747
#9	Control	2.6373	1.1554	2.3918	1.7157	1.2886	2.2783	0.8459	3.9076
	MOP	3.3507	1.5155	2.1857	2.0453	1.4127	2.8044	1.4923	14.6098
#10	Control	3.0536	0.4470	1.9469	1.5314	2.4048	2.0591	0.9430	2.8251
	MOP	3.2301	1.1609	1.2121	1.7197	1.6645	2.2995	0.8124	4.4877
#11	Control	2.6453	0.5761	1.7060	1.5373	1.0201	2.0762	1.1353	2.9449
	MOP	2.8778	1.1962	2.3236	1.7677	1.3125	2.3816	1.3372	4.7342

#22	Control	3.0861	0.6026	1.2583	1.5487	2.8260	2.1010	1.7371	3.0960
	MOP	2.7090	1.2279	1.4935	1.7918	1.2024	2.4453	0.7758	5.3465
#23	Control	2.2611	0.6718	1.0386	1.5759	1.0461	2.1107	0.9315	3.1101
	MOP	2.2687	1.2439	1.2320	1.7984	0.9379	2.5035	1.0233	5.4802
#24	Control	2.3523	0.6999	1.4854	1.5944	1.0071	2.1187	0.7418	3.1664
	MOP	1.9138	1.2867	1.0705	1.8280	1.5060	2.5053	0.7991	5.6427
#25	Control	2.0561	0.7600	1.8523	1.5970	1.2406	2.1297	0.6830	3.1909
	MOP	2.3261	1.3779	1.3244	1.8581	1.8509	2.5256	1.1071	6.1317
#26	Control	2.3759	0.7970	1.1473	1.6209	1.0799	2.1898	0.9189	3.2412
	MOP	2.0885	1.3889	1.6533	1.9313	1.4454	2.5607	1.1816	6.3562
#27	Control	3.0149	0.9632	1.9657	1.6465	0.8844	2.2146	1.8373	3.5182
	MOP	2.5751	1.4369	1.3916	1.9386	1.5885	2.5676	0.7304	7.8771

Figure 13. Mean linear discrepancy (ΔV) and relative errors for angular displacement (Δx° , Δy° , Δz°) for upper anterior teeth (#6-#11) for the experimental (MOP) and control samples with standard errors, where ΔV is millimeter, and the angular parameters are dimensionless.

Figure 14. Mean linear discrepancy (ΔV) and relative errors for angular displacement (Δx° , Δy° , Δz°) for lower anterior teeth (#22-#27) for the experimental (MOP) and control samples with standard errors, where ΔV is millimeter, and the angular parameters are dimensionless.

As shown in Table 2, one-way ANOVA revealed that the only significant difference was found in the rotational discrepancy about the y-axis (Δy°) of lower right canines ($p=0.0189^*$). The mean relative error value of the particular tooth movement for the control samples was 0.8844 ± 2.2146 , and that of the experimental samples was 1.5885 ± 2.5676 . In other words, the mean value of the experimental group for the particular parameter was almost twice the value of the control group. However, due to a large number of comparisons ($m=48$) tested, Bonferroni correction was applied in order to counteract the increasing likelihood of incorrectly rejecting a null hypothesis. At the corrected significance level of $\alpha = 0.05 \div 48 = 0.001$, the difference between the groups for #27 Δy° is no longer statistically significant. In fact, the means of all values were found to be not statistically different between two groups. In addition, for all the parameters with a wide range of data values, the Wilcoxon/Kruskal-Wallis Rank Sums test was performed, which found no significant difference between the groups as well.

Table 2. One-way ANOVA of the linear and angular discrepancies between the actual outcome and the predicted outcome for individual anterior teeth between the control and the experimental samples

	ΔV		Δx°		Δy°		Δz°	
	p value	S/NS	p value	S/NS	p value	S/NS	p value	S/NS
#6	0.0926	NS	0.1680	NS	0.6169	NS	0.7333	NS
#7	0.1419	NS	0.3660	NS	0.5623	NS	0.6495	NS
#8	0.0631	NS	0.1773	NS	0.3758	NS	0.1835	NS
#9	0.0733	NS	0.8772	NS	0.7751	NS	0.1703	NS
#10	0.7244	NS	0.1381	NS	0.6494	NS	0.5353	NS
#11	0.4782	NS	0.4565	NS	0.4447	NS	0.6099	NS
#22	0.4443	NS	0.6158	NS	0.1454	NS	0.4814	NS
#23	0.9842	NS	0.7010	NS	0.7179	NS	0.8364	NS
#24	0.1654	NS	0.6046	NS	0.2427	NS	0.7135	NS
#25	0.4645	NS	0.5835	NS	0.3095	NS	0.2044	NS
#26	0.4236	NS	0.4734	NS	0.3846	NS	0.5978	NS
#27	0.3825	NS	0.4340	NS	0.0189*	NS	0.4384	NS

2. Effect of MOP by Arch

The mean linear discrepancy and the relative errors for angular displacement were combined for the upper arch, the lower arch, and the entire dentition for all samples. The mean values for the parameters ranged between 0.8830 and 3.2932, and the standard deviations ranged from 0.0085 to 2.0470 (Table 3). Unlike the mean values and standard deviations for individual teeth, the values combined by the arch showed a smaller range and less variation. However, the values exhibited no pattern amongst themselves; neither group showed consistently higher mean

value than the other. This can be visually verified in Figure 15.

Table 3. Mean values of the linear and angular discrepancies of upper, lower, and both arches and the standard deviations for all parameters

		ΔV		Δx°		Δy°		Δz°	
		Mean	Std Dv	Mean	Std Dv	Mean	Std Dv	Mean	Std Dv
Mx	Control	2.7607	0.0859	1.8421	0.0713	1.9964	0.0206	0.8830	0.0486
	MOP	3.2932	0.2332	1.7961	2.0470	1.5595	0.2124	1.0236	0.7969
Md	Control	2.5244	0.4176	1.4584	0.0085	1.3449	0.0680	1.1422	0.0106
	MOP	2.3135	0.2958	1.3611	0.8331	1.4198	0.3133	0.9378	0.5990
Total	Control	2.6428	0.4354	1.6514	0.0967	1.6743	0.0315	1.0123	0.0363
	MOP	2.8034	0.5712	2.5284	1.7139	1.4872	0.2659	1.2967	0.6891

Figure 15. Mean linear discrepancy and relative errors for angular displacement for upper, lower, and combined arches for the experimental (MOP) and control samples and standard errors, where ΔV is millimeter, and the angular parameters are dimensionless.

One-way ANOVA revealed that there was a statistically significant difference between the groups when the linear discrepancy (ΔV) of the upper anterior teeth was considered ($p=0.0015^*$). The mean value of the linear discrepancy of the upper teeth for the control samples (2.7607 ± 0.0859) was lower than that of the experimental samples (3.2932 ± 0.2332). For some parameters, the control samples exhibited higher mean values than the experimental samples. However, no significant difference between the control and the experimental groups was found for the rest of the parameters when the teeth were combined by the arches (Table 4).

Table 4. One-way ANOVA of the linear and angular discrepancies between the actual outcome and the predicted outcome of upper, lower, and combined arches between the control and the experimental groups

	ΔV		Δx°		Δy°		Δz°	
	p value	S/NS	p value	S/NS	p value	S/NS	p value	S/NS
Mx	0.0015*	S	0.8864	NS	0.3949	NS	0.2466	NS
Md	0.2088	NS	0.7374	NS	0.7607	NS	0.5572	NS
Total	0.4073	NS	0.6874	NS	0.5233	NS	0.8130	NS

3. Effect of MOP on the Types of Orthodontic Tooth Movement

Table 5 shows the difference between the mean values of the groups according to the types of OTM and the statistical significance of the differences for upper and lower arches. As shown in Figure 16, the linear discrepancy and the angular relative errors are generally similar for both groups. Neither group has a consistently higher value for any parameter. However, the greatest discrepancy between the mean values of the groups was found in the translational movement (ΔV) of the upper anterior teeth, which was 0.8770 (MOP: 2.5284 ± 1.7139 , Control:

1.6514±0.0967). The difference in the mean values between the groups for all other movements was within 0.55. Multi-factor ANOVA indicated that the differences between the groups according to the types of orthodontic tooth movement were not statistically significant indicated by the p-values presented in Table 5.

Table 5. The difference in linear and angular discrepancy between the groups and the statistical significance

		ΔV		Δx°		Δy°		Δz°	
		Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
Mx	Control	2.7607	0.5325	1.8421	0.0460	1.9964	0.4369	0.8830	0.1406
	MOP	3.2932		1.7961		1.5595		1.0236	
Md	Control	2.5244	0.2109	1.4584	0.0973	1.3449	0.0749	1.1422	0.2044
	MOP	2.3135		1.3611		1.4198		0.9378	
Total	Control	2.6428	0.1606 (p=0.4073)	1.6514	0.8770 (p=0.6873)	1.6743	0.1871 (p=0.5233)	1.0123	0.2844 (p=0.8130)
	MOP	2.8034		2.5284		1.4872		1.2967

Figure 16. Comparison of mean tooth displacement by different types of orthodontic tooth movement with standard deviations, where the ΔV is millimeter, and the angular parameters are dimensionless.

Effect of Micro-Osteoperforation by Gender

The control group consisted of 23 male (39.0%) and 36 female (61.0%) subjects. The experimental group consisted of 13 male (28.3%) and 33 female (71.7%) subjects. Both groups had noticeably more female subjects, but the control group had a slightly higher rate of male subjects.

The effect of micro-osteoperforation in relation to gender of the subjects was analyzed using regression analysis with the least squares means. All anterior teeth were combined, but each parameter was analyzed separately. When gender was considered separately for all samples in both groups, linear displacement was the only parameter that was found significantly different between genders ($p = 0.0005^*$). For both groups, females had smaller linear and angular discrepancies between the predicted and the actual tooth positions, compared to males in the same group. As visually represented in Figure 18, males (mean = 2.98 ± 0.11) showed a greater linear discrepancy (ΔV) than females (mean = 2.57 ± 0.07) with the difference of approximately 0.41 when both the control and experimental samples were considered together. A similar pattern was observed in all other parameters. (See Appendix E) However, if the gender effect was combined with the effect of MOP, the interaction was only suggestive of statistical significance ($p = 0.0526$). On the other hand, the analyses of the angular parameters showed no significant difference between the genders or between the groups (Table 6).

Figure 17. Means of linear and angular discrepancies by gender with the groups combined with standard deviations, where the ΔV is millimeter, and the angular parameters are dimensionless.

Figure 18. Least Squares Means Plot of gender versus the linear discrepancy (ΔV) between the actual and the predicted outcomes for both control and experimental samples combined

Table 6. The mean linear and angular discrepancies for male and female subjects of both groups and the significance of the interaction between the gender and the orthodontic tooth movement in clear aligner treatment with or without MOPs

Parameter	Gender Mean		Gender p-value	Gender*Group Mean				Gender & Group p-value
	Male	Female		Male & Control	Female & Control	Male & MOP	Female & MOP	
ΔV	2.97916	2.57532	0.0005*	2.84341	2.51387	3.21356	2.64188	0.0526
Δx°	1.43202	1.73846	0.2149	1.41367	1.79470	1.46792	1.66174	0.6862
Δy°	1.59172	1.60492	0.9388	1.56108	1.73319	1.65034	1.43021	0.5303
Δz°	1.04956	0.97762	0.8025	1.09690	0.93612	0.95796	0.99749	0.6457

Effect of Micro-Osteoperforation by Age

The mean age for the control group was 29.3 years, ranging from 11.3 to 89.4 years. The mean age for the experimental group was 34.1 years, ranging from 17.1 to 60.2 years. Although the mean age was slightly higher for the experimental group, the range was smaller than that of the control group.

The relationship between MOPs and the age of the subjects was analyzed using multi-factorial ANOVA. As shown in Figure 19, the fit line of the experimental group has a negative slope between the linear discrepancy (ΔV) and the age of the patients, but the fit line of the control group has a slightly positive, almost flat slope. As indicated by the difference in the slopes, the negative correlation between the age and the linear discrepancy is more pronounced in the MOP group (estimated difference = 0.0204), while the linear discrepancy tends to increase

as the age increases for the control group. The analyses showed that the difference between the groups was statistically significant for ΔV that was affected by the age of the patients ($p < 0.0001^*$) (Table 7). There is a minimal difference in the linear discrepancy values between groups where the fit lines intersect around the age of 38. Nevertheless, as the age of the subjects increased, the MOP samples showed less linear discrepancy between the post-treatment and the prediction compared to the control.

Figure 19. Regression plot of the linear discrepancy (ΔV) and age and the fit lines for control and experimental groups

Table 7. Multi-factorial ANOVA of the significance of the interaction between MOP and the age of the subjects

Parameter	Estimated Difference	p-value	Significance
ΔV	0.0204	$<0.0001^*$	S
Δx°	-0.0126	0.1803	NS
Δy°	0.0232	0.0672	NS
Δz°	-0.0016	0.8366	NS

Effect of Micro-Osteoperforation by Severity of Anterior Malalignment

1. Maxillary Arch

Multi-factorial ANOVA was performed to analyze the relationship between the effect of MOP and the severity of anterior mal-alignment, indicated by the amount of crowding or spacing present in the anterior region. As shown in the regression analysis of Δx° and the space available in the anterior region in Figure 20, the blue fit line that represents the experimental group has a negative slope. This negative slope indicated a negative correlation between the space available in the anterior region and the angular discrepancy between the actual and the predicted tooth displacement about the x-axis. As more space became available, the experimental samples showed that the actual amount of rotation about x-axis was closer to the predicted amount. On the other hand, the red fit line in the same regression analysis showed a slightly positive slope, indicating a mildly positive correlation between the space available in the anterior region and the angular discrepancy between the actual and the predicted tooth movement.

Regression analyses of the linear and other angular discrepancy values exhibited a similar pattern, where the MOP fit lines showed a negative correlation and the control fit lines showed a slightly positive correlation (See Appendix E). However, as shown in Table 8, the analyses indicated no statistically significant difference between the control and the experimental groups for the translational movement ($p=0.1470$) and the rotational movement about the y- and z-axes ($p=0.5316$ and $p=0.3322$, respectively). The rotational movement about the x-axis was the only movement in the maxillary anterior region that the analysis indicated a statistically different between the groups ($p=0.0201^*$).

Figure 20. Regression analysis of the amount of upper anterior crowding or spacing versus the angular discrepancy about the x-axis (Δx°) between the actual and the predicted tooth displacements

Table 8. Multi-factorial ANOVA of the significance of the interaction between MOP and the amount of space available in the upper anterior region

Parameter	Estimated Difference	p-value	Significance
ΔV	-0.0487	0.1470	NS
Δx°	0.3993	0.0201*	S
Δy°	0.0638	0.5316	NS
Δz°	1.3921	0.3322	NS

2. Mandibular Arch

Multi-factorial ANOVA was performed to analyze the relationship between the amount of space available in the lower anterior region and the effect of micro-osteoperforations. In Figure 21, the regression plot shows a negative correlation between the linear discrepancy (ΔV) and the amount of space available in the lower anterior sextant for both groups. As the space became more available, samples in both groups resulted in a translational movement that was closer to the predicted movement. With a greater amount of crowding, both groups showed a greater discrepancy between the actual outcome and the predicted outcome. Although the difference is slight, the slope of the experimental fit line is steeper than that of the control, indicating that the experimental samples resulted in even less linear discrepancies with an increased amount of spacing compared to the control samples. Due to the point where two fit lines intersect (-3mm of crowding), the difference is more pronounced with more spacing. The regression plots of the angular discrepancies (Δx° , Δy° , and Δz°) showed a similar pattern where the fit lines were sloping downwards as the amount of available space increased. (See Appendix E) However, as reported in Table 9, the ANOVA indicated that the only statistically significant difference in the slopes between the groups was found with the linear discrepancy ($p < 0.0001^*$). The groups showed no statistically significant difference in terms of angular discrepancies in mesiodistal, faciolingual, and occlusogingival directions ($p = 0.1733$, 0.8701 , and 0.6158 , respectively).

Figure 21. Regression analysis of the amount of lower anterior crowding or spacing versus the linear discrepancy (ΔV) between the actual and the predicted tooth displacements

Table 9. Multi-factorial ANOVA of the significance of the interaction between MOP and the amount of space available in the lower anterior region

Parameter	Estimated Difference	p-value	Significance
ΔV	-0.2067	<0.0001*	S
Δx°	0.3168	0.1733	NS
Δy°	-0.3431	0.8701	NS
Δz°	-0.1713	0.6158	NS

Effect of Micro-Osteoperforation on the Frequency of Refinement

Contingency analysis was performed to analyze the effect of MOPs on the frequency of refinement treatment as determined at the end of the prescribed aligners (T.S.). As seen in Table 10, 49 out of 59 control samples (83.05%) required refinement treatment at the conclusion of the prescribed aligners. On the other hand, 42 out of 44 experimental samples (95.65%) required refinement. Out of the 105 samples included in the study, more control samples (9.52%) completed the treatment without requiring a treatment than the experimental samples (1.90%). As seen in Figure 22, the analysis showed that the difference in the frequency of the refinement between the groups is significant ($p=0.0343^*$), indicating that the refinement was more likely with the 3-day aligner wear protocol with the MOPs, compared to the 14-day aligner wear protocol.

Table 10. Contingency table of the frequency of refinement treatment needed per group

Count Total % Col % Row %	Completed Cases (C)	Refinement Needed (R)	Total
Control	10 9.52 83.33 16.95	49 46.67 52.69 83.05	59 56.19
Experimental	2 1.90 16.67 4.35	44 41.90 47.31 95.65	46 43.81
Total	12 11.43	93 88.57	105

Figure 22. Mosaic Plot of the frequency of refinement treatment necessary at the completion of the prescribed aligner wear for control and experimental samples

CHAPTER 5: DISCUSSION

The ability of clear aligners to improve the alignment of the anterior teeth and the effects of MOPs on the accuracy of anterior tooth movement with CAT was examined by comparing the actual amount of tooth displacement to the predicted amount of tooth displacement. The information gained through this study will shed light on whether clinicians can shorten the treatment duration when using clear aligners in conjunction with MOP. The linear discrepancy was represented by the difference in the magnitude of the ClinCheck prediction and the actual treatment outcomes. The angular discrepancy was represented by the relative error of the angular displacement about three different axes (x-, y-, and z-axes). When the discrepancy between the prediction and the actual outcome of individual teeth was analyzed in three separate planes, the difference between the control and the experimental samples in all of the values was found to be statistically insignificant. When these movements for each individual anterior tooth were considered, the linear and angular discrepancies between the actual outcome and the predicted outcome in the experimental samples with MOPs were comparable to those of the control samples without MOP.

On the other hand, the analyses indicated that the only value that was found to be statistically significant at $\alpha=0.05$ was the difference in the relative error of angular movement in faciolingual directions of lower right cuspids. This seemingly significant difference between the groups exists in other parameters. However, as a result of the high variability of the values as indicated by the standard deviations, the differences in these parameters were found to be statistically insignificant. In fact, when Bonferroni correction was applied due to a large number of comparisons performed for all teeth in all 3 dimensions, the difference between the groups for

Δy° of #27 was found to be not statistically significant. Thus, the data indicate that the 3-day aligner wear combined with MOPs resulted in a clinically comparable accuracy of anterior tooth movement.

When six anterior teeth were considered together, the analyses indicated a statistically significant difference between the groups with the linear discrepancy of the maxillary anterior teeth. Since the formula to obtain the linear discrepancy is a square root of the sum of the differences in the distances of the vectors, the magnitude of the difference between the actual and the predicted outcome may not be clinically significant despite the statistical significance. In fact, the numerical difference between the groups for this parameter was around 0.3mm per dimension, which may not be clinically significant. Likewise, the differences in all other parameters for the upper and lower teeth between the two groups were neither clinically nor statistically significant, indicating that the 3-day aligner wear protocol did not adversely affect the aligners' ability to control orthodontic tooth movement if combined with MOPs.

When the mean discrepancies were considered according to the different types of orthodontic tooth movement, the analyses indicated no statistically significant difference between the control and the experimental groups. Moreover, the effect of MOP is non-discriminatory towards the types of tooth movement, such as rotation and translation. However, this result is not in full agreement with the currently available literature, which reported that the most accurate tooth movement was lingual tipping (47.1%) and the least accurate was extrusion (29.6%).²⁸ Due to the method utilized to calculate the discrepancy of the orthodontic tooth movement in the current study, a direct comparison with the referenced study may not be applicable. Nevertheless, the results of this study show that the discrepancies in the accuracy of tooth movement also vary per parameter, suggesting differences in the accuracy of tooth

movement with clear aligners although the difference may be statistically insignificant.

Once the data were arranged according to the gender of the subjects, the statistical analysis indicated that females achieved a translational tooth movement that was significantly closer to the prediction compared to males. However, for other parameters, the data did not exhibit this trend or show any statistically significant difference between the genders. This is partially consistent with the study by Chisari et al., which showed a combined effect of age and gender on the accuracy of OTM in CAT.²⁷ Nevertheless, the gender differences presented in this study failed to indicate any clinical significance. In addition, the data indicate no significant interaction between the effects of MOP and gender. MOPs may have a favorable effect on translational tooth movement, possibly increasing the tracking ability for female subjects; however, the analysis is merely suggestive of a possible differential effect of MOP on gender.

If the age of the subjects was considered, a statistically significant effect of MOPs on the translational movement was observed with the increasing age of the subjects. The effect of MOP became more favorable as the patient's age increased, approximating the predicted tooth movement closer than the 14-day aligner wear protocol. This may be interpreted as a minimal effect of MOPs in younger individuals. As reported by Ren et al. in their animal study, younger samples exhibit a faster orthodontic tooth movement compared to older individuals especially during the initial phase of orthodontic treatment.⁷⁶ Thus, the effect of MOP may be masked by a naturally elevated bone turnover observed in younger patients. However, as the rate of orthodontic tooth movement becomes impeded in adult patients, an intervention to increase the rate of tooth movement may be more desirable. As supported by the results of the current study, increasing age may be an indication for MOPs.

The differential effect of MOPs on severity of anterior mal-alignment was measured by

the amount of crowding or spacing present initially. Regardless of the application of MOPs, the actual outcome seems to approximate closer to the prediction with anterior spacing compared to crowding. On the other hand, as the amount of crowding increases, the subjects who received MOPs were associated with slightly greater linear and angular discrepancies between the predicted and the actual outcomes for both upper and lower anterior teeth. This may be explained by the varying severity of mal-alignment in each group. In general, crowding greater than 4mm is considered severe, often necessitating extraction or a substantial amount of interproximal reduction, expansion, and proclination to resolve the crowding. For the samples included in the study, a total of 31% of the experimental group had severe crowding in either one or both arches, whereas 22% of the control group had crowding greater than 4mm. On the contrary, the control group had a higher rate (60%) of minimal crowding or spacing (i.e. less than 1mm crowding or spacing) compared to the experimental group (45%). In other words, the conclusion that MOPs may adversely affect the outcome of clear aligner treatment with severe crowding may be misleading. Nevertheless, the results mostly indicate that the outcome of CAT with or without MOPs is not significantly affected by the severity of anterior mal-alignment.

Lastly, when the frequency of refinement treatment at the completion of prescribed aligners was measured, the results revealed that the majority of the CAT cases considered in this study required refinement treatment, indicating that the actual treatment outcome did not satisfactorily approximated the predicted outcome for most cases. This is somewhat in agreement with the current studies that reported the efficiency of clear aligner treatment was anywhere between less than ideal and clinically unacceptable.^{26-28, 63, 64} The overall frequency reported in this study (88.57%) is slightly higher than that reported by Kravitz (70-80%).²⁶ However, the slight difference between the survey result and the samples used in the current study can be

explained by the different standards that may be used to evaluate the final outcome to decide the need for refinement treatment. Nevertheless, both studies agree that the majority of CAT cases often do not result in a satisfactory outcome.

Moreover, the experimental group was more likely to proceed with refinement treatment (95.65% versus 83.05%). Several explanations are possible: First, the 3-day aligner wear may result in slightly greater discrepancies in all three dimensions per aligner than the 14-day aligner wear, which may accumulate to a noticeable gap between the actual and the predicted outcome, necessitating a refinement. Although most of the analyses showed no statistical difference between the control and the experimental groups, many of the parameters showed a higher discrepancy for the experimental samples. The cumulative discrepancy between the actual and the predicted outcomes, though unnoticeable individually, may lead to a need for a refinement treatment. Second possible explanation is the difference in the severity of malocclusion, which can be extrapolated from the severity of mal-alignment and the number of prescribed aligners. The patients with a more severe malocclusion may be more inclined to elect an interventional procedure in an effort to increase the rate of tooth movement and shorten the treatment duration. Thus, the experimental group might have inadvertently included more severe cases with more complicated tooth movement. As mentioned earlier, a greater percentage of the experimental samples started with more severe anterior crowding. Additionally, the average number of prescribed aligners was higher for the experimental group (mean 24.7 aligners, ranging from 15 to 50) compared to the control group (mean 21.2 aligners, ranging from 10 to 46). Therefore, the sheer complexity of the cases might have resulted in a higher frequency of refinement treatment.

Hypotheses Testing

Summary of Results

1. ACCEPTED: There was no significant difference between the groups in tooth movements of the anterior teeth predicted by the ClinCheck compared to the actual treatment between the experimental and control groups.
2. PARTIALLY ACCEPTED: There was no significant difference between the groups in the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome among angular movements. However, there was a statistically significant difference in the *linear* tooth movement of upper anterior teeth predicted by the ClinCheck compared to the actual treatment outcome.
3. ACCEPTED: There was no statistically significant difference between the groups in the accuracy of tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome between genders. However, there was a statistically significant difference for the *translational* movements between genders when samples from both groups were combined. There was no significant difference in the interaction of MOPs and gender for the accuracy of anterior tooth movement.
4. REJECTED: There was a statistically significant difference between the groups in the accuracy of the tooth movements of anterior teeth predicted by the ClinCheck compared to the actual treatment outcome among different age groups.
5. PARTIALLY ACCEPTED: There was a statistically significant difference between the groups in the *rotational* tooth movements of upper anterior teeth and in the *linear* tooth movements of lower anterior teeth predicted by the ClinCheck compared to the actual

treatment outcome for varying severity of anterior mal-alignment. No other tooth movements showed any statistical difference between the groups.

6. REJECTED: There was a statistically significant difference between the groups in the frequency of refinement treatments at the completion of the prescribed aligner treatment.

Clinical Implications

The addition of MOP in clear aligner treatment seems to be a viable option to shorten the treatment duration without adversely affecting the quality of treatment outcome. The approximation of the actual tooth movement to the predicted tooth movement seems to be minimally affected by a significant shortening in the duration of the aligner wear (3 days versus 14 days). By shortening the treatment duration, the patients will more likely to maintain a high level of compliance throughout the treatment without exposing themselves to damaging side effects associated with prolonged orthodontic treatment.

For more complicated tooth movement, MOPs may be combined with a longer aligner wear to increase the efficiency of tooth movement. In cases where the impeded tooth movement becomes an evident concern, such as in older patients and male patients, MOP can be offered not just as a method of shortening the treatment duration, but also as an auxiliary to increase the accuracy of the orthodontic tooth movement with the longer duration of aligner wear.

CHAPTER 6: SUMMARY AND CONCLUSIONS

Summary

Accelerated CAT can offer many benefits to the clinicians and the patients. However, the accuracy of orthodontic tooth movement with the shorter aligner-wear with MOPs needed to be verified. In this retrospective study, the effect of MOP on the accuracy of tooth movement was examined by comparing the actual treatment outcomes to the prediction models of 49 experimental samples (3-day aligner wear and MOPs) and 56 control samples (14-day aligner wear without MOPs). Using CloudCompare software, the pre-treatment, post-treatment intraoral scans, and prediction models were superimposed to each other, and the differences between the predicted and the actual tooth position of the anterior teeth in both arches were measured. The results indicated that the accuracy of orthodontic tooth movement was not significantly affected by the shortened duration of the aligner wear if the treatment was combined with MOPs. Although the correlation was not strong, and most of the differences were clinically insignificant, MOPs seemed to be more effective in aligning anterior teeth in males, older patients, and anterior spacing cases, compared to CAT with the 14-day aligner protocol. On the other hand, the refinement treatment was more frequently considered for the experimental group, possibly due to the higher complexity of the cases included in the experimental group than the control. Thus, the current study suggests that the CAT 3-day aligner wear with MOPs may be a viable option to accelerate OTM without negatively affecting the quality of the treatment outcome.

Conclusions

Based on the results of the study, following conclusions can be made:

- The reduction of the duration of aligner wear from 14 days to 3 days with MOPs did not negatively affect the accuracy of the linear and angular tooth movement in clear aligner treatment.
 - The types of orthodontic tooth movement were not significantly influenced by the effect of MOP on the accuracy of tooth movement.
- MOPs had a clinically insignificant effect on gender, age, and the severity of mal-alignment.
- There is a significant increase in the frequency of refinement treatment in the CAT with MOPs probably due to a higher number of aligners and a greater amount of anterior crowding seen in the experimental samples.
 - Patients with more severe mal-alignment or longer treatment plan are more likely to elect an auxiliary procedure to accelerate orthodontic tooth movement.
 - The complexity of the treatment mechanics may need to be considered when determining the duration of the aligner wear despite the auxiliary procedure to increase the rate of orthodontic tooth movement.

CHAPTER 7: RECOMMENDATIONS FOR FUTURE RESEARCH

Recommendations on Sample Collection

The current study can yield a more definitive conclusion if the samples included the CAT with 3-day aligner wear *without* MOP and the CAT with 14-day aligner wear *with* MOP. However, this was not possible in this retrospective study due to the ethical reasons and the limitation of the available data. Moreover, Align Technology recently announced a change in the protocol, promoting a 7-day aligner wear instead of 14. It may be worthwhile to investigate the accuracy of tooth movement within 7 days and compare to the current data of the 3-day aligner wear CAT combined with MOPs.

Recommendations on Methodology

Visual verification to align the post-treatment and the prediction scans with the pre-treatment scans may introduce some variability in the interpretation of the direction and the magnitude of tooth movement. For future research, the same samples can be analyzed using software that can consistently superimpose the scans using a programmed algorithm to reduce the variability in overlaying of the scans. Also, the chosen method with the CloudCompare software introduces a fair amount of variability indicated by the reported standard deviations. Software that is more sensitive with small measurements can be used instead to reduce the variability in the angular and linear measurements of the tooth displacement.

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APPENDICES

Appendix A – IRB Exemption

Acknowledgement Letter Exempt Initial Protocol Review

Action Date	08/24/2016
To	Peter Ngan
From	WVU Office of Research Integrity and Compliance
Approval Date	08/24/2016
Expiration Date	08/23/2019
Subject	Acknowledgement Letter Exempt Initial Protocol Review
Protocol Number	1606156142
Title	Effect of Micro-Osteoperforation on Orthodontic Tooth Movement in Clear Aligner Therapy

The above-referenced study was reviewed by the West Virginia University Institutional Review Board IRB and was granted exemption in accordance with 45 CFR 46.101.

- This research study was granted an exemption in accordance with Research on existing data, documents, records, pathological specimens, or diagnostic specimens [45 CFR 46.101(4)]. In accordance with the Health Insurance Portability and Accountability Act, a waiver of research authorization has been granted. Please fulfill the subject accounting requirements associated with the granting of this waiver. All exemptions are only good for three years. If this research extends more than three years beyond the approved date, then the researcher will have to request another exemption. The following documents have been acknowledged for use in this study and are available in the WVU+kc system:

Documents reviewed and/or approved as part of this submission:

Signed HIPAA Data Use Agreement.pdf: 2016-08-22-04:00

HIPAA Waiver Form.pdf: 2016-08-22-04:00

Letter of Permission to Conduct Research Signed.pdf: 2016-08-22-04:00

Data Collection Sheet.xlsx: 2016-08-22-04:00

Documents for use in this study have been acknowledged and are available in the WVUkc system in the Notes and Attachments section of your protocol.

The Office of Research Integrity and Compliance is here to provide assistance to you from the initial submission of an IRB protocol and all subsequent activity. Please feel free to contact us by phone at 304.293.7073 with any question you may have. Thank you.

WVU Office of Research Integrity and Compliance

Date:08/24/2016

Signed:

Afton Wagner
IRB Administrator

Appendix B – Letter of Permission to Conduct Research

Letter of Permission to Conduct Research

I, Dr. Thomas Shipley, owner of Shipley Orthodontics, give my permission for Dr. DoBin Choi to conduct her study entitled "Effect of Micro-Osteoperforation on Orthodontic Tooth Movement with Clear Aligner Therapy" at Shipley Orthodontics in Peoria, AZ.

Signature of Location Administrator

Printed Location Administrator Name

Thomas Shipley

Date

2/4/2016

Appendix C – HIPAA Data Use Agreement for Limited Data Sets

DATA USE AGREEMENT FOR LIMITED DATA SETS

This Data Use Agreement ("Agreement"), effective as of October 23, 2015 ("Effective Date"), is entered into by and between Dr. DoBin Choi ("Recipient") and Dr. Thomas Shipley ("Covered Entity"). The purpose of this Agreement is to provide Recipient with access to a Limited Data Set ("LDS") for use in the following titled research project: The Effect of Micro-osteoperforation on Orthodontic Tooth Movement with Clear Aligner Therapy (Project Name) under the direct supervision of Dr. Peter Ngan (Principal Investigator) in accord with the HIPAA Regulations.

1. **Definitions.** Unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the "HIPAA Regulations" codified at Title 45 parts 160 through 164 of the United States Code of Federal Regulations, as amended from time to time.
2. **Preparation of the LDS.** Covered Entity shall prepare and furnish to Recipient a LDS in accord with the HIPAA Regulations or Covered Entity shall retain Recipient as a Business Associate (pursuant to an appropriate Business Associate Agreement) and direct recipient, as its Business Associate, to prepare such LDS. **NOTICE: This agreement is valid only if the Data do not include any of the following "Prohibited Identifiers": Names; postal address information other than town, cities, states and zip codes; telephone and fax numbers; email addresses, URLs and IP addresses; social security numbers; certificate and license numbers; vehicle identification numbers; device identifiers and serial numbers; biometric identifiers (such as voice and fingerprints); and full face photographs or comparable images.**
3. **Minimum Necessary Data Fields in the LDS.** In preparing the LDS, Covered Entity or its Business Associate shall include the data fields specified by the parties from time to time, which are the minimum necessary to accomplish the purposes set forth in Section 5 of this Agreement.
4. **Responsibilities of Recipient.** Recipient agrees to:
 - a. Use or disclose the LDS only as permitted by this Agreement or as required by law;
 - b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;
 - c. Report to Covered Entity any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law, including the presence of prohibited identifiers in the LDS;
 - d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Recipient under this Agreement; and

e. Not use the information in the LDS, alone or in combination to identify or contact the individuals who are data subjects.

5. Permitted Uses and Disclosures of the LDS. Recipient may use and/or disclose the LDS only for the Research described in this Agreement or as required by law.

6. Term and Termination.

a. Term. The term of this Agreement shall commence as of the Effective Date and terminate 5 years from Effective Date. Should the Recipient desire to keep the LDS for a longer period, a justification in writing should be made to the Covered Entity.

b. Termination by Recipient. Recipient may terminate this agreement at any time by notifying the Covered Entity and returning or destroying the LDS.

c. Termination by Covered Entity. Covered Entity may terminate this agreement at any time by providing thirty (30) days prior written notice to Recipient.

d. For Breach. Covered Entity shall provide written notice to Recipient within ten (10) days of any determination that Recipient has breached a material term of this Agreement. Covered Entity shall afford Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Covered Entity.

e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

COVERED ENTITY

By:

Print Name: Thomas Shirley
Print Title: orthodontist
2/4/2016

RECIPIENT

By:

Print Name: DoBin Choi, DDS
Print Title: Orthodontic Resident

Appendix D – HIPAA Waiver of Research Authorization Form

Health Insurance Portability and Accountability Act (HIPAA) Request for Waiver of Research Authorization

It is the responsibility of the Principal Investigator to ensure that the West Virginia University, as required, has on file a written account of all records accessed under this waiver of research authorization.

Indicate what will determine the termination of this waiver:
Upon study termination

Enter the waiver of research authorization end date: April 19, 2017

If you answered "Other" above, please explain:

Who will disclose, receive, and/or use the information?

The information will be provided by one of the co-investigators, Dr. Thomas Shipley from Shipley Orthodontics (Peoria, AZ). The information is received and analyzed by Dr. DoBin Choi and Dr. Peter Ngan.

What information will be used or disclosed?

The information used for the study involve pre- and post-treatment intraoral scans, intraoral scans of predicted treatment outcome, and pre- and post-treatment CBCT scans in addition to general demographic information, such as age, gender, and race.

Who will have access to, or use of, the Private Health Information (PHI)?

Only Dr. Thomas Shipley will have the access to the information of the subjects involved in the study. However, any of the personal/identifiable information will NOT be transferred to other investigators who are involved in data analysis.

How will the PHI be used or disclosed?

No identifiable information will be used or disclosed for the study.

Please describe the security measures to protect the HIPAA PHI:

Each subject will be assigned to a random ID number, which will be used to transfer the data instead of any identifiable information. The data transferred will not include any protected health information to protect the HIPAA PHI and ensure confidentiality of the subjects included in the study.

When do you plan to destroy the HIPAA PHI?

The patient information will be destroyed at the conclusion of the study, April 19, 2017.

How do you plan to destroy the HIPAA PHI?

The data will be in a digital form, which will be permanently deleted.

Why would the research be impracticable without the waiver of research authorization?

Analysis of the intraoral scans and CBCT images is an essential part of the study.

With respect to the waiver, you are only allowed to review the relevant minimum necessary information required in order to complete the study.

✓ Please check this box to assure the Institutional Review Board (IRB) that this is the minimum necessary information needed to conduct the study with this waiver.

Appendix E – Raw Data & Statistical Analyses

Raw Data

Control

#6				#7			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
2.049096	1.756936	0.361499	0.95196	2.157742	1.308557	0.746785	0.838368
1.450983	0.522909	6.478438	1.452057	0.984109	0.522497	0.555256	1.344574
4.787782	1.048626	0.105975	0.567682	1.649083	0.289595	1.238961	0.743022
1.995202	0.683417	0.027499	0.319329	3.443079	2.806072	3.323187	2.279155
4.350422	1.431219	1.128356	1.756287	3.613649	0.213732	0.294004	1.08581
3.229938	3.970314	0.829701	0.000744	2.053435	0.622711	0.696667	0.504289
2.634639	3.08932	4.637364	0.63511	3.461342	0.757185	12.88682	2.161923
0.848152	0.32796	0.098684	0.693938	2.750289	0.869971	1.124417	8.769427
0.792549	1.055538	0.140161	0.21998	6.895034	18.88837	2.941783	1.781111
2.196869	1.910957	4.571517	0.132927	0.807661	1.306757	1.301276	0.647371
1.149922	0.410011	0.369812	0.313097	5.638871	0.344924	45.35777	1.042123
4.276363	1.555788	0.790307	0.729122	0.485087	1.020621	1.125705	0.584998
1.85771	0.134062	0.708969	0.126644	1.643593	4.744837	1.415143	1.044166
3.066178	3.467783	0.935138	0.462539	2.832669	3.290714	0.466849	0.10771
2.231194	0.622546	3.157655	0.137701	1.859488	0.228888	0.911062	0.84801
2.013071	0.759917	0.149292	0.490558	1.108284	0.516254	0.222115	0.099836
2.656224	0.897132	0.971092	0.548337	3.355949	0.848009	0.498775	0.624137
3.878567	0.70423	0.253998	0.31601	2.431444	0.909437	0.457205	1.597374
1.832655	4.476667	1.097565	0.964344	3.409833	0.683413	2.022379	0.798754
2.835404	3.25411	1.036119	1.677988	2.235568	1.840137	0.077498	0.401145
5.402112	0.863831	0.654403	0.89572	3.291214	0.165361	0.971827	0.92704
4.139003	1.245245	0.894382	1.128684				
6.318498	0.795082	0.957237	3.57483	3.802987	0.706163	0.103104	0.757253
2.508384	0.877889	0.665125	0.536873	1.890797	1.570985	1.030102	0.166313
7.434493	1.449887	0.459638	0.685259	3.085863	0.323328	2.682984	0.258727
3.17788	1.288952	1.391584	1.227952	2.859587	1.172098	0.879213	0.016334
5.087044	0.694415	0.873556	0.701217	4.725453	0.948556	0.609116	0.379559
2.122073	0.607006	0.005785	0.49614	3.130209	0.307433	1.861487	0.178138
1.169507	0.408329	0.417527	0.242675	1.419468	2.599519	0.698153	2.206525
1.361124	5.555127	0.267269	0.054589	1.841306	1.170989	1.302916	0.25701

6.956593	1.073728	1.301938	0.960405	3.884771	0.109468	0.699686	1.351152
0.892341	15.75109	7.22571	1.117234	5.993379	0.961363	0.517234	0.905058
0.398883	0.08433	0.12424	3.036422	2.392079	3.379229	0.655337	0.282435
1.799886	0.787782	0.813904	0.154629	4.219237	0.488566	4.805526	0.909718
1.174583	0.338093	0.317347	0.271742	1.884892	0.841597	0.220273	0.582115
1.451107	6.17037	0.456701	0.511062	2.313279	1.060909	2.921241	0.734761
2.185136	0.959223	13.50475	1.519192	2.695793	0.49241	1.769523	0.182766
1.953102	0.636674	1.225381	0.53216	1.266603	19.41111	0.77895	0.453795
0.238051	0.023128	0.203292	0.017418	2.816849	0.540312	3.712196	0.443385
0.835677	0.304113	1.216899	0.051817	1.036909	1.800932	0.382119	0.538635
3.227008	0.038127	5.227369	0.032402	3.879173	0.605109	0.599348	0.30864
2.438809	1.764116	2.180872	0.329563	1.139859	0.707028	3.791008	0.030393
0.726818	0.058216	0.424921	0.070538	1.236344	1.122928	0.080911	0.507456
1.144021	0.060384	0.170725	0.549354	0.791855	5.172108	0.67968	0.200898
5.027946	1.730685	0.000985	0.432678	0.604556	0.76073	0.074163	0.303108
3.252003	1.939435	0.188305	0.390999	4.198485	5.290341	0.374309	1.491154
1.525424	0.663366	0.147982	7.569257	3.827691	1.123312	1.87105	0.871284
1.105356	0.434966	0.312023	0.351875	1.353727	2.000001	0.379374	0.492253
5.351674	1.458417	0.851144	0.702504	7.102558	1.252337	1.436688	0.765057
1.308666	2.650987	0.368135	0.324306	1.945197	0.29058	0.179877	1.242205
3.993698	1.200638	0.518764	0.790432	2.283317	3.09739	0.057062	0.256517
5.055615	0.808658	0.528155	0.516139	2.684846	0.701959	0.577675	0.675672
3.23397	1.776669	0.144205	1.600453	3.72544	1.285709	0.260507	1.423666
1.651448	0.936455	0.039278	0.268757	1.519953	1.255024	0.05168	0.714964
4.995333	2.992391	0.770358	0.864086	5.309003	0.964055	1.092193	0.809208
4.260628	0.715337	0.261075	0.915531	2.231164	1.212439	0.639663	0.262206
0.995346	0.838317	1.367059	0.075151	4.044867	2.673072	0.069006	0.51679
1.96966	0.828557	0.382012	4.89519	2.484561	0.778082	1.706562	1.736717

#8				#9			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
3.176327	0.958168	0.250471	0.576432	1.512504	0.604136	0.015443	0.547967
1.305187	0.431741	0.57813	1.279594	1.877008	0.647929	1.546015	0.366142
2.212921	0.572228	0.152411	0.266893	2.583212	0.53747	14.1954	0.387381
4.442844	4.102828	3.208358	1.165359				
3.621599	5.912757	1.429554	0.938246	2.113509	0.299153	0.761315	0.639706
1.908621	0.55146	0.796165	0.533889	0.606196	0.33557	3.134427	0.436299
1.755153	1.135631	0.873687	0.622658	0.80816	0.257713	0.372745	0.567152
1.738121	0.149143	0.165229	0.066416	0.295737	0.02023	0.378919	0.237735

2.264655	1.705407	0.100416	0.083584	1.671891	7.009276	1.342678	0.259443
3.487544	0.897582	0.46461	0.21688	1.614183	0.700633	1.23029	0.021433
1.860892	0.531606	0.281657	0.597157	1.158176	0.260216	0.047302	0.600517
6.656135	1.072366	3.764577	1.764289	0.960636	0.701003	0.503791	0.264248
4.085121	0.577857	0.117984	0.513543	3.366035	0.370815	3.489283	0.079693
3.371851	8.182992	67.89788	0.180664	2.44964	2.910898	0.433312	0.694509
1.976607	0.362792	0.35366	0.447667	1.306504	5.917286	0.403439	0.112118
0.904338	1.921207	0.843456	0.894441	0.933617	1.272457	0.325986	0.703443
4.731262	0.824131	1.682673	0.851715	4.605541	1.039491	7.070233	0.696423
2.7918	0.951876	0.61265	0.356331	2.260685	1.152204	0.227464	0.150265
2.431921	0.917435	2.518127	0.740656	5.621168	1.059753	0.088818	0.67305
4.373783	1.671799	0.418452	0.850815	2.624205	0.072078	0.259622	0.54816
5.884442	1.28741	1.054629	1.031032	4.401738	1.068821	0.964593	0.836198
3.018697	4.216881	88.751	0.456612	0.780458	1.061968	0.414488	0.269369
4.079722	1.26125	1.427428	0.141958	6.254056	0.626809	1.771635	0.74201
1.110082	0.803992	0.555208	2.657018	1.611656	0.487656	1.068724	0.251859
1.810934	0.67296	0.775775	0.542337	2.295654	0.681716	0.505103	0.164204
4.575906	1.546591	4.470209	0.76717	4.788557	1.574662	1.087814	1.196117
6.666044	0.752109	1.28321	0.667376	6.252091	0.666081	0.494626	0.569634
3.13866	0.109865	0.325918	0.465094	1.49275	1.56839	0.303753	0.122247
0.784177	1.21048	1.565289	0.00455	2.925767	0.857919	0.926558	0.645968
0.707862	0.422778	0.13816	0.049935	0.354443	1.140329	0.132109	0.093917
1.007579	0.292793	0.597429	0.440738	2.198321	0.756023	1.128525	0.696273
4.865653	1.151459	10.62832	0.609349	2.781141	0.38948	0.893726	1.211256
1.373573	2.255116	0.302793	0.541224	3.052933	2.979635	0.322019	0.478919
1.657724	0.345523	0.085929	0.405463	0.21655	0.264167	0.629437	0.301333
2.130485	1.406561	0.191465	0.393846	3.567011	0.747736	1.700017	0.433459
1.928364	0.189879	1.44729	0.458678	3.638153	0.591788	0.863125	0.027147
1.740327	0.462547	0.423095	0.339643	2.262905	0.398914	0.077553	0.302477
1.604886	0.043704	0.606585	0.219942	1.415318	1.640452	0.44065	0.693512
1.226885	3.854508	0.438891	0.282068	1.324233	5.047631	2.470605	0.928035
1.059061	2.83271	0.205538	0.352402	1.024685	1.032875	0.50998	0.130946
1.91248	3.971234	0.057754	0.19254	10.22508	0.790082	1.691912	6.543904
				1.287371	1.006736	0.020528	1.103198
0.445281	0.190624	12.32951	0.809921	0.74625	3.076362	1.762994	0.455384
1.213191	0.638173	0.514939	1.11644	1.397072	0.508355	0.736637	0.608841
1.809755	0.783394	0.058089	0.138652	2.977828	1.037991	0.784903	0.129108
5.990985	0.569689	0.434788	0.993756	3.187755		1.473066	0.294199
2.765559	0.37923	0.103394	0.876413	3.851511	0.533849	0.744382	2.724953
3.163707	6.125282	0.130223	0.237585	4.27922	3.770413	0.423463	0.383247

7.030072	1.34128	1.250187	0.550449	8.006138	1.261092	3.957293	0.214438
0.816553	0.509459	1.953555	0.405663	4.055225	1.161791	1.273688	0.534521
0.645925	0.504299	1.801717	0.678745	2.525481	2.301752	3.146523	0.452072
4.132305	0.8963	0.390536	0.626568	4.308706	0.622346	0.212154	0.566595
3.11422	1.513405	0.033071	0.198762	2.665379	1.514881	0.509344	0.074325
2.022233	4.36825	0.770266	1.23105	0.381709	60.60309	0.143988	5.113005
2.551127	0.703263	0.621165	0.462472	2.248179	0.866259	1.525144	1.23692
1.755788	0.022844	0.235125	0.470893	3.154203	0.432761	0.521685	8.217527
2.143899	2.506783	0.61653	0.363925	2.486045	4.804778	0.617302	0.746839
5.170052	1.144886	1.072179	0.716406	1.534898	0.898336	1.374345	0.737063

#10				#11			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
3.05174	1.041862	0.410113	0.652494	1.766487	1.327408	0.417848	0.73714
1.765522	0.417356	2.404407	1.839437	1.115592	0.840085	2.424687	3.445692
1.05503	0.305242	74.63278	0.483459	2.593243	0.924083	0.944272	0.339833
3.805674	1.914052	1.231103	0.410939	3.803603	1.453366	0.117634	0.334534
3.895745	6.385894	0.126998	0.762698	4.31905	7.099233	1.296653	0.772088
1.200331	0.23056	0.499105	0.439208	1.385236	1.682022	0.870474	0.675559
1.585067	1.715843	0.352008	0.484631	4.348677	0.315497	0.946675	0.827588
4.492801	12.84832	0.291771	5.228709	1.730578	1.414081	1.269645	0.330557
2.979769	0.788258	1.006044	0.16656	1.320792	0.700049	0.256624	0.339083
4.141654	0.497644	0.520975	0.7034	1.94307	1.174423	11.36268	0.61963
1.994165	1.107915	0.375775	0.721154	1.465511	1.131374	0.579105	0.35272
1.966356	0.233206	0.72033	1.530365	1.980041	0.572593	0.512825	1.579406
9.90659	1.455806	0.496161	0.88739	1.340392	0.350306	0.085658	0.366179
3.908418	2.935257	6.987703	6.876848	2.865772	0.422996	0.490455	0.499647
0.722644	0.613852	0.280564	0.639263	2.011854	4.547892	0.504733	0.311113
2.32997	0.65698	0.403029	1.382049	1.410999	0.706715	0.116764	0.915905
2.150617	0.89021	0.525467	0.410637	3.133421	13.27413	0.517035	0.463888
3.707721	0.841245	0.512207	1.390677	5.536776	3.178841	0.111345	0.356198
1.316531	1.013957	1.117135	1.00914	1.611488	0.848481	0.218861	0.685386
3.186689	0.269112	0.655202	0.5676	4.157205	1.138437	0.37928	5.14923
6.167893	0.983001	1.08663	0.982217	8.467115	1.029838	0.90854	0.898277
0.959593	1.767996	1.041756	1.519295	2.656792	0.888714	0.781144	1.062104
4.847455	0.23329	0.339179	0.452887	2.500746	0.632758	0.62337	4.152598
1.636965	0.584086	0.31407	0.36327	2.309988	0.939728	0.524326	6.766727
1.59799	0.267052	0.196626	0.496103	2.190061	2.499088	0.166848	1.089645

4.873522	1.306245	1.229969	0.947283	2.793318	1.540135	2.927969	0.721605
1.118438	3.430506	0.712293	0.924558	2.191054	0.956454	2.552737	0.938733
1.456717	0.112098	0.623431	0.214302	2.123567	0.625193	0.399508	0.15862
1.146619	2.23681	0.295784	0.828327	1.316226	0.476285	0.779376	0.063078
0.982852	2.899932	0.091091	0.180004	1.608022	1.099283	1.161814	5.946712
1.944046	0.100455	0.653159	0.523048	1.684268	3.395927	0.323206	0.497349
3.115789	1.386273	0.971276	0.451874	3.309743	0.012038	4.219487	1.528127
6.283119	5.1458	0.062278	0.533884	1.959528	0.497812	1.025882	0.205613
6.416451	0.850198	1.776097	1.31308	2.317168	2.821033	0.61058	7.689697
				0.756018	0.787322	1.022723	2.354019
3.741829	0.243373	0.855	0.888931	3.854765	1.98462	0.641884	0.776184
0.964082	0.640032	1.061769	0.366054	1.28427	4.264106	1.003368	0.588745
1.858128	4.314424	0.757338	0.335636	2.32685	1.010665	2.483742	0.305909
3.094616	1.363596	0.866822	0.515642	0.439366	0.123115	0.059755	0.044869
1.446029	0.693001	9.013699	0.024361	2.454431	1.931269	1.077345	0.024002
10.44026	0.824106	2.268454	2.371622	0.759886	0.973664	0.106795	0.044571
0.615595	0.06139	0.164612	0.175256	3.749957	2.979328	0.448601	0.977909
0.88694	0.542156	0.148791	0.121063	2.805885	0.287177	0.158973	0.486058
3.522303	0.235063	1.194772	0.782724	4.533818	1.714548	0.566991	1.212126
1.076332	1.249856	0.347085	0.318507	1.608528	0.412589	0.541074	0.462024
7.220785	5.165866	1.375178	0.522793	4.152125	1.134526	1.225284	0.407927
3.198319	0.96188	0.348304	0.607595	3.367664	0.376623	2.123478	
0.88037	3.173413	0.259414	3.212056	1.197022	0.484549	0.092362	0.165767
8.39954	1.243843	0.973576	0.769278	7.771883	1.266496	0.946673	0.815345
6.400668	14.67397	0.198674	0.643435	3.684864	0.568737	0.279558	0.55655
1.615118	3.278627	0.484193	0.01273	2.827844	0.809762	0.054998	0.474564
2.275046	7.934284	6.193514	1.550617	1.505948	0.549575	0.368973	0.427181
1.953133	2.418223	1.009908	0.712082	2.195271	2.753233	0.130462	0.112039
2.336942	0.695319	1.332155	0.05118	1.342212	11.35997	1.137517	0.456371
4.178421	0.513148	0.98752	0.831782	3.92686	0.267486	1.487471	0.824105
1.537288	0.113705	0.721387	0.307583	4.274942	1.072578	0.984937	0.943228
2.198825	2.366249	0.094568	0.295725	3.280929	0.498087	0.390989	0.234353
2.505779	0.803011	3.474341	2.016501	2.059473	0.824536	1.404526	1.195802

#22				#23			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
4.277382	0.573176	0.75396	0.773651	3.831018	0.501756	0.549248	0.816146
2.244759	0.009559	1.177029	0.36993	1.175931	0.590531	0.126766	0.205297
1.212753	2.995774	0.181232	0.235403	0.673987	0.26922	0.037709	

2.10792	1.628796	0.246032	0.723065	4.709107	6.029316	0.018494	0.711408
1.929198	0.032336	1.600129	1.745574	2.103595	0.126091	1.468276	3.98645
3.423802	0.770482	0.288713	0.599611	0.9747	0.690836	1.52778	2.070132
2.135499	0.049883	0.209838	0.123401	1.287509	0.354413	0.481554	0.210604
1.219622	0.231655	0.023025	0.057977	1.509286	0.104883	0.022029	0.349939
4.972066	0.908429	1.46841	0.902634	1.061378	0.189612	0.197915	0.313371
1.672548	0.064681	0.194898	0.566906	0.59747	0.304728	0.257924	0.072322
1.349719	1.541451	0.371773	0.190985	1.282245	0.020443	1.032468	0.317656
2.285699	0.671175	1.142218	4.73341	1.39241	1.430828	4.254594	0.054928
9.414432	0.902685	0.886433	0.930952	4.040211	0.117269	0.938359	0.892563
6.772857	1.329101	3.181945	2.103355	2.490634	0.618435	0.276296	0.231095
2.329484	3.837496	0.393798	0.662225	4.326506	5.753761	0.005169	0.961013
3.272508	0.097103	2.230483	1.317836	0.570606	0.34124	0.29739	0.16334
2.144448	0.094265	0.814968	0.239329	1.73994	2.199728	0.065225	0.283293
2.085408	1.227425	0.073787	0.8836	2.382343	2.116708	0.71878	0.609911
3.48446		0.178505	0.376565	2.729658	0.543934		0.725668
1.444512	0.509948	0.664451	0.615151	1.57789	0.176881	0.88598	0.312866
8.317364	0.293995	0.195947	1.036028	1.744158	0.559224	1.247559	0.536419
9.3956	1.027477	1.062883	1.014869	1.588606	0.782115	0.962116	0.739704
3.035513	0.473341	0.288774	1.278553	2.209023	1.005671	9.221143	0.37791
3.756295	1.077642	0.911864	0.522484	2.133527	0.448699	0.005583	0.708916
1.518788	0.62379	0.712766	0.385213	1.456242	0.614348	0.093478	0.416818
8.123335	0.86883	0.479472	0.664048	4.432894	0.968493	0.869179	1.201524
1.813645	1.044163	0.86655	60.99432	2.133783	1.280472	0.570235	0.15466
2.850949	0.485188	0.822302	0.616728	8.717498	0.932947	1.176661	1.345002
3.745524	0.407162	9.451492	0.284914	4.227414	0.626976	6.327158	0.0092
1.183695	0.075401	0.371846	0.133393	1.192272	0.5899	0.400392	0.335904
1.509219	0.401356	4.683483	0.278823	0.730275	0.505402	0.363834	1.992941
1.728081	0.693545		0.422581	0.951551	0.833788	0.414783	1.323996
1.51591	0.489565	3.252169	0.268653	1.423014	0.251971	2.848548	0.013606
0.551689	0.987774	35.54303	0.790601	0.361885	0.907765	1.027155	0.450768
4.066163	0.731295	0.016217	0.560336	3.134329	0.872178	0.952607	0.305473
1.329034	0.551239	0.784332	1.293041	1.324446	0.567718	1.80948	14.78597
2.084819	0.749661	0.322215	1.038886	2.682459	0.118735	0.387078	0.486387
4.857747	0.773741	28.62826	0.359051	1.519981	0.252133	1.024081	0.17615
1.019582	1.914925	1.33256	0.652575	1.490313	0.130289	0.78549	0.711673
1.683922	19.01066	0.279624	0.331881	1.648571	0.71222		0.26649
1.048179	0.511817	0.777556	0.710843	1.931708	1.049753	0.595846	0.019887
8.187405	1.145494	0.548696	0.509051	2.791627	0.138614	0.887566	0.474971
1.8284	1.598639	7.60768	0.272463	0.275837	0.282475	1.330093	0.125344
2.410744	0.317806	11.86448	1.427367	0.878012	0.785458	0.622156	0.869828

0.572893	1.420977	3.712045	0.66996	0.437828	0.007048	0.643361	0.16826
1.579386	2.526552	0.331834	0.147982	2.38338	0.219181	0.613345	0.155539
1.293701	1.025195	1.387448	1.457942	2.689509	0.928387	0.820225	0.154091
0.49336	2.824074	0.274579	0.332238	3.029174	0.868872	0.439488	1.554432
1.274417	0.848843	0.055747	0.345911	1.94452	0.735915	0.138597	1.374255
2.510305	0.966338	6.488917	0.741782	3.036865	0.846624	1.389782	1.079546
6.443606	1.09089	1.293076	0.514893	2.061023	0.469045	0.576043	0.540174
3.019185	0.589338	1.511922	0.118995	2.777954	0.481701	1.255182	1.122317
4.89333	0.757478	0.802221	1.05262	3.68371	0.218875	0.152828	0.497436
1.024809	0.316805	3.532924	0.559185	1.298217	0.974293	0.458338	0.941007
1.486295	0.382404	0.009156	0.190072	2.176284	0.681358	0.173965	2.708501
10.31727	0.927767	0.932421	0.889993	2.344529	0.395351	0.983451	1.012604
4.742654	1.155231	0.752558	0.794426	11.55601	0.875286	0.804753	0.975643
4.279638	1.215506	0.039708	0.293882	1.764325	14.74713	3.675996	0.01078
0.808377	3.20539	15.89919	0.378832	0.783294	1.131882	0.416934	0.615694

#24				#25			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
2.182289	0.534194	0.565229	0.643319	2.363731	0.65732	0.390523	0.695286
1.839466	0.333515	1.618665	0.814677	0.174057	1.043546	0.582195	1.079708
2.649999	0.216418	0.127296	0.289539	3.469605	0.106091	0.324381	0.278019
3.322474		0.062679	1.658812	2.558796	3.032146	0.701867	0.922988
5.154721	0.677292	0.718231	1.420333	4.799354	3.994433	0.185578	0.671533
1.105221	0.714644	1.329004	0.258008	2.229282	0.648246	0.782451	1.249813
1.786195	0.577789	0.948887	2.263531	2.508286	3.340459	0.113168	0.251688
3.625191	0.503568	0.295409	0.346724	0.914261	0.448368	0.932854	0.067988
4.381914	0.25238	7.234854	0.827463	2.297521	0.050361	1.146608	0.416677
2.594228	0.459418	0.034668	0.33599	1.980994	1.216891	0.237498	0.828877
1.070174	0.377444	0.107575	0.298591	0.80289	0.918072	1.059249	1.166281
0.379378	0.629928	1.403124	0.783309	3.699927	1.374947	0.957043	1.181787
3.303928	0.871012	0.939499	0.99757	1.238602	7.125203	0.553253	0.733851
1.921428	0.552408	0.192082	0.807011	2.044783	0.268669	0.030185	0.967294
4.390566	31.35324	0.144515	0.029801	4.637821	37.87329	0.622449	0.179297
1.852025	0.232351	0.692024	1.233821	0.945513	0.442011	0.313789	0.211414
0.593987	0.205534	0.333559	4.036575	0.765011	0.08792	0.244104	0.322979
1.732705	0.842621	0.042288	0.265792	2.434033	0.528507	1.831951	0.644007
2.32119	0.74778	0.115425	0.377096	2.658633	0.513647	0.898231	0.587038
6.099451	1.849906	1.881957	0.6927	1.815347	0.037774	2.001302	0.693382
2.895334	0.427818	5.034074	0.415207	1.690524	0.465237	8.069392	0.7394

8.29715	1.008673	0.832918	1.030668	4.196915	1.036937	0.68553	0.286099
3.526665	0.778522	0.351921	0.840054	1.736763	0.410443	1.277242	1.117833
3.147867	1.367313	0.874419	0.80037	2.105199	1.259879	1.083009	0.156949
0.923672	0.47514	0.375767	0.321562	2.219069	0.737513	0.240231	0.728273
3.010809	0.81368	0.796493	0.665588	1.669701	0.891406	1.405357	0.241203
3.392099	1.911598	0.932736	0.081759	1.822147	1.32172	2.996361	1.510212
2.420935	0.552172	0.401872	0.435417	0.690585	0.957826	0.103604	0.661274
3.157071	1.295698	0.978881	0.323148	2.247834	0.529412	0.782063	0.401145
0.728318	0.001889	1.020965	0.874014	0.865673	0.193727	4.137656	0.298373
1.006684	0.166526	0.247462	1.327969	2.059275	0.11295	0.441804	0.350187
2.578247	0.601283	1.724959	0.596582	2.177907	1.019051	1.392777	1.111283
2.017541	1.02451	0.266641	0.265646	1.504176	1.627907	0.68164	0.007532
0.981768	15.88305	0.060359	1.619078	1.444325	1.801797	1.889526	0.434281
0.709676	0.044025	4.494875	0.159963	0.834777	0.127425	1.221145	0.090718
0.823155	1.564907	1.920718	0.004729	1.401077	2.717528	0.397298	0.226647
2.122223	0.45667	1.865257	0.518202	1.406376	0.356584	1.822143	0.281621
2.700429	0.116837	1.15947	0.392366	1.133565	0.271164	0.031296	0.160663
2.104717	0.114065	0.524719	0.021008	3.310729	0.324817	0.651012	0.47717
1.156559	0.796872	0.128533	0.578242	3.230346	0.6242	0.436724	0.227091
1.04834	1.311511	1.218678	0.837776	0.831259	3.291014	0.279572	0.488497
0.926343	0.248818	0.867201	1.43404	1.291098	0.645534	0.176579	0.008389
1.223768	0.799024	0.951503	0.746478	1.133616	0.541341	0.363583	0.128389
1.098269	0.90244	1.189057	0.21471	0.668505	0.130524	0.755178	0.145457
0.942612	0.118839	1.100496	0.468224	0.586887	0.120933	0.639129	0.251243
1.751272	0.232546	0.681398	0.248948	0.291302	0.190199	0.702663	1.058443
3.047589	1.419566	0.057821	2.370964	3.389052	1.310296	1.242089	0.307594
2.069853	1.252913	0.527682	0.455467	2.210605	0.678392	2.096952	0.27239
1.25322	2.236223	0.350515	0.168581	1.048685	17.11207	0.35884	0.28226
1.92524	0.74249	0.827066	1.970747	1.360565	0.101592	17.85929	0.713383
1.044171	0.404123	0.383679	0.649726	2.916097	0.46342	0.775701	0.890077
1.295056	0.459246	0.866146	0.434734	1.56781	0.409876	0.105304	0.627689
2.413981	0.254295	0.860962	0.336505	0.951103	0.198414	0.942066	0.149237
2.011741	0.599251	1.057056	0.043162	1.120151	0.501539	0.904014	0.089127
1.783903	1.317117	2.033135	0.148441	1.067671	0.642068	0.128368	0.06089
4.289949	0.877377	0.919021	1.459838	12.56293	0.885103	0.793387	1.077992
6.463429	0.763405	0.319073	0.482102	4.315354	0.522988	1.064582	10.69167
3.00926	0.04907	1.79949	0.407006	1.472575	0.542802	0.264099	0.317284
1.17978	0.83375	0.63011	1.236261	0.439291	0.504867	0.089627	0.081515

#26

#27

ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
4.120809	0.564565	0.036419	0.451254	7.264307	1.127722	0.772298	0.844474
0.694114	0.024144	0.449468	1.242084	5.631887	0.431585	1.737456	0.507576
1.475498	0.380437	0.473701	0.667185	1.651017	0.279636	0.007249	0.375854
3.44737	5.534384	0.325959	0.463764	1.166518	0.052427	0.596607	0.80555
3.794371	3.057991	8.24617	0.337342	2.380055	0.957387	0.780694	0.349115
2.258518	0.691048	0.950976	1.025636	2.291138	1.161486	0.325171	0.007577
2.017881	0.371477	0.212754	0.309731	2.222416	0.950329	2.214506	0.23369
3.507297	0.206392	0.584123	0.687387	0.325703	1.240333	0.045303	0.124709
3.180855	0.209764	0.213368	0.345022	1.587698	0.352056	0.109847	0.463259
2.796894	0.377502	0.042827	0.313172	0.492279	0.064023	0.184622	0.196901
2.40998	0.212033	2.96919	0.170086	1.447955	1.492091	0.480245	0.230461
1.0849	0.834874	0.876633	5.662862	2.200509	0.416839	0.359746	0.278836
2.258675	0.480639	0.926789	0.965863	4.892882	0.835761	0.808571	0.989348
2.410843	3.577965	0.351135	0.313784	8.248374	0.723793	2.071762	2.057931
4.591127	8.923771	1.425403	0.024741	3.696905	2.447979	0.318089	0.195964
0.784275	0.210423	7.246717	1.30881	2.817553	1.719913	0.241881	0.122492
1.272479	0.433474	0.12679	0.115877	0.754456	0.44042	0.294554	0.45625
2.562072	3.069909	0.926023	1.198398	3.264647	0.638852	0.90911	61.3879
1.490464	0.39841	3.234244	0.118193	2.448386	0.103512	0.030383	0.339336
5.001054	0.109924	1.319738	2.028014	1.744035	0.185499	0.350216	0.715035
1.288148	0.517086	0.844344	0.329219	5.196328	22.19433	0.625433	0.61491
4.92622	1.120832	0.871062	0.971856	9.734989	0.969681	0.727826	1.000504
2.692162	0.279752	0.498218	0.444978	4.500515	2.041654	0.511809	0.620558
2.773915	0.296884	0.757775	0.41116	2.327134	0.89153	0.469929	0.446274
1.602128	0.676988	0.655206	0.42449	0.850524	0.552602	1.960864	1.194324
4.86341	0.968011	1.326264	0.468141	12.93085	1.115182	0.570185	0.770672
2.453212	1.081798	0.559283	0.015901	2.638316	4.061613	2.607826	0.68038
2.473832	3.04383	0.458279	1.161749	1.728819	0.833663	0.426628	1.052328
4.078007	0.614799	3.059361	0.466037	4.120722	0.61103	1.577057	0.20683
2.525783	0.129263	0.391411	0.516248	3.233631	0.781876	4.918801	0.375209
0.339317	0.691448	0.75841	0.184234	0.729165	1.745257	1.683933	0.775305
0.688519	0.767275	0.938096	0.19394	0.913045	0.896672	0.912909	0.63139
7.547024	0.762577	0.641098	1.166177	2.793528	1.353927	1.308807	0.166718
1.104754	1.29524	1.277257	0.25743	0.841406	0.397212	0.478526	0.0495
1.154053	1.091927	1.39933	0.081812	6.104702	0.681887	1.001299	2.131101
0.68669	0.992347	0.51819	0.326783	2.116297	1.142807	1.12626	2.544065
3.710817	0.010557	0.876252	0.568107	2.120658	0.743945	0.367387	0.336753
0.714215	0.275016	0.485042	0.362978	1.778598	1.252069	0.946102	0.143673
2.776897	0.05003	0.583842	0.077366	1.70738	6.369141	0.090387	0.708083

1.71933	0.329135	0.971137	1.735438	1.213914	0.900694	0.109786	0.080064
0.913011	1.667151	0.32037	0.119744	0.766862	18.96939	0.431938	0.393419
5.61912	0.023469	0.158398	0.394028	3.150601	0.533961	0.63454	0.416204
0.507246	0.230663	0.36992	1.609982	3.025173	4.130975	2.408031	0.267916
1.03505	1.102516	0.995492	11.24081	1.002791	0.233296	0.852432	0.114743
1.039903	0.320307	0.966489	2.095901	0.567132	10.35076	2.317176	0.377792
1.728323	0.299007	0.805472	0.619821	3.001222	0.933316	0.044566	0.279549
4.598999	0.820244	0.642242	0.504269	3.901341	5.247696	1.140369	1.094439
3.322769	1.021308	1.182051	2.656164	1.328307	0.433371	0.141	3.61173
1.393403	0.666212	0.004912	0.359524	2.163088	0.69633	0.276544	0.317948
2.231656	1.22895	0.987802	1.03279	2.853152	0.674366	0.880789	0.820808
0.895179	0.53654	0.772448	0.188305	8.047017	0.819006	0.384994	0.627259
0.709709	0.311778	1.119737	0.956017	1.291979	0.653468	0.424224	5.916578
0.528868	11.50978	0.520406	0.370525	2.837138	1.834832	0.532689	0.539373
1.069336	0.614613	0.645033	0.093032	0.852689	0.381413	0.43732	0.066413
0.700548	0.347683	0.040436	0.618801	1.283603	0.264768	0.198552	0.268383
8.348646	0.889283	1.009253	1.024528	9.207369	0.902126	0.914272	0.90283
1.385479	0.322194	0.703379	0.326283	4.888359	1.65355	0.20387	0.18495
0.890865	0.022657	2.722465	0.186315	2.88353	1.435754	0.220782	0.372099
1.981094	1.092187	0.9381	1.904644	0.719076	0.666721	4.675806	6.618709

Experimental

#6				#7			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
3.440625	0.839239	1.218498	0.187924	6.667263	1.084499	0.824798	0.870908
0				0			
3.092129	0.624368	1.146749	0.258936	6.187275	3.638518	0.765209	0.16715
0.616787	0.401034	1.318718	0.387451	1.54373	6.243448	6.735225	0.605573
2.074229	0.54158	1.853475	1.066822	2.918066	0.846361	0.19474	0.768491
3.107353	1.104968	0.598042	1.055186	5.284727	0.710966	0.028241	0.743584
1.933664	0.563147	0.452233	0.477987	4.404483	2.454173	0.823375	0.721933
4.907295	0.72592	0.682862	0.652896	3.251113	1.248913	0.356404	1.398174
4.698148	1.012851	5.089697	0.890086	4.467338	0.338665	0.832737	0.741216
2.975149	2.256525	0.808174	0.731529	2.750136	0.423711	0.549808	0.509671
0				0			
2.374469	1.068771	0.441688	0.113971	1.451003	0.40669	0.459505	0.103069
2.28483	0.896683	0.682345	0.6593	2.217818	0.278308	0.649925	0.908908
3.026913	1.747875	1.277411	0.571618	2.425091	5.744494	0.347234	0.076185
3.4928	1.940116	0.656778	0.276615	1.831698	5.802647	0.010146	0.368902

3.219041	0.05507	0.097794	0.938347	3.342901	0.141176	1.135525	1.806017
3.29195	0.196249	0.727547	0.809558	5.431108	0.657943	0.834191	0.79935
2.422228	1.090263	0.465873	0.59047	5.763985	0.985226	0.30162	1.319514
1.844301	0.542967	0.522186	0.263726	3.897934	1.304578	2.884079	0.970115
9.638285	0.922287	0.683328	0.24557	0			
5.973581	1.064638	0.909159	0.975338	3.323546	1.27221	0.020089	0.819281
2.312816	0.715761	0.771317	0.493869	7.686208	1.264852	0.298049	0.587161
2.784714	0.74209	0.440534	1.668229	0.921686	0.209412	3.480961	0.514291
3.922804	0.387336	0.89038	0.740861	3.752085	0.666729	18.23627	0.918158
13.87161	3.072709	0.772675	0.95906	7.724437	2.856741	0.67947	1.685232
11.60085	1.205389	0.84834	0.764998	3.251211	1.898301	1.313514	1.132169
2.059142	1.76687	0.583616	0.32631	0			
3.134326	0.920158	0.514697	2.143882	1.901753	0.10653	0.669647	0.297575
1.569772	2.91764	0.571015	1.926442	2.16826	0.3684	0.582	3.42018
12.16346	1.213448	1.681156	0.968945	3.932858	1.322732	1.374799	0.666861
2.740087	1.304205	1.04282		3.671444	2.937138	1.203766	1.118183
5.273046	0.833308	0.849843	0.907113	1.982559	0.11071	0.088229	0.466221
2.462971	1.204669	0.041248	1.212272	3.953249	1.605527	1.522733	1.065997
0.713494	0.863101	1.479076	0.691916	3.038992	0.819819	1.275254	0.713107
1.732842	1.017331	0.770492	0.094407	4.004565	0.63879	1.950876	1.307509
0.962117	1.524333	0.797653	6.511793	2.637769	1.046039	0.716997	0.310476
8.431273	1.209275	1.155357	0.979976	8.237087	1.39283	3.351686	0.820559
0				0			
1.616791	2.064543	0.618512	3.646382	0.913604	0.119517	0.331505	0.113835
1.377226	0.835402	1.534492	0.751737	2.472058	0.554021	0.77761	0.584468
4.547888	1.065418	23.46908	0.239494	3.932788	1.712311	0.855316	0.749037
1.021555	0.539989	1.444999	1.919991	3.542008	0.788037	0.433188	0.658899
4.529873	0.89191	0.828684	0.770369	5.037198	0.897472	0.772306	0.919396
0.417895	2.39028	0.772013	0.175846	1.24648	1.416039	0.932883	0.704515
4.338318	0.364721	5.398219	0.817546	4.035581	0.658272	1.533674	0.383524
4.80796	0.604991	0.990078	0.431705	4.145346	0.598567	0.203723	0.391064

#8				#9			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
6.265865	0.738978	0.932467	0.719932	4.87707	0.784572	1.342451	0.855635
0				0			
3.02884	26.37862	4.995803	2.039486	3.081352	4.874138	2.162173	1.610328
2.276785	24.71878	3.363323	0.528453	2.017281	3.041806	1.081532	6.336705
4.621341	0.935213	0.124805	0.635149	2.439594	1.459288	0.185158	0.68046
4.315523	0.944569	1.18569	0.665185	3.027347	0.920064	0.729391	0.787651

1.613062	4.64361	1.468728	0.763952	5.835151	14.52584	7.255824	0.64533
6.103351	1.322601	2.822752	0.326661	6.161373	1.432649	0.661963	1.914966
0.632035	0.341493	1.940843	0.470508	1.42674	1.70701	0.332512	0.46664
2.1836	0.503005	10.76506	2.503845	2.049589	0.419084	0.608788	2.558156
0				0			
4.396228	0.699677	0.742875	0.396727	5.394632	0.799015	0.343221	0.440496
3.449065	0.425152	0.391466	0.476671	3.262657	0.422327	1.925075	18.98676
1.459291	0.545165	0.928272	0.264252	1.174698	0.469021	0.579927	0.22832
5.25873	0.950302	0.57741	0.449684	1.830099	0.685664	0.216383	0.276274
10.20074	0.379826	3.158932	0.788419	4.137125		0.425537	0.684756
6.758823	1.12289	1.657235	1.906124	4.255883	1.453185	1.164284	1.831266
2.643804		0.125888	0.650169	3.605569	1.585656	1.023563	0.160403
2.494304	0.795478	0.548125	0.723205	1.372351	0.62786	1.299826	0.313941
5.60197	1.344924	6.279054	0.489456	9.387163	2.429364	12.70952	6.84721
3.084716	0.861218	14.52576	2.922403	3.700235	0.799418	1.005932	0.989162
2.586223	0.621134	1.036299	0.078627	2.85521	0.698413	0.72481	0.330742
2.240035	0.476924	12.38025	0.759179	2.299088	1.065495	0.353176	0.446633
5.980657	1.332324	0.690691	0.744497	3.04663	0.728097	0.504322	0.810805
7.332305	0.835988	0.107708	0.932962	8.48598	9.641721	0.395866	0.115764
1.807392	0.878411	0.353517	0.175373	3.895368	1.28771	0.068124	0.659498
6.39693	0.836579	1.248963	0.344225	5.641615	1.074445	1.130775	0.709672
2.832021	0.557847	0.191892	1.039413	2.465885	0.476389	3.250332	1.106445
1.653463	5.546252	0.116923	1.471015	2.104184	1.855801	0.713299	0.968212
1.764073	0.841529	0.631076	0.024603	3.69621	2.701222	0.348823	2.626479
3.287741	1.143901	0.115329	0.703299	2.917453	0.522226	0.023216	0.30921
1.101417	0.331446	0.251318	0.235352	2.883628	0.260148	0.19483	0.373606
2.40757	1.307738	0.096194	0.8397	2.298539	3.36878	1.097647	1.105647
1.622309	0.714318	0.686795	0.506693	4.092383	0.719813	0.233146	0.682449
3.192342	0.956237	0.969981	0.779385	3.630329	1.028676	3.184151	0.402602
6.456959	1.139057	0.514508	0.338026	2.635551	0.627312	1.273584	0.469683
4.64071	0.064003	0.206301	0.813943	8.95286	0.950711	1.194169	0.780354
0				0			
1.843633	8.802877	0.704424	0.255469	3.659462	3.129358	1.552254	0.099548
1.633241	1.107699	0.703379	0.49504	4.221894	0.873606	1.618589	1.844871
5.217097	3.285766	0.641596	0.491462	3.487537	0.943058	4.260797	
2.147163	5.256982	0.100638	0.643844	2.183558	2.292726	0.968317	0.239853
2.677646	0.929744	0.940326	0.913951	2.425846	0.793396	1.082803	0.829842
1.888247	0.532763	0.460251	0.581754	1.820378	17.43292	0.394119	0.440217
7.614341	0.60279	0.932502	0.608981	1.438002	0.398058	0.171306	0.386589
4.952115	0.570265	1.576189	0.076936	3.959557	0.49294	0.956377	0.324973

#10				#11			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
7.794309	1.209529	0.812707	0.855394	2.540114	0.896917	0.698935	0.832707
0				0			
1.89146	1.611137	0.48066	1.07503	2.900253	1.142479	6.007	0.696698
1.487349	1.950919	0.477117	0.731914	2.117961	0.86058	0.818444	1.400246
1.652381	0.784224	5.63145	0.726872	2.156574	0.090449	13.58906	1.041072
1.724745	0.40162	7.349116	0.708998	2.116296	0.170112	0.281262	0.455209
4.06871		1.425713	0.45803	2.625237	2.730466	1.218869	0.538795
4.393103	1.271418	1.261806	0.532113	4.329838	0.71632	0.503636	0.899181
2.127627	0.182796	0.476571	0.450702	4.409075	0.784561	1.760284	10.08441
1.145544	0.141139	0.80149	0.279632	2.202434	2.088718	0.986037	11.54001
0				0			
1.543132	0.35766	0.344359	0.403572	3.31842	1.347951	0.151108	0.902582
6.392733	0.605813	0.535104	0.951271	6.432317	0.027704	0.995008	0.973637
1.058747	0.381531	0.298436	0.033524	4.334881	0.327441	0.759702	3.425145
0.728865	0.141992	0.093566	0.192955	5.26318	35.48945	0.599621	0.643828
5.848406	0.582746	0.528146	1.403182	2.306736	0.560882	2.629935	0.840203
9.712572	2.095208	0.881977	0.949212	2.47511	0.512353	1.491624	0.788693
4.16739	1.621178	1.364585	0.979868	1.809174	0.8599	0.093248	0.113899
5.484175	0.985627	0.643373	0.89963	4.363033	1.70947	0.836905	0.113443
0				1.637491	1.441326	0.287228	0.078602
1.436227	0.312086	0.785767	0.739025	5.100298	1.408301	1.061449	0.88301
2.768838	0.26922	0.08567	0.58776	2.155738	0.698746	0.106275	0.664621
4.920143	1.351385	0.522237	0.618535	1.713412	13.25136	0.50805	0.878032
4.8056	1.0795	0.94077	0.898804	2.173246	0.882334	0.901447	0.747376
10.88009	1.804918	1.248875	0.913026	0			
6.7139	1.873205	0.587025	0.622357	3.504713	1.27193	0.623407	0.396123
0				3.185375	1.10933	1.058	1.196064
1.424413	10.26289	0.098573	0.010074	1.114173	2.097105	0.559934	0.284569
0.921435	0.96715	2.874117	0.533347	1.456048	1.646755	1.692836	0.400166
4.003879	0.59418	0.85468	0.691429	7.398546	2.762083	0.446396	0.946161
4.092571	0.32959	0.805719	0.046454	3.39211	0.314105	0.731852	0.963793
1.637027	2.303504	0.945374	5.037193	2.941606	0.444953	0.372449	0.433352
1.559285	1.017734	0.126825	0.814342	3.904454	1.188932	0.891854	0.771418
2.695431	0.516063	1.225147	0.244618	1.772311	1.167691	0.783504	0.774091
2.308717	0.717284	0.369825	0.840314	4.723322	1.029787	1.893827	1.169636
4.032112	0.54459	23.46047	0.250903	2.365729	1.144862	0.495384	0.55251
10.35163	0.670217	0.440316	0.735357	6.219733	0.910709	2.346473	0.943677
0				0			

6.494476	1.269815	0.140792	1.027049	3.931853	1.817642	0.822978	0.355884
0.905217	1.117622	0.57372	0.390553	1.171098	0.751333	0.139692	0.897731
2.854901	1.934977	1.51983	1.332971	3.38905	0.751481	3.591965	
0.777927	0.883359	0.255236	1.99629	2.052011	0.921269	0.268837	0.461338
0.899924	2.082518	0.904954	0.804411	6.802955	1.493066	1.013657	0.911046
5.575248	1.382968	1.022046	0.834795	0.279057	5.768683	0.069023	2.062427
4.077625	0.239526	0.879436	0.062522	2.73696	0.934283	0.495951	0.383934
1.228479	0.636587	4.170843	1.643753	1.558689	2.065592	0.540198	2.38173

#22				#23			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
0				0			
1.440992	0.284835	1.577294	0.132825	1.257825	0.483912	0.493747	0.209521
0.338826	3.423746	0.614983	0.831753	1.497398	0.307018	3.317123	0.121573
3.990541	0.462834	0.73392	0.515162	1.420503	0.201017	0.005948	0.444707
0				0			
0				0			
8.642865	2.132574	1.457789	1.644099	2.687355	1.208775	1.063634	0.731191
0.399008	0.570052	1.060557	0.532722	6.768182	1.268268	0.486175	0.517408
5.697406	3.77133	0.691901	0.466846	2.636858	0.460702	4.697592	0.516885
0.90173	0.093373	0.020471	0.386634	1.845689	1.238108	1.801286	0.114881
1.415147	1.964213	2.040347	1.536981	3.487467	0.002492	0.365882	0.703126
4.934308	3.067679	0.321078	0.484961	3.501661	0.161498	1.407898	0.231866
0				0			
2.019712	5.033867	4.603272	0.306331	1.058373	1.179104	0.41682	0.272785
4.227378	0.397841	6.418218	0.641208	0.91833	0.127757	0.234313	0.04999
6.456436	1.530506	0.924743	0.043591	3.031072	0.960284	0.242066	0.504041
0				0			
3.611413	1.283285	0.209895	1.864702	7.257698	0.597369	0.780321	0.580953
2.663501	1.026201	0.933405	0.676252	3.471787	15.46334	0.496828	0.524011
2.237208	0.604249	0.51888	0.032786	7.168533	0.45415	0.427638	0.388393
3.039606	0.949945	0.824964	0.943957	1.745057	0.943631	0.738231	0.58633
3.431561	0.751405	0.95155	0.206626	2.060121	0.595017	0.804149	1.356454
2.382976	2.943181	1.727016	0.043222	4.320657	1.319778	3.537611	0.415655
4.928775	3.364709	1.20542	0.855177	2.787915	1.145633	0.772272	1.330047
7.373142	1.607053	0.192614	0.59414	3.398789	0.028528	1.61467	
0				0			
0				0			
2.582955	0.366746	0.645382	5.590195	6.037009	0.573095	0.26351	0.558199
0				0			

4.308245	1.010552	0.678501	0.985336	3.918965	0.535496	0.529562	0.59032
3.454068	0.909914	0.733063	0.427871	6.149535	0.759911	1.100014	0.628594
3.536911	0.673823	0.412346	0.524245	1.337846	0.416524	1.202467	0.018179
4.888816	5.44157	1.432159	0.555423	2.91216		0.283533	0.376408
3.914308	1.180344	2.101632	1.099832	1.620703	0.014589	0.949022	3.733958
6.449083	0.858122	1.58094	0.829341	0.862211	0.430582	0.832857	0.395228
1.465162	0.717365	1.370122	0.22746	2.773189	1.717458	0.130269	0.783721
0				0			
0.998913	0.209304	0.430879	0.330163	2.153502	1.468851	0.649931	0.213217
7.357883	1.236308	0.563546	1.229083	4.005106	1.748809	0.463093	0.686366
3.73271	1.822067	0.557298	0.707721	3.000106	0.647977	0.603983	3.952238
1.233326	0.317929	0.117268	0.135014	3.021036	0.748936	0.599172	0.195158
0				0			
0				0			
0				0			
8.951671	0.081082	2.926007	0.253038	2.002963	0.029045	0.418097	0.248741
1.608195	0.691435	0.304974	0.741709	2.242917	3.417381	0.157529	11.78722

#24				#25			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
0				0			
1.22665	0.261771	0.155534	3.655249	0.839712	0.24443	0.62706	0.212366
0.896021	0.033547	1.130293	0.21778	2.780136	7.60239	1.609463	0.948864
1.923813	5.175717	0.315251	0.562838	3.850021	0.299002	0.485884	0.664426
0				0			
0				0			
1.120946	0.56931	0.506245	0.221207	4.003116	4.409307	0.837496	0.517341
2.829571	2.473705	0.958565	0.894363	3.218319	1.131553	0.66683	0.653921
3.608423	0.719099	0.833645	0.62699	4.431707	0.676579	0.785725	3.295064
2.196468	0.453014	0.768602	0.499987	3.302979	0.309433	0.051509	1.026398
3.570077	0.453395	1.776285	2.404835	3.470805	0.188337	1.889979	2.37722
3.11384	0.279688	0.676118	0.282456	1.692604	0.312363	0.170511	0.200449
0				0			
0.542018	0.705869	0.02578	0.19542	2.241724	0.854464	0.12847	0.360942
3.224671	0.509866	1.270553	0.938398	0.671504	0.144053	15.35327	0.549989
5.24512	0.357071	0.196207	0.561018	7.119375	0.472501	0.258475	0.558011
0				0			
1.471634	1.117343	1.351789	0.19318	1.963071	0.394929	0.744879	0.509558
2.573475	0.537121	0.51024	0.425376	1.823502	1.247763	1.322079	0.148747
6.674005	0.308037	0.280693	0.524576	5.120205	0.248005	0.725421	1.707071

4.325274	0.942488	0.272369	0.681181	3.017287	0.973814	1.799723	1.078042
1.984522	0.600495	2.079245	1.268685	2.593466	0.620143	1.347589	10.26612
1.1158	1.135176	0.401672	0.548937	2.595539	1.354958	1.144014	0.705529
3.629591	0.793897	0.373625	0.815576	3.654894	0.957287	0.050244	1.116326
1.030994	0.500167	5.954972	0.487301	2.439464	0.218171	0.571888	0.390009
0				0			
0				0			
2.406007	0.585065	0.03779	0.178045	7.619917	0.340174	1.885125	2.795398
0				0			
0.698879	0.291511	3.827779	0.496026	2.729201	0.523294	1.032714	1.022166
4.366253	0.524018	15.57851	2.161143	6.080028	0.653109	7.833475	0.066042
1.687613	0.453841	0.744674	0.54756	1.253782	0.631686	0.123573	0.227077
3.322706	7.159284	0.352966	1.088819	1.360094	0.346727	1.536177	0.33091
2.829528	0.624306	1.346924	2.387033	4.855293	0.688118	0.754307	1.539285
0.780898	0.761556	0.894345	0.441452	3.70143	1.220634	9.638633	0.294495
2.033731	1.015128	0.519634	0.404526	1.643671	2.566591	0.604334	0.047485
0				0			
2.260182	0.342945		0.32146	4.908857	0.337573	1.489032	1.219354
4.650269	5.060417	0.589773	0.619278	1.527049	4.47993	0.041285	0.220466
2.878643	0.549823	3.8228	0.586024	2.856186	0.649154	0.001947	0.311694
1.772386	0.296741	0.493857	0.362193	2.712421	0.095087	1.127523	0.726794
0				0			
0				0			
0				0			
2.844967	0.21018	1.637288	0.830131	1.694302	0.217161	5.70409	0.188357
3.201634	0.594611	0.014175	0.739543	3.227722	9.619267	0.587067	1.366216

#26				#27			
ΔV	Δx°	Δy°	Δz°	ΔV	Δx°	Δy°	Δz°
0				0			
0.431022	0.969433	0.260348	0.057525	3.743756	0.799812	0.48655	0.143099
1.456836	0.186294	0.98078	0.289383	2.453886	5.182354	0.511998	0.858647
0.915934	2.266558	0.168239	18.43283	1.258938	6.500278	1.21537	0.791056
0				0			
0				0			
2.964973	1.047647	2.524518	0.345856	2.024444	3.562836	0.26403	0.327739
3.480284	5.181331	0.492002	0.544429	1.898973	1.674471	0.385808	0.075481
3.485886	0.667227	0.643062	0.039818	2.703279	0.451906	0.619835	0.735593
1.654172	0.928626	0.533306	0.544282	6.468408	0.867504	0.685831	6.797493
3.410007	27.94853	6.171814	0.105572	4.313938	1.481877	5.80492	1.544691

3.03766	0.225976	0.469668	0.209746	2.155846	0.209485	0.664953	0.322984
0				0			
0.776194	0.956242	0.448191	0.161215	0.53936	0.269098	0.86917	0.104974
0.486657	0.212586	0.871947	0.744729	3.232758	0.535449	5.764409	0.223334
1.867638	0.203887	0.206618	0.807928	5.177673	0.072646	1.10451	0.428905
0				0			
3.083386	0.866749	1.197932	0.126742	2.239198	0.848156	0.305773	1.042683
2.2247	0.526004	0.565718	0.877811	2.176201		0.987626	0.412278
3.184055	0.266761	0.179988	4.899605	0			
2.496369	0.974425	0.596386	0.91907	1.232257	1.895453	1.509766	0.834973
2.417864	0.619644	11.24971	0.218205	1.934409	0.574545	1.741793	0.488205
1.864158	1.398753	0.874159	0.007595	8.417091	0.522147	2.714541	0.365029
2.478127	0.726196	8.916779	0.708599	7.665421	0.684933	1.583247	0.981633
1.063067	0.507227	1.022466	1.542871	5.038888	0.378417	1.169079	0.520894
0				0			
0				0			
7.511171	0.561621	0.111773	0.56254	1.219866	1.788271	1.738955	0.127281
0				0			
6.891743	0.900739	0.414728	0.841394	1.072738	0.39946	0.701404	1.044561
5.448023	0.763297	0.40269	0.152994	9.723448	3.968095	0.186224	0.362582
1.213139	0.326767	0.463848	0.953247	5.244754	0.296978	6.734441	0.822808
2.693872	0.593981	0.292944	0.25195	4.59017	0.483182	0.117272	0.403113
5.316245	0.590808	0.861863	0.875695	0			
1.667384	0.307302	5.880138	0.453478	4.43843	0.929198	0.990719	0.732289
2.239023	0.830167	0.007467	0.431125	2.612103	0.88521	5.34601	0.368254
0				0			
5.238935	1.60592	0.343346	1.658348	5.600256	1.842351	0.482275	0.45026
1.690049	1.852387	0.283125	0.487843	3.0987	1.252291	0.195899	0.345506
4.774339	0.650314	0.548464	0.443636	3.393916	0.943081	0.314296	0.301718
1.759508	0.08878	0.112044	0.010002	5.021889	2.100998	3.630454	0.309056
0				0			
0				0			
0				0			
3.746248	0.293318	0.610859	0.248491	5.032579	1.675139	0.625375	0.404299
3.101242	0.166825	0.435394	1.21944	2.731268	0.063654	1.378439	0.701539

DISCREPANCY BY INDIVIDUAL TEETH

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#10

Missing Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.001236
Adj Rsquare	-0.00865
Root Mean Square Error	2.519095
Mean of Response	3.132458
Observations (or Sum Wgts)	103

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.1765	t Ratio	0.353526
Std Err Dif	0.4993	DF	101
Upper CL Dif	1.1670	Prob > t	0.7244
Lower CL Dif	-0.8139	Prob > t	0.3622
Confidence	0.95	Prob < t	0.6378

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.79311	0.79311	0.1250	0.7244
Error	101	640.92985	6.34584		
C. Total	102	641.72296			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	3.05363	0.33366	2.3917	3.7155
MOP	46	3.23014	0.37142	2.4933	3.9669

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#11

Missing Rows 1

Oneway Anova

Summary of Fit

Rsquare	0.004943
Adj Rsquare	-0.00481
Root Mean Square Error	1.654534
Mean of Response	2.748162
Observations (or Sum Wgts)	104

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.23253	t Ratio	0.711822
------------	---------	---------	----------

Std Err Dif	0.32666	DF	102
Upper CL Dif	0.88046	Prob > t	0.4782
Lower CL Dif	-0.41541	Prob > t	0.2391
Confidence	0.95	Prob < t	0.7609

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.38706	1.38706	0.5067	0.4782
Error	102	279.22307	2.73748		
C. Total	103	280.61013			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	2.64531	0.21725	2.2144	3.0762
MOP	46	2.87784	0.24395	2.3940	3.3617

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#22

Oneway Anova

Summary of Fit

Rsquare	0.005693
Adj Rsquare	-0.00396
Root Mean Square Error	2.496394
Mean of Response	2.920902
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.3771	t Ratio	-0.76795
------------	---------	---------	----------

Std Err Dif	0.4910	DF	103
Upper CL Dif	0.5967	Prob > t	0.4443
Lower CL Dif	-1.3509	Prob > t	0.7779
Confidence	0.95	Prob < t	0.2221

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	3.67532	3.67532	0.5898	0.4443
Error	103	641.89430	6.23198		
C. Total	104	645.56962			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	3.08610	0.32500	2.4415	3.7307
MOP	46	2.70902	0.36807	1.9790	3.4390

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#23

Oneway Anova

Summary of Fit

Rsquare	3.848e-6
Adj Rsquare	-0.0097
Root Mean Square Error	1.942134
Mean of Response	2.26439
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.00760	t Ratio	0.019907
------------	---------	---------	----------

Std Err Dif	0.38200	DF	103
Upper CL Dif	0.76522	Prob > t	0.9842
Lower CL Dif	-0.75001	Prob > t	0.4921
Confidence	0.95	Prob < t	0.5079

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.00149	0.00149	0.0004	0.9842
Error	103	388.50406	3.77188		
C. Total	104	388.50555			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	2.26106	0.25284	1.7596	2.7625
MOP	46	2.26866	0.28635	1.7008	2.8366

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#24

Oneway Anova

Summary of Fit

Rsquare	0.018593
Adj Rsquare	0.009065
Root Mean Square Error	1.595756
Mean of Response	2.160208
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.4385	t Ratio	-1.3969
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Std Err Dif	0.3139	DF	103
Upper CL Dif	0.1840	Prob > t	0.1654
Lower CL Dif	-1.0609	Prob > t	0.9173
Confidence	0.95	Prob < t	0.0827

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	4.96897	4.96897	1.9513	0.1654
Error	103	262.28312	2.54644		
C. Total	104	267.25209			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	2.35229	0.20775	1.9403	2.7643
MOP	46	1.91384	0.23528	1.4472	2.3805

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#25

Oneway Anova

Summary of Fit

Rsquare	0.005206
Adj Rsquare	-0.00445
Root Mean Square Error	1.869503
Mean of Response	2.174375
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.26997	t Ratio	0.734181
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Std Err Dif	0.36772	DF	103
Upper CL Dif	0.99926	Prob > t	0.4645
Lower CL Dif	-0.45931	Prob > t	0.2323
Confidence	0.95	Prob < t	0.7677

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.88391	1.88391	0.5390	0.4645
Error	103	359.98931	3.49504		
C. Total	104	361.87322			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	2.05610	0.24339	1.5734	2.5388
MOP	46	2.32607	0.27564	1.7794	2.8727

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#26

Oneway Anova

Summary of Fit

Rsquare	0.006229
Adj Rsquare	-0.00342
Root Mean Square Error	1.818604
Mean of Response	2.249972
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.28741	t Ratio	-0.80347
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Std Err Dif	0.35771	DF	103
Upper CL Dif	0.42202	Prob > t	0.4236
Lower CL Dif	-0.99684	Prob > t	0.7882
Confidence	0.95	Prob < t	0.2118

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.13508	2.13508	0.6456	0.4236
Error	103	340.65415	3.30732		
C. Total	104	342.78923			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	2.37588	0.23676	1.9063	2.8454
MOP	46	2.08848	0.26814	1.5567	2.6203

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#27

Oneway Anova

Summary of Fit

Rsquare	0.007413
Adj Rsquare	-0.00222
Root Mean Square Error	2.549331
Mean of Response	2.822233
Observations (or Sum Wgts)	105

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.4398	t Ratio	-0.87709
------------	---------	---------	----------

Std Err Dif	0.5014	DF	103
Upper CL Dif	0.5547	Prob > t	0.3825
Lower CL Dif	-1.4343	Prob > t	0.8088
Confidence	0.95	Prob < t	0.1912

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	4.99965	4.99965	0.7693	0.3825
Error	103	669.40618	6.49909		
C. Total	104	674.40583			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	3.01491	0.33189	2.3567	3.6731
MOP	46	2.57511	0.37588	1.8296	3.3206

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#6

Missing Rows 1

Oneway Anova

Summary of Fit

Rsquare	0.027486
Adj Rsquare	0.017951
Root Mean Square Error	2.43156
Mean of Response	3.084696
Observations (or Sum Wgts)	104

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.8151	t Ratio	1.697871
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Std Err Dif	0.4801	DF	102
Upper CL Dif	1.7673	Prob > t	0.0926
Lower CL Dif	-0.1371	Prob > t	0.0463*
Confidence	0.95	Prob < t	0.9537

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	17.04430	17.0443	2.8828	0.0926
Error	102	603.07323	5.9125		
C. Total	103	620.11754			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	2.72417	0.31928	2.0909	3.3575
MOP	46	3.53927	0.35851	2.8282	4.2504

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#7

Missing Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.021237
Adj Rsquare	0.011546
Root Mean Square Error	1.782519
Mean of Response	3.000757
Observations (or Sum Wgts)	103

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.5230	t Ratio	1.480352
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Std Err Dif	0.3533	DF	101
Upper CL Dif	1.2238	Prob > t	0.1419
Lower CL Dif	-0.1778	Prob > t	0.0709
Confidence	0.95	Prob < t	0.9291

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.96303	6.96303	2.1914	0.1419
Error	101	320.91480	3.17737		
C. Total	102	327.87782			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	2.76718	0.23610	2.2988	3.2355
MOP	46	3.29018	0.26282	2.7688	3.8115

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#8

Missing Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.033774
Adj Rsquare	0.024207
Root Mean Square Error	1.964156
Mean of Response	3.066161
Observations (or Sum Wgts)	103

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.7315	t Ratio	1.87894
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Std Err Dif	0.3893	DF	101
Upper CL Dif	1.5037	Prob > t	0.0631
Lower CL Dif	-0.0408	Prob > t	0.0316*
Confidence	0.95	Prob < t	0.9684

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	13.62002	13.6200	3.5304	0.0631
Error	101	389.64879	3.8579		
C. Total	102	403.26882			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	2.73949	0.26016	2.2234	3.2556
MOP	46	3.47095	0.28960	2.8965	4.0454

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Tooth=#9

Missing Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.031402
Adj Rsquare	0.021812
Root Mean Square Error	1.989245
Mean of Response	2.955904
Observations (or Sum Wgts)	103

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.7134	t Ratio	1.809526
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Std Err Dif	0.3943	DF	101
Upper CL Dif	1.4956	Prob > t	0.0733
Lower CL Dif	-0.0687	Prob > t	0.0367*
Confidence	0.95	Prob < t	0.9633

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	12.95705	12.9571	3.2744	0.0733
Error	101	399.66653	3.9571		
C. Total	102	412.62358			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	2.63728	0.26348	2.1146	3.1600
MOP	46	3.35072	0.29330	2.7689	3.9325

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#10

Missing Rows 8

Oneway Anova

Summary of Fit

Rsquare	0.023005
Adj Rsquare	0.01272
Root Mean Square Error	2.381894
Mean of Response	1.64392
Observations (or Sum Wgts)	97

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.7348	t Ratio	-1.49563
------------	---------	---------	----------

Std Err Dif	0.4913	DF	95
Upper CL Dif	0.2405	Prob > t	0.1381
Lower CL Dif	-1.7101	Prob > t	0.9310
Confidence	0.95	Prob < t	0.0690

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	12.69087	12.6909	2.2369	0.1381
Error	95	538.97462	5.6734		
C. Total	96	551.66550			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.94693	0.31549	1.3206	2.5733
MOP	40	1.21214	0.37661	0.4645	1.9598

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#11

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.005671
Adj Rsquare	-0.00448
Root Mean Square Error	4.076782
Mean of Response	1.965403
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.6175	t Ratio	0.74759
------------	--------	---------	---------

Std Err Dif	0.8260	DF	98
Upper CL Dif	2.2567	Prob > t	0.4565
Lower CL Dif	-1.0217	Prob > t	0.2282
Confidence	0.95	Prob < t	0.7718

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	9.2889	9.2889	0.5589	0.4565
Error	98	1628.7752	16.6202		
C. Total	99	1638.0640			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.70605	0.53531	0.6437	2.7684
MOP	42	2.32356	0.62906	1.0752	3.5719

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#22

Missing Rows 13

Oneway Anova

Summary of Fit

Rsquare	0.002809
Adj Rsquare	-0.00827
Root Mean Square Error	2.162552
Mean of Response	1.345241
Observations (or Sum Wgts)	92

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.2352	t Ratio	0.503515
------------	--------	---------	----------

Std Err Dif	0.4671	DF	90
Upper CL Dif	1.1632	Prob > t	0.6158
Lower CL Dif	-0.6928	Prob > t	0.3079
Confidence	0.95	Prob < t	0.6921

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.18565	1.18565	0.2535	0.6158
Error	90	420.89692	4.67663		
C. Total	91	422.08258			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.25832	0.28396	0.69419	1.8225
MOP	34	1.49351	0.37087	0.75671	2.2303

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#23

Missing Rows 13

Oneway Anova

Summary of Fit

Rsquare	0.001646
Adj Rsquare	-0.00945
Root Mean Square Error	2.308971
Mean of Response	1.107978
Observations (or Sum Wgts)	92

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.1933	t Ratio	0.385216
------------	--------	---------	----------

Std Err Dif	0.5019	DF	90
Upper CL Dif	1.1905	Prob > t	0.7010
Lower CL Dif	-0.8038	Prob > t	0.3505
Confidence	0.95	Prob < t	0.6495

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.79112	0.79112	0.1484	0.7010
Error	90	479.82103	5.33134		
C. Total	91	480.61216			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.03863	0.30060	0.44143	1.6358
MOP	33	1.23197	0.40194	0.43345	2.0305

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#24

Missing Rows 13

Oneway Anova

Summary of Fit

Rsquare	0.002992
Adj Rsquare	-0.00809
Root Mean Square Error	3.696739
Mean of Response	1.332075
Observations (or Sum Wgts)	92

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.4149	t Ratio	-0.51968
------------	---------	---------	----------

Std Err Dif	0.7985	DF	90
Upper CL Dif	1.1714	Prob > t	0.6046
Lower CL Dif	-2.0013	Prob > t	0.6977
Confidence	0.95	Prob < t	0.3023

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	3.6907	3.6907	0.2701	0.6046
Error	90	1229.9293	13.6659		
C. Total	91	1233.6200			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.48543	0.48541	0.5211	2.4498
MOP	34	1.07048	0.63399	-0.1890	2.3300

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#25

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.003316
Adj Rsquare	-0.00764
Root Mean Square Error	4.456897
Mean of Response	1.659316
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.5280	t Ratio	-0.5502
------------	---------	---------	---------

Std Err Dif	0.9596	DF	91
Upper CL Dif	1.3782	Prob > t	0.5835
Lower CL Dif	-2.4342	Prob > t	0.7082
Confidence	0.95	Prob < t	0.2918

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.0132	6.0132	0.3027	0.5835
Error	91	1807.6175	19.8639		
C. Total	92	1813.6307			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.85235	0.58024	0.6998	3.0049
MOP	34	1.32435	0.76435	-0.1939	2.8426

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#26

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.005665
Adj Rsquare	-0.00526
Root Mean Square Error	3.26395
Mean of Response	1.332288
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.5060	t Ratio	0.720008
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Std Err Dif	0.7028	DF	91
Upper CL Dif	1.9020	Prob > t	0.4734
Lower CL Dif	-0.8900	Prob > t	0.2367
Confidence	0.95	Prob < t	0.7633

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	5.52284	5.5228	0.5184	0.4734
Error	91	969.45678	10.6534		
C. Total	92	974.97962			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.14730	0.42493	0.30322	1.9914
MOP	34	1.65330	0.55976	0.54140	2.7652

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#27

Missing Rows 15

Oneway Anova

Summary of Fit

Rsquare	0.006971
Adj Rsquare	-0.00431
Root Mean Square Error	3.29266
Mean of Response	1.76792
Observations (or Sum Wgts)	90

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.5741	t Ratio	-0.78596
------------	---------	---------	----------

Std Err Dif	0.7304	DF	88
Upper CL Dif	0.8775	Prob > t	0.4340
Lower CL Dif	-2.0256	Prob > t	0.7830
Confidence	0.95	Prob < t	0.2170

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.69716	6.6972	0.6177	0.4340
Error	88	954.06143	10.8416		
C. Total	89	960.75859			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.96565	0.42867	1.1138	2.8175
MOP	31	1.39159	0.59138	0.2163	2.5668

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#6

Missing Rows 4

Oneway Anova

Summary of Fit

Rsquare	0.019109
Adj Rsquare	0.009201
Root Mean Square Error	1.798827
Mean of Response	1.387514
Observations (or Sum Wgts)	101

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.5027	t Ratio	-1.38875
------------	---------	---------	----------

Std Err Dif	0.3620	DF	99
Upper CL Dif	0.2156	Prob > t	0.1680
Lower CL Dif	-1.2210	Prob > t	0.9160
Confidence	0.95	Prob < t	0.0840

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.24058	6.24058	1.9286	0.1680
Error	99	320.34214	3.23578		
C. Total	100	326.58272			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.60154	0.23620	1.1329	2.0702
MOP	43	1.09882	0.27432	0.5545	1.6431

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#7

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.00852
Adj Rsquare	-0.00181
Root Mean Square Error	2.859625
Mean of Response	1.713536
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.5319	t Ratio	-0.90828
------------	---------	---------	----------

Std Err Dif	0.5856	DF	96
Upper CL Dif	0.6305	Prob > t	0.3660
Lower CL Dif	-1.6943	Prob > t	0.8170
Confidence	0.95	Prob < t	0.1830

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.74617	6.74617	0.8250	0.3660
Error	96	785.03587	8.17746		
C. Total	97	791.78203			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.93606	0.37877	1.1842	2.6879
MOP	41	1.40418	0.44660	0.5177	2.2907

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#8

Missing Rows 6

Oneway Anova

Summary of Fit

Rsquare	0.018684
Adj Rsquare	0.008567
Root Mean Square Error	3.782214
Mean of Response	1.929723
Observations (or Sum Wgts)	99

t Test

MOP-CONTROL

Assuming equal variances

Difference	1.0452	t Ratio	1.358979
------------	--------	---------	----------

Std Err Dif	0.7691	DF	97
Upper CL Dif	2.5718	Prob > t	0.1773
Lower CL Dif	-0.4813	Prob > t	0.0887
Confidence	0.95	Prob < t	0.9113

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	26.4191	26.4191	1.8468	0.1773
Error	97	1387.5989	14.3051		
C. Total	98	1414.0180			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.48629	0.50097	0.4920	2.4806
MOP	42	2.53153	0.58361	1.3732	3.6898

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Tooth=#9

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.00025
Adj Rsquare	-0.01016
Root Mean Square Error	6.516316
Mean of Response	2.303482
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.2061	t Ratio	-0.15497
------------	---------	---------	----------

Std Err Dif	1.3301	DF	96
Upper CL Dif	2.4342	Prob > t	0.8772
Lower CL Dif	-2.8464	Prob > t	0.5614
Confidence	0.95	Prob < t	0.4386

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.0198	1.0198	0.0240	0.8772
Error	96	4076.3885	42.4624		
C. Total	97	4077.4083			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	56	2.39183	0.8708	0.66334	4.1203
MOP	42	2.18569	1.0055	0.18981	4.1816

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#10

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.002162
Adj Rsquare	-0.00823
Root Mean Square Error	7.926351
Mean of Response	2.095082
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.7403	t Ratio	-0.45609
------------	---------	---------	----------

Std Err Dif	1.6231	DF	96
Upper CL Dif	2.4816	Prob > t	0.6494
Lower CL Dif	-3.9622	Prob > t	0.6753
Confidence	0.95	Prob < t	0.3247

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	13.0692	13.0692	0.2080	0.6494
Error	96	6031.3956	62.8270		
C. Total	97	6044.4648			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	2.40480	1.0499	0.3208	4.4888
MOP	41	1.66450	1.2379	-0.7927	4.1217

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#11

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.005973
Adj Rsquare	-0.00417
Root Mean Square Error	1.880265
Mean of Response	1.142899
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.2923	t Ratio	0.767397
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Std Err Dif	0.3810	DF	98
Upper CL Dif	1.0484	Prob > t	0.4447
Lower CL Dif	-0.4637	Prob > t	0.2223
Confidence	0.95	Prob < t	0.7777

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.08199	2.08199	0.5889	0.4447
Error	98	346.46879	3.53540		
C. Total	99	348.55078			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.02011	0.24689	0.53017	1.5101
MOP	42	1.31246	0.29013	0.73670	1.8882

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#22

Missing Rows 13

Oneway Anova

Summary of Fit

Rsquare	0.023407
Adj Rsquare	0.012556
Root Mean Square Error	5.118069
Mean of Response	2.226
Observations (or Sum Wgts)	92

t Test

MOP-CONTROL

Assuming equal variances

Difference	-1.6236	t Ratio	-1.4687
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Std Err Dif	1.1055	DF	90
Upper CL Dif	0.5726	Prob > t	0.1454
Lower CL Dif	-3.8198	Prob > t	0.9273
Confidence	0.95	Prob < t	0.0727

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	56.5039	56.5039	2.1571	0.1454
Error	90	2357.5163	26.1946		
C. Total	91	2414.0202			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	2.82603	0.67204	1.491	4.1611
MOP	34	1.20242	0.87774	-0.541	2.9462

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#23

Missing Rows 14

Oneway Anova

Summary of Fit

Rsquare	0.001474
Adj Rsquare	-0.00975
Root Mean Square Error	1.377797
Mean of Response	1.005645
Observations (or Sum Wgts)	91

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.10822	t Ratio	-0.36247
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Std Err Dif	0.29856	DF	89
Upper CL Dif	0.48501	Prob > t	0.7179
Lower CL Dif	-0.70145	Prob > t	0.6411
Confidence	0.95	Prob < t	0.3589

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.24941	0.24941	0.1314	0.7179
Error	89	168.95093	1.89833		
C. Total	90	169.20034			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.04608	0.18249	0.68347	1.4087
MOP	34	0.93786	0.23629	0.46836	1.4074

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#24

Missing Rows 13

Oneway Anova

Summary of Fit

Rsquare	0.015131
Adj Rsquare	0.004188
Root Mean Square Error	1.951761
Mean of Response	1.186068
Observations (or Sum Wgts)	92

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.4989	t Ratio	1.175881
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Std Err Dif	0.4243	DF	90
Upper CL Dif	1.3418	Prob > t	0.2427
Lower CL Dif	-0.3440	Prob > t	0.1214
Confidence	0.95	Prob < t	0.8786

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	5.26721	5.26721	1.3827	0.2427
Error	90	342.84332	3.80937		
C. Total	91	348.11053			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.00712	0.25410	0.50231	1.5119
MOP	33	1.50601	0.33976	0.83102	2.1810

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#25

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.011345
Adj Rsquare	0.000481
Root Mean Square Error	2.773618
Mean of Response	1.463713
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.6103	t Ratio	1.021886
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Std Err Dif	0.5972	DF	91
Upper CL Dif	1.7965	Prob > t	0.3095
Lower CL Dif	-0.5760	Prob > t	0.1548
Confidence	0.95	Prob < t	0.8452

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	8.03338	8.03338	1.0443	0.3095
Error	91	700.05892	7.69296		
C. Total	92	708.09230			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.24060	0.36109	0.52333	1.9579
MOP	34	1.85088	0.47567	0.90601	2.7957

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#26

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.008319
Adj Rsquare	-0.00258
Root Mean Square Error	1.942789
Mean of Response	1.213495
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.3655	t Ratio	0.873714
------------	--------	---------	----------

Std Err Dif	0.4183	DF	91
Upper CL Dif	1.1964	Prob > t	0.3846
Lower CL Dif	-0.4654	Prob > t	0.1923
Confidence	0.95	Prob < t	0.8077

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.88131	2.88131	0.7634	0.3846
Error	91	343.47318	3.77443		
C. Total	92	346.35449			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.07988	0.25293	0.57746	1.5823
MOP	34	1.44536	0.33319	0.78353	2.1072

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#27

Missing Rows 14

Oneway Anova

Summary of Fit

Rsquare	0.060379
Adj Rsquare	0.049822
Root Mean Square Error	1.340998
Mean of Response	1.131988
Observations (or Sum Wgts)	91

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.70406	t Ratio	2.391459
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Std Err Dif	0.29441	DF	89
Upper CL Dif	1.28904	Prob > t	0.0189*
Lower CL Dif	0.11908	Prob > t	0.0094*
Confidence	0.95	Prob < t	0.9906

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	10.28447	10.2845	5.7191	0.0189*
Error	89	160.04650	1.7983		
C. Total	90	170.33097			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	0.88441	0.17458	0.5375	1.2313
MOP	32	1.58847	0.23706	1.1174	2.0595

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#6

Missing Rows 4

Oneway Anova

Summary of Fit

Rsquare	0.002537
Adj Rsquare	-0.00754
Root Mean Square Error	2.881362
Mean of Response	1.411961
Observations (or Sum Wgts)	101

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.2910	t Ratio	0.50178
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Std Err Dif	0.5798	DF	99
Upper CL Dif	1.4415	Prob > t	0.6169
Lower CL Dif	-0.8596	Prob > t	0.3085
Confidence	0.95	Prob < t	0.6915

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.09037	2.09037	0.2518	0.6169
Error	99	821.92241	8.30225		
C. Total	100	824.01278			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	1.28809	0.37834	0.53738	2.0388
MOP	43	1.57904	0.43940	0.70717	2.4509

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#7

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.003509
Adj Rsquare	-0.00687
Root Mean Square Error	5.054236
Mean of Response	1.82166
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.6018	t Ratio	-0.58144
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Std Err Dif	1.0350	DF	96
Upper CL Dif	1.4527	Prob > t	0.5623
Lower CL Dif	-2.6562	Prob > t	0.7188
Confidence	0.95	Prob < t	0.2812

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	8.6361	8.6361	0.3381	0.5623
Error	96	2452.3493	25.5453		
C. Total	97	2460.9854			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	2.07343	0.66945	0.7446	3.4023
MOP	41	1.47164	0.78934	-0.0952	3.0385

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#8

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.008014
Adj Rsquare	-0.00211
Root Mean Square Error	11.24598
Mean of Response	3.063489
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	-2.0212	t Ratio	-0.88976
------------	---------	---------	----------

Std Err Dif	2.2716	DF	98
Upper CL Dif	2.4867	Prob > t	0.3758
Lower CL Dif	-6.5290	Prob > t	0.8121
Confidence	0.95	Prob < t	0.1879

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	100.125	100.125	0.7917	0.3758
Error	98	12394.258	126.472		
C. Total	99	12494.383			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	3.93258	1.4896	0.977	6.8886
MOP	43	1.91143	1.7150	-1.492	5.3148

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Tooth=#9

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.000837
Adj Rsquare	-0.00936
Root Mean Square Error	2.144932
Mean of Response	1.341988
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.12413	t Ratio	0.286507
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Std Err Dif	0.43325	DF	98
Upper CL Dif	0.98391	Prob > t	0.7751
Lower CL Dif	-0.73565	Prob > t	0.3875
Confidence	0.95	Prob < t	0.6125

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.37766	0.37766	0.0821	0.7751
Error	98	450.87192	4.60073		
C. Total	99	451.24958			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.28861	0.28410	0.72482	1.8524
MOP	43	1.41274	0.32710	0.76362	2.0619

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#10

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.004016
Adj Rsquare	-0.00636
Root Mean Square Error	1.025081
Mean of Response	0.888344
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.13060	t Ratio	-0.62214
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Std Err Dif	0.20991	DF	96
Upper CL Dif	0.28608	Prob > t	0.5353
Lower CL Dif	-0.54727	Prob > t	0.7323
Confidence	0.95	Prob < t	0.2677

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.40672	0.40672	0.3871	0.5353
Error	96	100.87596	1.05079		
C. Total	97	101.28268			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	0.942981	0.13578	0.67347	1.2125
MOP	41	0.812385	0.16009	0.49461	1.1302

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#11

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.002723
Adj Rsquare	-0.00767
Root Mean Square Error	1.926672
Mean of Response	1.219765
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.20198	t Ratio	0.511947
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Std Err Dif	0.39454	DF	96
Upper CL Dif	0.98514	Prob > t	0.6099
Lower CL Dif	-0.58117	Prob > t	0.3049
Confidence	0.95	Prob < t	0.6951

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.97289	0.97289	0.2621	0.6099
Error	96	356.35807	3.71206		
C. Total	97	357.33096			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	1.13526	0.25519	0.62871	1.6418
MOP	41	1.33725	0.30090	0.73997	1.9345

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#22

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.005462
Adj Rsquare	-0.00547
Root Mean Square Error	6.315376
Mean of Response	1.385628
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.9613	t Ratio	-0.70693
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Std Err Dif	1.3598	DF	91
Upper CL Dif	1.7398	Prob > t	0.4814
Lower CL Dif	-3.6624	Prob > t	0.7593
Confidence	0.95	Prob < t	0.2407

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	19.9323	19.9323	0.4998	0.4814
Error	91	3629.4421	39.8840		
C. Total	92	3649.3744			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.73707	0.8222	0.104	3.3703
MOP	34	0.77578	1.0831	-1.376	2.9272

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#23

Missing Rows 14

Oneway Anova

Summary of Fit

Rsquare	0.000482
Adj Rsquare	-0.01075
Root Mean Square Error	2.031801
Mean of Response	0.964782
Observations (or Sum Wgts)	91

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.09174	t Ratio	0.207073
------------	---------	---------	----------

Std Err Dif	0.44303	DF	89
Upper CL Dif	0.97203	Prob > t	0.8364
Lower CL Dif	-0.78855	Prob > t	0.4182
Confidence	0.95	Prob < t	0.5818

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.17702	0.17702	0.0429	0.8364
Error	89	367.41124	4.12822		
C. Total	90	367.58826			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	0.93151	0.26679	0.40141	1.4616
MOP	33	1.02325	0.35369	0.32048	1.7260

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#24

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.001489
Adj Rsquare	-0.00948
Root Mean Square Error	0.722255
Mean of Response	0.762737
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.05728	t Ratio	0.368332
------------	---------	---------	----------

Std Err Dif	0.15551	DF	91
Upper CL Dif	0.36619	Prob > t	0.7135
Lower CL Dif	-0.25163	Prob > t	0.3567
Confidence	0.95	Prob < t	0.6433

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.070772	0.070772	0.1357	0.7135
Error	91	47.470333	0.521652		
C. Total	92	47.541104			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	0.741796	0.09403	0.55502	0.9286
MOP	34	0.799076	0.12387	0.55303	1.0451

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#25

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.017638
Adj Rsquare	0.006842
Root Mean Square Error	1.540877
Mean of Response	0.838081
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.4241	t Ratio	1.278217
------------	--------	---------	----------

Std Err Dif	0.3318	DF	91
Upper CL Dif	1.0831	Prob > t	0.2044
Lower CL Dif	-0.2349	Prob > t	0.1022
Confidence	0.95	Prob < t	0.8978

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	3.87923	3.87923	1.6338	0.2044
Error	91	216.06152	2.37430		
C. Total	92	219.94075			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	0.68304	0.20061	0.28456	1.0815
MOP	34	1.10712	0.26426	0.58220	1.6320

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#26

Missing Rows 12

Oneway Anova

Summary of Fit

Rsquare	0.003071
Adj Rsquare	-0.00788
Root Mean Square Error	2.304466
Mean of Response	1.014933
Observations (or Sum Wgts)	93

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.2627	t Ratio	0.529425
------------	--------	---------	----------

Std Err Dif	0.4962	DF	91
Upper CL Dif	1.2483	Prob > t	0.5978
Lower CL Dif	-0.7229	Prob > t	0.2989
Confidence	0.95	Prob < t	0.7011

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.48850	1.48850	0.2803	0.5978
Error	91	483.26112	5.31056		
C. Total	92	484.74962			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	0.91889	0.30002	0.32295	1.5148
MOP	34	1.18159	0.39521	0.39655	1.9666

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#27

Missing Rows 14

Oneway Anova

Summary of Fit

Rsquare	0.006762
Adj Rsquare	-0.0044
Root Mean Square Error	6.477066
Mean of Response	1.448077
Observations (or Sum Wgts)	91

t Test

MOP-CONTROL

Assuming equal variances

Difference	-1.1069	t Ratio	-0.77843
------------	---------	---------	----------

Std Err Dif	1.4220	DF	89
Upper CL Dif	1.7186	Prob > t	0.4384
Lower CL Dif	-3.9324	Prob > t	0.7808
Confidence	0.95	Prob < t	0.2192

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	25.4209	25.4209	0.6059	0.4384
Error	89	3733.7625	41.9524		
C. Total	90	3759.1834			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	59	1.83732	0.8432	0.162	3.5128
MOP	32	0.73040	1.1450	-1.545	3.0055

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#6

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.00119
Adj Rsquare	-0.009
Root Mean Square Error	1.184523
Mean of Response	0.911881
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.08200	t Ratio	0.341666
------------	---------	---------	----------

Std Err Dif	0.24000	DF	98
Upper CL Dif	0.55826	Prob > t	0.7333
Lower CL Dif	-0.39427	Prob > t	0.3667
Confidence	0.95	Prob < t	0.6333

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.16379	0.16379	0.1167	0.7333
Error	98	137.50318	1.40309		
C. Total	99	137.66697			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	58	0.877441	0.15554	0.56879	1.1861
MOP	42	0.959440	0.18278	0.59673	1.3222

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#7

Missing Rows 7

Oneway Anova

Summary of Fit

Rsquare	0.002161
Adj Rsquare	-0.00823
Root Mean Square Error	0.986416
Mean of Response	0.863966
Observations (or Sum Wgts)	98

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.09209	t Ratio	-0.45592
------------	----------	---------	----------

Std Err Dif	0.20200	DF	96
Upper CL Dif	0.30887	Prob > t	0.6495
Lower CL Dif	-0.49305	Prob > t	0.6753
Confidence	0.95	Prob < t	0.3247

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.202251	0.202251	0.2079	0.6495
Error	96	93.409576	0.973016		
C. Total	97	93.611827			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	0.902495	0.13065	0.64315	1.1618
MOP	41	0.810401	0.15405	0.50461	1.1162

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#8

Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.017977
Adj Rsquare	0.007956
Root Mean Square Error	0.519418
Mean of Response	0.654179
Observations (or Sum Wgts)	100

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.14053	t Ratio	1.339407
------------	---------	---------	----------

Std Err Dif	0.10492	DF	98
Upper CL Dif	0.34873	Prob > t	0.1835
Lower CL Dif	-0.06768	Prob > t	0.0918
Confidence	0.95	Prob < t	0.9082

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.484016	0.484016	1.7940	0.1835
Error	98	26.439965	0.269796		
C. Total	99	26.923981			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	0.593753	0.06880	0.45722	0.73028
MOP	43	0.734279	0.07921	0.57709	0.89147

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Tooth=#9

Missing Rows 6

Oneway Anova

Summary of Fit

Rsquare	0.019298
Adj Rsquare	0.009188
Root Mean Square Error	2.300853
Mean of Response	1.12015
Observations (or Sum Wgts)	99

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.6464	t Ratio	1.381583
------------	--------	---------	----------

Std Err Dif	0.4679	DF	97
Upper CL Dif	1.5751	Prob > t	0.1703
Lower CL Dif	-0.2822	Prob > t	0.0851
Confidence	0.95	Prob < t	0.9149

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	10.10490	10.1049	1.9088	0.1703
Error	97	513.51063	5.2939		
C. Total	98	523.61553			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	57	0.84591	0.30476	0.24105	1.4508
MOP	42	1.49234	0.35503	0.78770	2.1970

DISCREPANCY BY ARCH

Oneway Analysis of Data By Group parameter= ΔV , Arch=Lower

Oneway Anova

Summary of Fit

Rsquare	0.002514
Adj Rsquare	0.000926
Root Mean Square Error	2.087169
Mean of Response	2.432013
Observations (or Sum Wgts)	630

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.21086	t Ratio	-1.25813
Std Err Dif	0.16760	DF	628
Upper CL Dif	0.11826	Prob > t	0.2088
Lower CL Dif	-0.53998	Prob > t	0.8956
Confidence	0.95	Prob < t	0.1044

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.8955	6.89552	1.5829	0.2088
Error	628	2735.7415	4.35628		
C. Total	629	2742.6370			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	354	2.52439	0.11093	2.3065	2.7422
MOP	276	2.31353	0.12563	2.0668	2.5602

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= ΔV , Arch=Upper

Missing Rows 10

Oneway Anova

Summary of Fit

Rsquare	0.016103
Adj Rsquare	0.014511
Root Mean Square Error	2.071772
Mean of Response	2.99776
Observations (or Sum Wgts)	620

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.532451	t Ratio	3.180353
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Std Err Dif	0.167419	DF	618
Upper CL Dif	0.861229	Prob > t	0.0015*
Lower CL Dif	0.203672	Prob > t	0.0008*
Confidence	0.95	Prob < t	0.9992

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	43.4145	43.4145	10.1146	0.0015*
Error	618	2652.6036	4.2922		
C. Total	619	2696.0181			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	344	2.76073	0.11170	2.5414	2.9801
MOP	276	3.29318	0.12471	3.0483	3.5381

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Arch=Lower

Missing Rows 78

Oneway Anova

Summary of Fit

Rsquare	0.000205
Adj Rsquare	-0.00161
Root Mean Square Error	3.278466
Mean of Response	1.42315
Observations (or Sum Wgts)	552

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.09738	t Ratio	-0.33545
------------	----------	---------	----------

Std Err Dif	0.29030	DF	550
Upper CL Dif	0.47286	Prob > t	0.7374
Lower CL Dif	-0.66762	Prob > t	0.6313
Confidence	0.95	Prob < t	0.3687

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	1.2095	1.2095	0.1125	0.7374
Error	550	5911.5872	10.7483		
C. Total	551	5912.7967			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	352	1.45843	0.17474	1.1152	1.8017
MOP	200	1.36105	0.23182	0.9057	1.8164

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δx° , Arch=Upper

Missing Rows 37

Oneway Anova

Summary of Fit

Rsquare	3.458e-5
Adj Rsquare	-0.00166
Root Mean Square Error	3.869363
Mean of Response	1.822681
Observations (or Sum Wgts)	593

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.04600	t Ratio	-0.14295
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Std Err Dif	0.32177	DF	591
Upper CL Dif	0.58596	Prob > t	0.8864
Lower CL Dif	-0.67796	Prob > t	0.5568
Confidence	0.95	Prob < t	0.4432

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.3060	0.3060	0.0204	0.8864
Error	591	8848.4340	14.9720		
C. Total	592	8848.7400			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	343	1.84207	0.20893	1.4317	2.2524
MOP	250	1.79607	0.24472	1.3154	2.2767

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Arch=Lower

Missing Rows 78

Oneway Anova

Summary of Fit

Rsquare	0.000169
Adj Rsquare	-0.00165
Root Mean Square Error	2.778569
Mean of Response	1.372129
Observations (or Sum Wgts)	552

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.07490	t Ratio	0.304751
------------	---------	---------	----------

Std Err Dif	0.24578	DF	550
Upper CL Dif	0.55767	Prob > t	0.7607
Lower CL Dif	-0.40787	Prob > t	0.3803
Confidence	0.95	Prob < t	0.6197

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.7170	0.71702	0.0929	0.7607
Error	550	4246.2439	7.72044		
C. Total	551	4246.9609			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	351	1.34486	0.14831	1.0535	1.6362
MOP	201	1.41976	0.19599	1.0348	1.8047

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δy° , Arch=Upper

Missing Rows 33

Oneway Anova

Summary of Fit

Rsquare	0.001217
Adj Rsquare	-0.00046
Root Mean Square Error	6.19614
Mean of Response	1.8112
Observations (or Sum Wgts)	597

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.4369	t Ratio	-0.85133
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Std Err Dif	0.5132	DF	595
Upper CL Dif	0.5710	Prob > t	0.3949
Lower CL Dif	-1.4447	Prob > t	0.8025
Confidence	0.95	Prob < t	0.1975

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	27.825	27.8253	0.7248	0.3949
Error	595	22843.329	38.3921		
C. Total	596	22871.154			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	344	1.99635	0.33407	1.3402	2.6525
MOP	253	1.55946	0.38955	0.7944	2.3245

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Arch=Lower

Missing Rows 76

Oneway Anova

Summary of Fit

Rsquare	0.000625
Adj Rsquare	-0.00119
Root Mean Square Error	3.938009
Mean of Response	1.068048
Observations (or Sum Wgts)	554

t Test

MOP-CONTROL

Assuming equal variances

Difference	-0.20438	t Ratio	-0.58735
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Std Err Dif	0.34797	DF	552
Upper CL Dif	0.47913	Prob > t	0.5572
Lower CL Dif	-0.88790	Prob > t	0.7214
Confidence	0.95	Prob < t	0.2786

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	5.3499	5.3499	0.3450	0.5572
Error	552	8560.3697	15.5079		
C. Total	553	8565.7197			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	353	1.14220	0.20960	0.73049	1.5539
MOP	201	0.93782	0.27777	0.39221	1.4834

Std Error uses a pooled estimate of error variance

Oneway Analysis of Data By Group parameter= Δz° , Arch=Upper

Missing Rows 37

Oneway Anova

Summary of Fit

Rsquare	0.002271
Adj Rsquare	0.000582
Root Mean Square Error	1.458696
Mean of Response	0.942267
Observations (or Sum Wgts)	593

t Test

MOP-CONTROL

Assuming equal variances

Difference	0.14068	t Ratio	1.159753
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Std Err Dif	0.12130	DF	591
Upper CL Dif	0.37892	Prob > t	0.2466
Lower CL Dif	-0.09756	Prob > t	0.1233
Confidence	0.95	Prob < t	0.8767

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.8619	2.86194	1.3450	0.2466
Error	591	1257.5267	2.12779		
C. Total	592	1260.3886			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
CONTROL	343	0.88296	0.07876	0.72827	1.0376
MOP	250	1.02364	0.09226	0.84245	1.2048

Std Error uses a pooled estimate of error variance

GENDER

Response Data parameter= ΔV

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	62.6285	20.8762	4.7501
Error	1246	5476.0418	4.3949	Prob > F 0.0027*
C. Total	1249	5538.6703		

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	2.8031036	0.064155	43.69	<.0001*
Gender[F]	-0.225228	0.064155	-3.51	0.0005*
Group[CONTROL]	-0.124465	0.064155	-1.94	0.0526
Gender[F]*Group[CONTROL]	0.0604603	0.064155	0.94	0.3462

Effect Details

Gender

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
F	2.5778754	0.07304577	2.57532
M	3.0283317	0.10548735	2.97916

LS Means Plot

Group

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
CONTROL	2.6786382	0.08152058	2.64087
MOP	2.9275689	0.09908411	2.80336

LS Means Plot

Gender*Group

Least Squares Means Table

Level	Least Sq Mean	Std Error
F,CONTROL	2.5138704	0.10121519
F,MOP	2.6418804	0.10534811
M,CONTROL	2.8434061	0.12781982
M,MOP	3.2132574	0.16784641

LS Means Plot

Response Data parameter= Δx°

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	28.039	9.3463	0.7216
Error	1141	14779.132	12.9528	Prob > F 0.5392
C. Total	1144	14807.171		

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.5845063	0.115811	13.68	<.0001*
Gender[F]	0.143712	0.115811	1.24	0.2149
Group[CONTROL]	0.0196779	0.115811	0.17	0.8651
Gender[F]*Group[CONTROL]	0.0468023	0.115811	0.40	0.6862

Effect Details

Gender

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
F	1.7282183	0.13390025	1.73846
M	1.4407943	0.18899550	1.43202

LS Means Plot

Group

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
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Level	Least Sq Mean	Std Error	Mean
CONTROL	1.6041843	0.14023703	1.64777
MOP	1.5648284	0.18434249	1.60273

LS Means Plot

Gender*Group

Least Squares Means Table

Level	Least Sq Mean	Std Error
F,CONTROL	1.7946985	0.17416773
F,MOP	1.6617381	0.20342741
M,CONTROL	1.4136700	0.21984381
M,MOP	1.4679186	0.30748317

LS Means Plot

Response Data parameter= Δy°

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	17.446	5.8155	0.2452
Error	1145	27155.961	23.7170	Prob > F
C. Total	1148	27173.407		0.8648

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.5937065	0.156198	10.20	<.0001*
Gender[F]	-0.012004	0.156198	-0.08	0.9388
Group[CONTROL]	0.0534302	0.156198	0.34	0.7324
Gender[F]*Group[CONTROL]	0.0980597	0.156198	0.63	0.5303

Effect Details

Gender

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
F	1.5817030	0.18067680	1.60492
M	1.6057100	0.25484677	1.59172

LS Means Plot

Group

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
CONTROL	1.6471367	0.19003027	1.66732
MOP	1.5402763	0.24795056	1.49761

LS Means Plot

Gender*Group

Least Squares Means Table

Level	Least Sq Mean	Std Error
F,CONTROL	1.7331929	0.23512629
F,MOP	1.4302130	0.27439397
M,CONTROL	1.5610805	0.29859947
M,MOP	1.6503395	0.41306885

LS Means Plot

Response Data parameter= Δz°

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	3.3260	1.10867	0.1289
Error	1143	9827.3137	8.59782	Prob > F
C. Total	1146	9830.6397		0.9429

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.0038667	0.094212	10.66	<.0001*
Gender[F]	-0.023564	0.094212	-0.25	0.8025
Group[CONTROL]	0.026144	0.094212	0.28	0.7814
Gender[F]*Group[CONTROL]	-0.043327	0.094212	-0.46	0.6457

Effect Details

Gender

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
F	0.9803026	0.10898468	0.97762
M	1.0274308	0.15370806	1.04956

LS Means Plot

Group

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
CONTROL	1.0300107	0.11428379	1.01444
MOP	0.9777227	0.14981002	0.98539

LS Means Plot

Gender*Group

Least Squares Means Table

Level	Least Sq Mean	Std Error
F,CONTROL	0.9631201	0.14156818
F,MOP	0.9974851	0.16573801
M,CONTROL	1.0969014	0.17944802
M,MOP	0.9579603	0.24960584

LS Means Plot

AGE

Response Data parameter= ΔV

Regression Plot

Summary of Fit

RSquare	0.019423
RSquare Adj	0.017062
Root Mean Square Error	2.08778
Mean of Response	2.712624
Observations (or Sum Wgts)	1250

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	107.5750	35.8583	8.2266
Error	1246	5431.0953	4.3588	Prob > F
C. Total	1249	5538.6703		<.0001*

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	94	1208.0278	12.8514	3.5057
Pure Error	1152	4223.0675	3.6659	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	1246	5431.0953		<.0001*

Max RSq

0.2375

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.399233	0.166633	20.40	<.0001*
Age	-0.019779	0.004696	-4.21	<.0001*
Group[CONTROL]	-0.141622	0.061028	-2.32	0.0205*
(Age-31.103)*Group[CONTROL]	0.0204225	0.004696	4.35	<.0001*

Response Data parameter= Δx°

Regression Plot

Summary of Fit

RSquare	0.004856
RSquare Adj	0.002239
Root Mean Square Error	3.593654
Mean of Response	1.630069
Observations (or Sum Wgts)	1145

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	71.901	23.9669	1.8558
Error	1141	14735.270	12.9143	Prob > F
C. Total	1144	14807.171		0.1353

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	94	1694.837	18.0302	1.4476
Pure Error	1047	13040.433	12.4550	Prob > F
Total Error	1141	14735.270		0.0047*
				Max RSq
				0.1193

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.9318393	0.321624	2.90	0.0038*
Age	0.0216664	0.009369	2.31	0.0209*
Group[CONTROL]	0.0737516	0.111104	0.66	0.5069
(Age-30.3344)*Group[CONTROL]	-0.01256	0.009369	-1.34	0.1803

Response Data parameter= Δy°

Regression Plot

Summary of Fit

RSquare	0.004954
RSquare Adj	0.002347
Root Mean Square Error	4.859493
Mean of Response	1.600262
Observations (or Sum Wgts)	1149

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	134.609	44.8697	1.9001
Error	1145	27038.798	23.6147	Prob > F
C. Total	1148	27173.407		0.1278

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	94	2157.556	22.9527	0.9695
Pure Error	1051	24881.242	23.6739	Prob > F
Total Error	1145	27038.798		0.5634
				Max RSq
				0.0844

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.7456962	0.434782	4.02	<.0001*
Age	-0.003735	0.012665	-0.29	0.7681
Group[CONTROL]	0.0670169	0.149743	0.45	0.6546
(Age-30.3823)*Group[CONTROL]	0.0232065	0.012665	1.83	0.0672

Response Data parameter= Δz°

Regression Plot

Summary of Fit

RSquare	0.004628
RSquare Adj	0.002016
Root Mean Square Error	2.925906
Mean of Response	1.003019
Observations (or Sum Wgts)	1147

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	45.4992	15.1664	1.7716
Error	1143	9785.1405	8.5609	Prob > F
C. Total	1146	9830.6397		0.1508

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	94	777.0652	8.26665	0.9627
Pure Error	1049	9008.0753	8.58730	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	1143	9785.1405		0.5816

Max RSq

0.0837

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.5805838	0.264223	2.20	0.0282*
Age	0.0134782	0.007677	1.76	0.0794
Group[CONTROL]	0.0443676	0.090508	0.49	0.6241
(Age-30.3968)*Group[CONTROL]	-0.001583	0.007677	-0.21	0.8366

SEVERITY OF MAL-ALIGNMENT

Response Data Upper or Lower?=Lower, Parameters=ΔV

Effect Summary

Source	LogWorth	PValue
Lower 1	5.644	0.00000
Lower 1*Group	0.316	0.48285
Group	0.089	0.81500 ^

Regression Plot

Summary of Fit

RSquare	0.037277
RSquare Adj	0.032618
Root Mean Square Error	2.456496
Mean of Response	2.535953
Observations (or Sum Wgts)	624

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	144.8641	48.2880	8.0022
Error	620	3741.3110	6.0344	Prob > F
C. Total	623	3886.1751		<.0001*

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	30	297.5388	9.91796	1.6992
Pure Error	590	3443.7723	5.83690	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	620	3741.3110		0.0123*

Max RSq
0.1138

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	2.0217398	0.148121	13.65	<.0001*
Lower 1	-0.206726	0.043314	-4.77	<.0001*
Group[Control]	0.0233045	0.09956	0.23	0.8150
(Lower 1+2.44712)*Group[Control]	0.0304126	0.043314	0.70	0.4829

Response Data Upper or Lower?=Lower, Parameters= Δx°

Effect Summary

Source	LogWorth		PValue
Lower 1	0.761		0.17332
Lower 1 *Group	0.167		0.68125
Group	0.112		0.77226 ^

Regression Plot

Summary of Fit

RSquare	0.005737
RSquare Adj	0.000353
Root Mean Square Error	12.26496
Mean of Response	2.20346
Observations (or Sum Wgts)	558

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	480.854	160.285	1.0655
Error	554	83337.799	150.429	Prob > F
C. Total	557	83818.653		0.3632

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	30	2429.828	80.994	0.5246
Pure Error	524	80907.971	154.405	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	554	83337.799		0.9834

Max RSq

0.0347

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.0002921	0.805692	3.72	0.0002*
Lower 1	0.3167809	0.232353	1.36	0.1733
Group[Control]	-0.156776	0.541425	-0.29	0.7723
(Lower 1+2.43548)*Group[Control]	0.0954925	0.232353	0.41	0.6812

Response Data Upper or Lower?=Lower, Parameters= Δy°

Effect Summary

Source	LogWorth		PValue
Group	0.524		0.29899
Lower 1 *Group	0.078		0.83548
Lower 1	0.060		0.87008 ^

Regression Plot

Summary of Fit

RSquare	0.002161
RSquare Adj	-0.00325
Root Mean Square Error	110.6776
Mean of Response	8.525555
Observations (or Sum Wgts)	557

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	14668.2	4889.4	0.3991
Error	553	6773988.5	12249.5	Prob > F
C. Total	556	6788656.7		0.7537

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	30	203422.5	6780.7	0.5397
Pure Error	523	6570566.0	12563.2	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	553	6773988.5		0.9794

Max RSq

0.0321

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	6.38774	7.276625	0.88	0.3804
Lower 1	-0.343087	2.096753	-0.16	0.8701
Group[Control]	5.0871797	4.893473	1.04	0.2990
(Lower 1+2.43537)*Group[Control]	-0.435651	2.096753	-0.21	0.8355

Response Data Upper or Lower?=Lower, Parameters= Δz°

Effect Summary

Source	LogWorth	PValue
Group	0.348	0.44841
Lower 1	0.211	0.61585
Lower 1*Group	0.165	0.68381

Summary of Fit

RSquare	0.002312
RSquare Adj	-0.00309
Root Mean Square Error	18.01167
Mean of Response	1.884385

Observations (or Sum Wgts)

558

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	416.54	138.847	0.4280
Error	554	179728.77	324.420	Prob > F
C. Total	557	180145.32		0.7330

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	30	8688.71	289.624	0.8873
Pure Error	524	171040.06	326.412	Prob > F
Total Error	554	179728.77		0.6415
				Max RSq
				0.0505

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.3295364	1.183197	1.12	0.2616
Lower 1	-0.171302	0.341221	-0.50	0.6158
Group[Control]	0.6031815	0.795109	0.76	0.4484
(Lower 1+2.43548)*Group[Control]	-0.139042	0.341221	-0.41	0.6838

Response Data Upper or Lower?=Upper, Parameters= ΔV

Regression Plot

Summary of Fit

RSquare	0.032431
RSquare Adj	0.027794
Root Mean Square Error	2.134533
Mean of Response	2.980339
Observations (or Sum Wgts)	630

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	95.5993	31.8664	6.9940
Error	626	2852.2013	4.5562	Prob > F
C. Total	629	2947.8007		0.0001*

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
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Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	29	367.9473	12.6878	3.0491
Pure Error	597	2484.2541	4.1612	Prob > F
Total Error	626	2852.2013		<.0001*
				Max RSq
				0.1573

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	2.9351191	0.096403	30.45	<.0001*
Upper 1	-0.048711	0.033546	-1.45	0.1470
Group[Control]	-0.309013	0.08673	-3.56	0.0004*
(Upper 1+1.12381)*Group[Control]	0.0761774	0.033546	2.27	0.0235*

Response Data Upper or Lower?=Upper, Parameters= Δx°

Effect Summary

Source	LogWorth	PValue
Upper 1	1.697	0.02010
Group	1.122	0.07557
Upper 1*Group	1.117	0.07639

Regression Plot

Summary of Fit

RSquare	0.014769
RSquare Adj	0.009801
Root Mean Square Error	10.65926
Mean of Response	2.62509
Observations (or Sum Wgts)	599

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	1013.393	337.798	2.9730
Error	595	67603.849	113.620	Prob > F
C. Total	598	68617.242		0.0312*

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	29	4166.568	143.675	1.2819
Pure Error	566	63437.281	112.080	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	595	67603.849		0.1500

Max RSq

0.0755

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.305485	0.495891	6.67	<.0001*
Upper 1	0.3993148	0.171325	2.33	0.0201*
Group[Control]	-0.79355	0.445783	-1.78	0.0756
(Upper 1+1.1227)*Group[Control]	-0.304117	0.171325	-1.78	0.0764

Response Data Upper or Lower?=Upper, Parameters= Δy°

Effect Summary

Source	LogWorth	PValue
Group	0.444	0.36011
Upper 1	0.274	0.53163
Upper 1*Group	0.071	0.84944

Regression Plot

Summary of Fit

RSquare	0.00241
RSquare Adj	-0.00262
Root Mean Square Error	6.340136
Mean of Response	1.864955
Observations (or Sum Wgts)	599

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	57.774	19.2579	0.4791
Error	595	23917.412	40.1973	Prob > F
C. Total	598	23975.185		0.6969

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	29	1789.519	61.7076	1.5784
Pure Error	566	22127.892	39.0952	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	595	23917.412		0.0291*

Max RSq
0.0771

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.9067661	0.294956	6.46	<.0001*
Upper 1	0.0637803	0.101904	0.63	0.5316
Group[Control]	0.2428441	0.265152	0.92	0.3601
(Upper 1+1.1227)*Group[Control]	-0.019353	0.101904	-0.19	0.8494

Response Data Upper or Lower?=Upper, Parameters= Δz°

Effect Summary

Source	LogWorth		PValue
Group	0.563		0.27341
Upper 1	0.479		0.33217
Upper 1*Group	0.021		0.95354

Regression Plot

Summary of Fit

RSquare	0.003209
RSquare Adj	-0.00182
Root Mean Square Error	89.23974
Mean of Response	5.610982
Observations (or Sum Wgts)	599

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	15255.4	5085.13	0.6385
Error	595	4738419.8	7963.73	Prob > F
C. Total	598	4753675.2		0.5904

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	29	382889.3	13203.1	1.7157
Pure Error	566	4355530.6	7695.3	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
Total Error	595	4738419.8		0.0121*

Max RSq

0.0838

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.8260849	4.151615	1.89	0.0599
Upper 1	1.3920765	1.434338	0.97	0.3322
Group[Control]	-4.091309	3.732107	-1.10	0.2734
(Upper 1+1.1227)*Group[Control]	-0.083609	1.434338	-0.06	0.9535

FREQUENCY OF REFINEMENT

Contingency Analysis of R or C By Group

Mosaic Plot

Contingency Table

Group By R or C

Count	C	R	Total
Total %			
Col %			
Row %			
Control	10	49	59
	9.52	46.67	56.19
	83.33	52.69	
	16.95	83.05	
MOP	2	44	46
	1.90	41.90	43.81
	16.67	47.31	
	4.35	95.65	
Total	12	93	105
	11.43	88.57	

Tests

N	DF	-LogLike	RSquare (U)
105	1	2.2386745	0.0600

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	4.477	0.0343*
Pearson	4.055	0.0440*

Fisher's Exact	Prob	Alternative Hypothesis
Test		
Left	0.9928	Prob(R or C=R) is greater for Group=Control than MOP
Right	0.0405*	Prob(R or C=R) is greater for Group=MOP than Control
2-Tail	0.0628	Prob(R or C=R) is different across Group

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