Analysis of Orthodontic Tooth Movement Using 3D Imaging

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TITLE OF PROJECT: Analysis of orthodontic tooth movement using 3D imaging

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ABSTRACT OF RESEARCH PLAN: Provide structured abstract with 1. Objective (Specific Aims) 2. Significance/Background 3) Methods. The abstract should be self- contained so that it can serve as a succinct and accurate description of the proposed project.

ABSTRACT. Specific Aims: The purpose of this study is to study the effect of wire dimension, timing and ligation method on the efficacy of Stage I orthodontic treatment (leveling and aligning) using 3D imaging. A secondary aim is to correlate clinical tooth movements with bench data for four types of malalignment (in-out, rotation, tip, and vertical step). **Background:** Little objective clinical evidence is available to indicate which archwire dimension is ideal for leveling and aligning in a given patient with an individual type and degree of malalignment. The effects of ligation method (twin vs. self-ligating) and time-course on the efficacy of this stage are similarly unclear. When 014 and 016 NiTi archwires are tested in vitro using multiple brackets, some combinations increase correction, while others decrease it(5). And while Fleming and Johansson have demonstrated no significant difference in the efficacy of traditional brackets compared with either active or passive self-ligating appliances(2, 3), many clinicians continue to claim self-ligating brackets are superior for leveling and aligning. Whitecotton showed in a pilot study that archwire dimension affects the efficacy of alignment in a time-dependent fashion. However, these data don't correlate with benchtop studies by Gibson and Ko, who propose that differences in the "constraining force" may dictate the efficiency of alignment(10). This study seeks to use an increased sample size to further investigate that correlation and analyze the influence of wire dimension, timing and ligation method on the efficacy of leveling and aligning. **Methods:** A sample of 80 patients who are receiving fixed orthodontic treatment at UNC-Chapel Hill or at Selden Orthodontics in Charlotte, NC will be recruited to participate. Subjects will be assigned into one of four groups: 014 wire with twin brackets; 016 wire with twin brackets; 014 wire with self-ligating brackets; and 016 wire with self-ligating brackets. All subjects will be indirect-bonded following a digital Insignia setup reviewed and approved by the principal investigator. Intraoral scans taken as part of treatment before bonding, 6 weeks after bonding, and 12 weeks after bonding will be analyzed. From these scans, Little Index measurements and superimpositions will be completed to determine changes in alignment as well as translation and rotation of the teeth in three dimensions.

Specific Aims

The aim of this study is to study the effect of wire dimension, timing and ligation method on leveling and aligning in orthodontic treatment using 3D imaging.
Specifically to:

1. Analyze the effect of wire dimension (.014 vs. .016) and time-course (first six weeks or second six weeks) on Stage I treatment
2. Correlate clinical tooth movements with bench data for four types of malalignment
    a. In-out
    b. Rotation
    c. Tip
    d. Vertical step
3. Analyze effect of ligation method (twin vs. self-ligating) on Stage I treatment

These specific aims will serve to address this hypothesis: Archwire dimension affects tooth movement in Stage I of orthodontic treatment, depending upon:

1. Variation in constraining force;
2. Time-course due to force decay of superelastic wires; and
3. Method of ligation.

Significance

Many archwire dimensions are available to orthodontists for leveling and aligning, but little objective clinical evidence is available to indicate which archwire dimension is ideal for a given patient with an individual type and degree of malalignment during this stage. The effects of bracket type (twin vs. self-ligating) and time-course on this stage are similarly unclear. Superelastic wires like NiTi and CuNiTi allow a light, continuous force to be maintained over an extended period of time and large range of deflection, which tends to make them the preferred archwires for Stage I treatment(1). Some clinicians believe that self-ligating brackets and thermoelastic wires like CuNiTi are more efficacious for leveling and aligning than twin brackets and superelastic wires. However, Fleming and Johansson have demonstrated no significant difference in the efficacy of traditional brackets compared with either active or passive self-ligating appliances(2, 3), and Pandis found the difference between laboratory and clinical settings appears to dispel any laboratory-based claims that Cu NiTi is superior(4). It is also unclear if one wire dimension is superior to others for Stage I treatment. When 014 and 016 NiTi archwires were tested by Montasser using multiple brackets in vitro, some combinations increased the correction while others decreased it(5). But there is even disagreement on how to measure that alignment. Macauley and Sjogren found that precision and accuracy are lacking in traditional measurement techniques for Little Index calculations(6,7). These measurements become more reliable, however, when digital models are used to reduce subjectivity in choosing contact points and increase precision in measuring contact point displacement(8). Whitecotton used these methods along with 3D superimposition to demonstrate in a pilot study that archwire dimension has an effect on the efficacy of alignment, and that the efficacy of alignment is time-dependent. During the first 12 weeks of treatment, 014 wires produced greater mesiodistal effects (distalization), while 016 produced greater vertical effects and in-out effects (extrusion and buccal movement, respectively). More distalization occurred during the first six weeks, while more extrusion and buccal movement occurred during the second six weeks(9). Benchtop tests have also shown that there is a critical point at which the deflection of a wire becomes large

enough that it can no longer slide through the brackets. Gibson and Ko have proposed the concept of "constraint" to describe the point at which the wire binds, creating a spring-like force similar to that of an open coil between neighboring teeth. In four types of malalignment (in-out, rotation, tip and vertical step), they found a critical value where the constraining force increases. This critical point is reached at different degrees of discrepancy in different malalignment types. Gibson and Ko hypothesized these differences may dictate efficiency of the alignment(10). However, the correlation between clinical data and constraining force on efficacy of alignment has not been performed.

Whitecotton's study was relatively underpowered. The current study seeks to use an expanded sample size to investigate possible correlations with Gibson and Ko's benchtop data and analyze the influence of wire dimension and timing on leveling and alignment. To our knowledge, no previous studies have used 3D imaging to compare twin and self-ligating brackets in Stage I of orthodontic treatment.

In a larger sense, we hope this study will help move orthodontics in the direction of personalized medicine. More specifically, we hope it will provide insight into which archwire dimension and ligation method is ideal for a given patient with an individual type and degree of malalignment.

Methods

With IRB approval, we plan to recruit 80 participants from the post-doctoral orthodontic clinic and the private practice of UNC orthodontic faculty member, Dr. Robert Selden, using notes and photographs from the initial records appointment to screen for exclusion and inclusion criteria.

- Inclusion:
    - Non-extraction treatment
    - Little Index of 1-15 mm
    - Presence of all permanent anterior teeth
    - Age 10-45 years
    - Consent to participate in the study.

- Exclusion:
    - Systemic diseases such as diabetes, hypertension, temporomandibular disorders (TMD), craniofacial syndrome, etc.
    - Spacing between anterior teeth
    - Subjects who have incisor mandibular plane angle (IMPA) greater than or equal to 100 degrees
    - Anterior tooth completely blocked from the arch form
    - Periodontal pocketing of any anterior teeth greater than 4mm

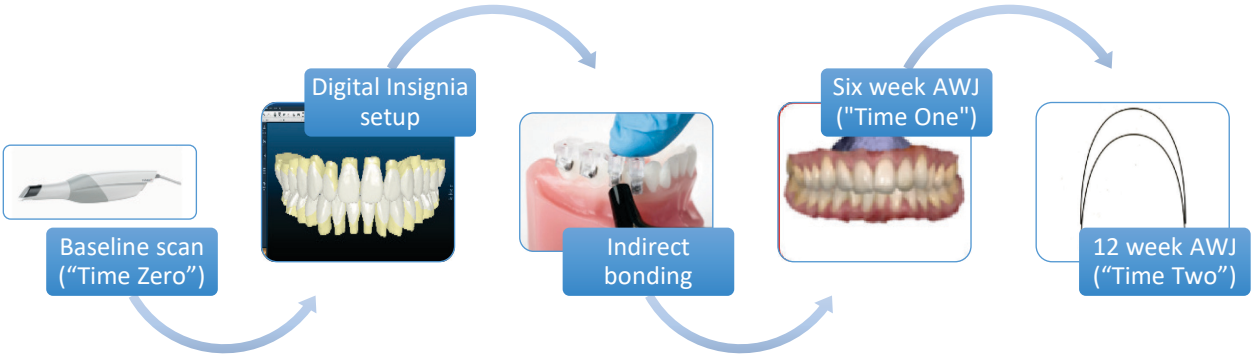
Potential participants will be identified by their treating orthodontists. If potential participants are interested, their treating clinician will notify research personnel. Research personnel will meet with potential participants at the case presentation appointment. The study information and consent forms will be reviewed and signed by interested patients.

The intraoral scan completed by the treating orthodontist using the Trios 3Shape intraoral scanner as a part of treatment will serve as the baseline (Time Zero) scan. It will also be sent to

the Ormco corporation for digital setup and custom Insignia bracket fabrication. The resident assigned to the case will complete the digital setup, which will be assessed and verified by the principal investigator (CK). Subjects in the twin group will receive 022 Ormco Insignia custom milled metal twin brackets, and those in the self-ligation group will receive 022 Ormco Insignia SL (custom laser-welded Damon Q) brackets.

The indirect bonding appointment will be completed by the assigned resident, at which time the wires will be distributed and tied in. The distribution will be double-blinded with each wire assigned an ID from a random number generator via a third party. Each patient will receive an upper and lower Ormco Cu NiTi archwire of the same dimension (either 014 or 016).

The patient will return in six weeks for their normally-scheduled archwire adjustment, and the scan completed by their treating clinician as part of treatment will serve as the Time One scan. The same arch wires will then be tied back in, as per normal treatment protocol. Subjects will return six weeks after that (twelve weeks post-bonding), and the scan completed by their treating clinician as part of treatment will serve as the third and final scan of the study (Time Two). At this time the archwires removed by the treating orthodontist will be retrieved by research personnel and the patient will continue with standard treatment according to provider preference. After that, we will begin the process of analyzing the data.



Data Analysis

After the scans are completed, we will calculate the differences in several numbers as they change from Time Zero to Time One to Time Two: Little's Index, calculated using the line measurement method; translation in three planes, calculated using the superimposition method; and rotation around three axes, calculated using the superimposition method. We'll then use 3-way ANOVA to evaluate the effect of 3 factors: wire dimension, time, and ligation method. We will also use a repeated measure linear regression model to evaluate any correlation between the degrees of malalignment and the rate of tooth movement.

Possible Limitations

There are limitations to this study. It will be impossible to completely randomize bracket type (twin vs. self-ligation) because part of this study will be conducted in a post-doctoral orthodontic clinic where not all attending faculty members are comfortable using both self-ligating and twin brackets. Bracket type will thus be assigned according to faculty member preference.

Additionally, while we hope to have 80 patients complete all scans, it may be difficult to recruit 80 patients and keep scans at correct time intervals due to patient compliance with appointments. Bonding errors may also occur during indirect bonding appointments and cause bracket placement errors that negate the accuracy of the custom Insignia indirect-bonding jigs.

During the data analysis, contact point selection for the Little Index will be subjective even using digital models in the method described by Dowling(8). Point selection for the rigid movement (translation and rotation) portion of the study will be similarly subjective.

Timeline

- Fall 2017-Summer 2018: Data collection
- Fall 2018: Data and statistical analysis
- Spring 2019: Manuscript preparation

Human Subjects

IRB approval has not yet been obtained but will be before patient screening begins. There are no direct benefits to the patient for participating in the study, and there are no risks associated with participating in the study since we are just observing normal orthodontic treatment. The risks that are inherent in any orthodontic treatment (risks of discomfort, tooth mobility, root resorption, and allergic reactions) are neither increased nor decreased by participation in this study. There are no extra appointments necessary for participation in the study, and steps will be taken to de-identify all patient information and study data.

References

1. Proffit, W.R., H.W. Fields, and D.M. Sarver, *Contemporary Orthodontics*. 5th ed. 2013: Mosby.

2. Fleming, P.S., et al., *Comparison of maxillary arch dimensional changes with passive and active self-ligation and conventional brackets in the permanent dentition: a multicenter, randomized controlled trial.* Am J Orthod Dentofacial Orthop, 2013. **144**(2): p. 185-93.

3. Johansson, K. and F. Lundstrom, *Orthodontic treatment efficiency with self-ligating and conventional edgewise twin brackets: a prospective randomized clinical trial.* Angle Orthod, 2012. **82**(5): p. 929-34.

4. Pandis, N., A. Polychronopoulou, and T. Eliades, *Alleviation of mandibular anterior crowding with copper-nickel-titanium vs nickel-titanium wires: a double-blind randomized control trial.* Am J Orthod Dentofacial Orthop, 2009. **136**(2): p. 152 e1-7;discussion 152-3.

5. Montasser, M.A., L. Keilig, and C. Bourauel, *Archwire diameter effect on tooth alignment with different bracket-archwire combinations.* Am J Orthod Dentofacial Orthop, 2016. **149**(1): p. 76-83.

6. Macauley, D., et al., *Using Little's Irregularity Index in orthodontics: outdated and inaccurate?* J Dent, 2012. **40**(12): p. 1127-33.

7. Sjogren, A.P., J.E. Lindgren, and J.A. Huggare, *Orthodontic study cast analysis--reproducibility of recordings and agreement between conventional and 3D virtual measurements.* J Digit Imaging, 2010. **23**(4): p. 482-92.

8. Dowling, A.H., et al., *Can the intra-examiner variability of Little's Irregularity Index be improved using 3D digital models of study casts?* J Dent, 2013. **41**(12): p. 1271-80.

9. Whitecotton, B. *014 versus .016 in Alignment and Leveling: Does it Make a Difference?* UNC Masters Thesis, May 2017.

10. Gibson, C., Lin, F-C., Phillips, C., Edelman, A., Ko, C., *Characterizing constraining forces in the alignment phase of orthodontic treatment.* Conditionally accepted. Angle Orthodontist, 2017.