Brace Yourselves: The Variation of Forces from Tooth Movements through the use of Orthodontic Braces

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Introduction

- Orthodontic braces have been a solution for many that desire aesthetic advantages. They have not only provided cosmetic benefits but they have also been one of the most effective ways in ameliorating quality of life related to oral health, mechanical limitations with the breakdown of food, and many other issues[1]
- One's treatment plan can vary depending on the severity of misalignment within the patient's teeth

  ➔ As a result, different archwire sizes can be utilized to fit the desired movement for the teeth of interest

Objective

- To study the differences of forces with the displacements of 3 teeth of interest: the canine (1), the central incisor (2) and the second premolar (3)
- Investigate how much these forces differ with the use of two different archwire sizes (0.014" and 0.016")
- Conduct these tooth displacements in the buccal-lingual direction (tongue to cheek) between the range of 0 mm to 0.5 mm
- To better understand if there is a large difference in forces by performing minimal displacements as part of a sensitivity analysis

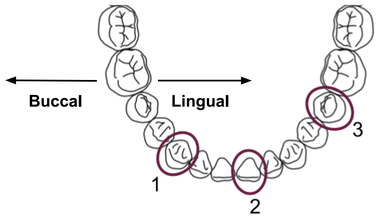

***Figure 1**. Illustration of the canine (1), central incisor (2), and second premolar (3) with the buccal-lingual directions indicated*

https://pnghut.com/png/EvK2wPPXMQ/dental-arch-dentistry-human-tooth-midline-arches-transparent-png

Methods

- An orthodontic simulator (OSIM) was used to collect all the data for the experiments[2]
- A self-ligating bracket was used (Carrick SLX, slot size: 0.018 x 0.022)
- Damon Copper Nickel Titanium (CuNiTi) archwires were used
- The experiment had 3 archwires tested for each size

Experimental Setup

- Five trials for each archwire were conducted to receive averaged force data
- Experiments were repeated with the 3 archwires (15 trials total)
- The chosen teeth for the experiment were located on the mandibular (bottom) arch
- Tooth movements were conducted in the Fy (buccal-lingual) direction
- All trials were conducted at 37°C to closely replicate oral temperature
- All teeth were set at a neutral position (no forces acting on brackets) before archwires were ligated on

***Figure 2**. Orthodontic Simulator (OSIM)*

- Residual forces were lowered after archwire had been inserted
- The tested canine, central incisor, and second premolar were distinctly chosen at different locations to balance out the displacements of the archwire

Experiment Details

- Initially, each tooth of interest was displaced 0.5 mm buccally, then lingually moved 0.5 mm back to its neutral position
- Every experiment moved all three teeth individually in random orders each time to minimize variability
- The OSIM software was used to record all force magnitude data
- Data collected from the OSIM gets transferred to excel, where all the forces are averaged

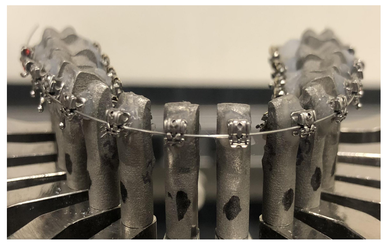

Figure 3. Inserted archwire on brackets through OSIM

***Figure 4a**. Arrows indicate the direction of buccal **displacement** of teeth from the 0 mm to 0.5 mm increment*

***Figure 4b**. Arrows indicate the lingual direction of **reactionary force** acting on the brackets, as the teeth displace in the buccal direction*

Results

Positive magnitudes on y-axis represent lingually directed force

***Figure 5.** Averaged forces from all the trials of the 0.014" archwires tested*

0.014" Archwire - Maximum forces reached at the maximum displacement (0.5mm)

Tooth	Average Force & Standard Deviation
Canine	0.71N ± 0.030N
Central Incisor	0.37N ± 0.15N
Second Premolar	0.90N ± 0.030N

***Figure 6.** Averaged forces from all the trials of the 0.016" archwires tested*

0.016" Archwire - Maximum forces reached at the maximum displacement (0.5mm)

Tooth	Average Force & Standard Deviation
Canine	1.1N ± 0.070N
Central Incisor	0.66N ± 0.020N
Second Premolar	1.4N ± 0.080N

Discussion and Conclusions

Discussion

- The second premolar experienced the highest force magnitudes during trials for both archwire sizes
- The central incisor experienced the least amount of force from the trials, which is consistent in both archwire sizes as well
- Both graphs taken into account show that the thicker 0.016" archwire allowed the teeth of interest to experience higher force magnitudes compared to the 0.014" archwire

Conclusions

- Our findings signify how important it is to understand the effects of using different archwire sizes within clinical practice, as the use of various sizes can show pertinent force differences
- The results can help us better investigate clinical cases where their treatment plans align with our experimental objectives, in terms of relating to the teeth of interest we used and the displacements simulated

References

[1] Leck, R., Paul, N., Rolland, S., & Birnie, D. (2021). The consequences of living with a severe malocclusion: A review of the literature. *Journal of Orthodontics*, *49*(2), 228–239. https://doi.org/10.1177/14653125211042891

[2] Badawi, H. M., Toogood, R. W., Carey, J. P. R., Heo, G., & Major, P. W. (2009). Three-dimensional orthodontic force measurements. *American Journal of Orthodontics and Dentofacial Orthopedics*, *136*(4), 518–528. https://doi.org/10.1016/j.ajodo.2009.02.025

Acknowledgements

I'd like to personally thank the WISEST Program and the Alberta Government for their sponsorship of my project and for supporting me as a student researcher