Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

Replication of Landmarked Orthodontic Bracket Positions from Patient Intraoral Scans onto Laboratory Orthodontic Simulator

Arya Subramanian[1], Robyn de Wet[1], Manuel O. Lagravere[2], Paul W. Major[2], Dan L. Romanyk[1,2*]
[1]Department of Mechanical Engineering, University of Alberta, Edmonton, Canada
[2]Department of Dentistry, University of Alberta, Edmonton, Canada
*dromanyk@ualberta.ca

Abstract

Orthodontic treatment is in high demand for its positive effects on the quality of life, comfort, and well-being of the public. A common treatment option is orthodontic braces; however, braces lack predictability and efficacy in tooth movement and treatment outcome. This is due to the lack of research linking the clinically observed tooth movement and the biomechanical loads produced from using braces. As a result of the limited biomechanics knowledge, this can lead to undesirable tooth movements, longer treatment times, and possible tissue damage. Therefore, this work will outline the proposed methodology of accurately selecting and transferring orthodontic bracket position data from patient intraoral scans onto an electro-mechanical in vitro orthodontic simulator (OSIM) to measure expected forces/moments throughout treatment.

A patient intraoral scan provided as a digital dental model was manually landmarked using 3D Slicer software for collecting patient bracket position coordinates. Subsequent scans were registered (aligned) with the initial dental model to consistently landmark bracket positions in the same coordinate system. Work has been completed in analyzing the accuracy of the surface registration process in 3D Slicer by systematically testing registration settings, different start positions, and simulating tooth movements for two identical mandibular models. For a stable reference region, the second molars were manually surface segmented and used for registering the mandibular models. The output transformation from registering only the segmented molars was then applied to align the entire model.

To simulate model scenarios at different time points, tooth movement was simulated on one of the identical models to establish how accurately predefined tooth movements can be measured after model alignment. From preliminary analysis, tooth movements of 1 mm, 0.1 mm, and 0.05 mm can be measured within an absolute error range of 0.002-0.005 mm. Variability in results is expected as additional user error is introduced from manually selecting the molars (during the registration process) and bracket points (for tooth movement measurement). Once the registration process has been thoroughly evaluated, this information will be used for analyzation of tooth movement over treatment by physically replicating the landmarked bracket positions onto the OSIM.

From current work, a repeatable and accurate method of superimposing intraoral scans from different time points has been generated and a tooth movement of 0.05 mm can be measured within expectations. Future work will now focus on finalizing a 3D-printed jig design and supplemental code for evaluation of required coordinate positions for physical replication on the OSIM.