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Pengaruh kemampuan ekspresi torque bracket passive self-ligating dan konvensional terhadap perpindahan inisial gigi dan distribusi stress: analisis finite element = The influence of torque expression among passive self-ligating and conventional brackets on initial tooth displacement and stress distribution: a finite element analysis

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Abstrak

Latar Belakang: Ekspresi penuh dari preskripsi torque bracket dipengaruhi oleh faktor yang berkaitan dengan bracket, kawat, torque play, dan faktor klinis. Hingga saat ini belum ada penelitian yang membandingkan kemampuan ekspresi torque antara berbagai ukuran kawat pada penggunaan bracket passive self-ligating (PSL) dan konvensional melalui simulasi finite element, serta menganalisis interaksi dari faktor-faktor tersebut, sekaligus memberikan gambaran pergerakan gigi dan respon jaringan periodontal. Penelitian ini bertujuan untuk mengukur besar torque play dan menganalisis pola perpindahan inisial gigi, serta distribusi stress antara berbagai ukuran kawat pada penggunaan bracket PSL dan konvensional melalui simulasi finite element.
Metode: Model 3D dikonstruksi dengan skenario kasus yang membutuhkan pencabutan premolar pertama dan retraksi masse gigi anterior maksila, menggunakan penjangkaran temporary anchorage device dan gaya retraksi 150 g. Simulasi finite element dilakukan untuk mengukur torque play antara penggunaan kawat stainless steel 0.016 x 0.022", 0.017 x 0.025" dan 0.019 x 0.025", serta mengukur perpindahan inisial pada tepi insisal dan apeks akar insisif sentral maksila, serta distribusi stress pada PDL dan tulang alveolar antara penggunaan ketiga ukuran kawat pada kedua jenis bracket.
Hasil: Pada penggunaan kawat 0.019 x 0.025", 0.017 x 0.025", dan 0.016 x 0.022" didapatkan torque play sebesar 7.6º, 11.6º, dan 18.7º untuk bracket PSL, dan 9.5º, 14º, dan 18º untuk bracket konvensional. Retraksi dan ekstrusi tepi insisal terbesar dihasilkan oleh kawat 0.016 x 0.022", sedangkan perpindahan palatal dari apeks terbesar dihasilkan oleh kawat 0.019 x 0.025". Konsentrasi stress terbesar terletak pada area 1/3 servikal pada sisi palatal dan 1/3 apikal pada sisi labial, yang menunjukkan pola perpindahan uprighting atau lingual crown tipping. Penggunaan kawat dengan diameter terbesar dan bracket konvensional menghasilkan stress terbesar pula.
Kesimpulan: Torque play antara kawat dan bracket berbanding terbalik dengan ukuran kawat. Besarnya lingual crown tipping berbanding lurus terhadap torque play antara kawat dan bracket, dan dikonfirmasi oleh pola distribusi stress di PDL dan tulang alveolar. Kendali torque yang paling baik didapatkan oleh penggunaan kawat stainless steel 0.019 x 0.025". Perbedaan metode ligasi dan geometri bracket konvensional dan PSL kemungkinan menyebabkan adanya perbedaan besar moment yang dihasilkan.
.....Introduction: The full expression of torque prescription of a bracket is influenced by bracket-related factors, wire-related factors, torque play and clinical factors. Finite element analysis (FEA) could be utilized to deepen our understanding and study the interaction between these factors, as well as to produce a simulation of the predicted tooth movement and tissue response. This study aims to measure the amount of torque play, and to analyse the pattern of initial tooth displacement, among different wire sizes and between passive self-ligating and conventional brackets using FEA.

Methods: A 3D model was constructed simulating a case which required first premolar extractions and en masse anterior retraction using temporary anchorage device and 150 g of retraction force on each side. Finite element simulation was performed to measure torque play, to investigate the pattern of initial tooth displacement at the incisal tip and of apex of the central maxillary incisor, as well as to analyse the pattern of stress distribution at the periodontal ligament (PDL) and alveolar bone, among different stainless steel wire diameters (0.016 x 0.022", 0.017 x 0.025" and 0.019 x 0.025") and between PSL and conventional brackets.
Results: The use of 0.019 x 0.025", 0.017 x 0.025", and 0.016 x 0.022" wires on PSL brackets produced a torque play of 7.6º, 11.6º, and 18.7º, respectively. While the use of the same wire sizes on conventional brackets produced a play of 9.5º, 14º, dan 18º, respectively. The use of 0.016 x 0.022 produced the farthest retraction and extrusion of the incisal tip. However, the greatest apex retraction was produced when 0.019 x 0.025" was used. The largest stress concentration was observed at the 1/3 cervical area on the palatal side and at the 1/3 apical area on the labial side. This shows that there is a pattern of uprighting or lingual crown tipping of the teeth. The use of 0.019 x 0.025" and conventional brackets yielded the greatest amount of stress on the PDL and alveolar bone.
Conclusion: The degree of torque play between wire and bracket was inversely proportional to the wire size, and the amount of lingual crown tipping was directly proportional to the degree of play. This pattern of tooth movement was confirmed by the pattern of stress distribution on the PDL and alveolar bone. Torque expression was better achieved using the 0.019 x 0.025" wire. Differences in the geometry and method of ligation between PSL and conventional brackets possibly generated different force magnitudes.