

Optimizing Orthodontic Force for an Endodontically Treated Maxillary Central Incisor

A Finite Element Study

Lamiaa A. Hasan¹, Afrah Khazal Al Hamdany¹, Mohammed Najeeb Abdullah Alrawi², Emad Hazim Kasim Alhajar²

¹College of Dentistry, University of Mosul, Mosul, Iraq

²College of Engineering, University of Mosul, Mosul, Iraq

Abstract

Objective: The aim of this study was to assess orthodontic mechanotherapy treatment effects on the prognosis of endodontically treated teeth. **Materials and Methods:** Ten three-dimensional (3D) model for the four maxillary incisors and their related structure were constructed; five of them have vital tooth property while the remaining have the property for endodontically treated tooth. Five forms of tooth movements that involved through orthodontic mechanotherapy were simulated on each right central incisor: Intrusion (0.2 N), Extrusion, Rotation and, Tipping (0.6 N), and Translation (1.2 N). **Results:** The results show that the highest von mises stress was recorded within Translation movement for both vital and non-vital tooth within the highest value was recorded for vital teeth model (24.36 MPa). In general, in all orthodontic tooth movement for the four anterior teeth in both proposed condition the tension stress that have been recorded are higher than the compressive stress. **Conclusion:** Nativity and language preference interact to limit access to dental care. Spanish-When optimal force was maintained during orthodontic tooth movement, finite element study show that; for vital teeth only the Translation orthodontic tooth movement resulted in PDL compression stress higher than MTS suggesting ischemic and resorptive risks occurrence. While for non-vital teeth this risk appeared in both Rotation and Translation orthodontic tooth movement.

Open Access

Citation: Hasan LA et al. (2026) Optimizing Orthodontic Force for an Endodontically Treated Maxillary Central Incisor. Dentistry 3000. 1:a001
doi:10.5195/d3000.2026.1160
Received: January 31, 2026
Accepted: February 5, 2026
Published: March 17, 2026
Copyright: ©2026 Hasan LA et al. This is an open access article licensed under a Creative Commons Attribution Work 4.0 United States License.
Email: lamiaaabdulrhman@uomosul.edu.iq

Introduction

Orthodontics treatment moves the tooth within dentoalveolar complex to achieve optimum esthetics. Orthodontic movement in adults may involve endodontically treated teeth. Although orthodontist can move tooth within root canal treatment (RCT) in similar biomechanics as untreated teeth; the association between orthodontics and the endodontically conserved teeth during the treatment planning

phase remains controversial to this day [1,2]. Pathological evidence of the tooth apical root and periodontium association within non-vital teeth may be the main conflict point between the researchers [3]. Other biological risk reaction of endodontically treated teeth movement may involve tooth ankylosis and fractures due to extensive preparation and customized post. Some authors found that teeth endodontically treated are more vulnerable to root resorption,

while other state that there is no significant difference [4,5].

Wickwire et al. [6] and Spurrier et al. [7] found that external apical root resorption (EARR) was more prevalent in the teeth treated within pulp therapy. However, pure clinical level may not reflect these pathological differences; other researcher found that there is no significant difference in the rate of the EARR after orthodontic tooth movement between vital and

endodontically treated teeth [3]. More ever, Bender et al. [8] found that EARR was more prevalent in sound teeth when compared with those endodontically treated.

In general, orthodontic induce EARR is usually associated with the periodontal ligament inflammatory process that shorten the clinical root length. The amount of the external root resorption can be varied according to the, age and gender, root structure, root morphology, bone composition, type of orthodontic tooth movement, presence of history of trauma, habits, root development stage, the type of orthodontic appliances used, and the amount and duration of the orthodontic treatment forces. Other systemic factors may include nutrition, hypothyroidism, hypophosphatemia, and genetics can be also exaggerated external apical root resorption [4,9]. However, the magnitude of resorption can be decrease by comprehensive clinical diagnosis, orthodontic mechanotherapy within light continuous force, and periapical radiographical follow up [4].

The modulus of elasticity for an endodontically treated tooth is typically lower than that of a vital tooth due to the loss of the tooth's original structure and the changes in its mechanical properties after endodontic treatment. Loss of tooth structural integrity during caries removal, access opening and canal preparation make endodontically treated teeth more fragile [10].

However, orthodontic treatment effects on the prognosis of endodontically treated teeth have not been widely assessed [2]. This article aims to plot and describe the effects of different orthodontic movement for endodontically treated maxillary incisor, illustrated with a finite element model and compare them with vital tooth. Error! Reference source not found.

Material and Methods

Mosul University approved this research by the Ethical Committee within reference no. UoM.Dent.25/1039. This study was conducted at Mosul university/college of Dentistry from March to July/2025. This paper analyzes the response of teeth and their related periodontium (PDL) in term of the von mises, displacement, compressive and tension stress distribution during application of different orthodontic movement for vital and endodontically treated teeth. An axisymmetric three-dimensional virtual model for the four maxillary teeth and its related structure PDL, surrounding cortical and cancellous bone will be constructed using Auto CAD (2010) based on CBCT data base for more anatomic accuracy. The bone architecture will be simulated as thin shell of cortical bone within a 2 mm

thickness; trabecular bone occupies the underlying space. The PDL was constructed with a uniform thickness of 0.5 mm for healthy intact PDL [11]. The FEA was performed in Auto Desk Inventor Professional 2022 software. Using the material assigning representation the material properties assigned according to the previous study as labeled in Table 1 [12]. The moduli of elasticity were 17.8 ± 2.9 GPa and 18.9 ± 2.9 GPa for root canal-treated teeth and controls teeth, respectively [10]. The materials supposed to be elastic, isotropic, linear, and homogeneous [12]. The models will be meshed with fine grain element 0.1 mm, dense mesh of high order. Completed models consist of 240098 elements, 337942 nodes as shown in the Figure 1. Vital movements in all directions will be suppressed at nodes situated on the base of the basal bone. The force applied on the right central incisor. Five types of orthodontic tooth movements were simulated on each right central incisor: Intrusion (0.2 N), Extrusion, Rotation and, Tipping (0.6 N), and Translation (1.2 N) [12]. We performed ten models, five of them within proposed vital tooth property while the remaining five had the property for endodontically treated tooth. The statistical analysis was carried out using a personal computer (Lenovo, Hong Kong). The resulting von mises, compressive, tensile stresses, and deformation were calculated and plotted for both vital teeth and non-vital teeth within their related PDL. Figure 2 summarizes our protocol.

Results

The results were recorded as Von mises stress, Compression principal stress, Tension principal stress and, Displacement for the four vital and non-vital anterior teeth and their related periodontal ligament during different orthodontic force (Extrusion, Intrusion Tipping, Rotation and, Translation) as appear in Tables 2 and 3, and in Figures 3 and 4.

The results show that the highest von mises stress was recorded within Translation movement for both vital and non-vital tooth within the highest value was recorded for vital teeth model (24.36 MPa). Within PDL similarly the highest stress value was recorded within Translation movement for both vital and non-vital tooth within the highest value was recorded for vital teeth model (0.01639 MPa). While the lowest von mises stress was observed within Intrusion movement for both vital and non-vital anterior teeth model and their related periodontal ligament structure as shown in Tables 1 and 2. In general, in all orthodontic tooth movement for the four anterior teeth in both proposed condition the

tension stress that have been recorded are higher than the compressive stress. Within healthy intact PDL the compression stresses and tension stresses were nearly similar for both vital and non-vital tooth condition within different orthodontic tooth movement. The von mises stress for non-vital teeth were lower than those for vital tooth throughout all performed orthodontic movement, the displacement for the non-vital teeth were slightly more than those for vital tooth. For the four anterior teeth when non-vital property where assumed this result in reduction compression and the tension stresses, while for the PDL both compression and the tension stresses appeared to increase as the teeth assumed to be non-vital.

Discussion

There is increased request for orthodontic treatment by young people to improve facial esthetics. Orthodontic involvement of endodontically preserved teeth in adults is become more common. Although endodontically preserved teeth can be orthodontically replace like untreated teeth many doubts endure about the relationship between orthodontics involvement and root canal treatment (RCT). Most recent papers have focused on incidence of root resorption of RCT teeth during orthodontic treatment as the main side effect [2]. This study simulates orthodontic tooth movement for endodontically treated and vital teeth in attempt to explain this relationship utilizing the finite element method as non-invasive reproducible method.

Endodontically treated tooth, are more fragile than a vital tooth; this resultant from tooth structural removal throughout the access cavity preparation, canal instrumentation more over tooth strength reduce due to routine use of specific chemicals for disinfection and sterilization. All other dentin physical properties microhardness, modulus of elasticity and fracture resistance appear to be altered due to reduction in moisture conditioning and loss of the circulatory blood source.

For the past eras, up until 1990, endodontically non-vital tooth practically not involved orthodontically. This apprehensive approach due to ambiguous thought that those teeth are at a greater risk of root resorption during orthodontic force application [13]. Since the 90s, as Spurrier et al. [7] published that tooth within precious endodontically management, during orthodontic force application, the risk of inflammatory root resorption neither increased, nor reduced. External inflammatory apical root resorption (EARR) is one of the most undesirable side effects that may occur throughout the

orthodontic treatment, in 1914 Ottolengui [14] for the first time reported EARR association within orthodontic treatment. Inflammatory root resorption may occur in 90% percent in orthodontically treated cases, the maxillary incisors are the most commonly affected tooth. EARR associated with orthodontic forces is typically root surface resorption and even cause an imbalanced ratio of crown and root in the affected teeth [15]. The associated risk factors for EARR can be either those patient-associated factors or treatment-associated ones. The extent of the orthodontic treatment, applied force magnitude, tooth movement direction, apical displacement, and force application technique all are treatment-associated factor [16]. The higher occurrence of root resorption in females than males was recorded by Levander et al. [17] and Kjaer [18]. The long treatment extent and extraction cases are the highly linked factors. moreover, class II elastics could increase the risk for incisors root resorption [15]. Inflammatory response to the applied orthodontic force is the main concept for orthodontic tooth move causing bone remodeling process and root surface resorption [19]. Orthodontic forces should be as light as possible, since heavy orthodontic force will totally occlude the blood supply and hyalinization will occur and no further tooth movement occur [20]. Root resorption occurs through hyalinized tissue undermined removal [21].

For the accuracy of FEA analysis failure criteria of analyzed material should be carefully selected. since most of the tooth tissues (enamel, dentin, and cementum) are brittle material within a certain amount of plastic deformation before failure ("ductile-like" behavior) so Von Mises stress and Tresca shear stress are more fit for this material [22]. While for PDL, which is a connective tissue within vascular supply, both Von Mises stress and principal stress can be used, principal stress give more accurately qualitative results (compressive stress distribution) [12].

For PDL the maximum tolerable stress (MTS) which represents the compressive stress limit that the PDL can withstand before structural damage occurs are (15-26 Kpa). The optimal compressive stress for PDL is 26 kPa. If stress exceeds this value, it may lead to PDL fiber damage, bone resorption, or compromised function [12].

In general, this research paper results were showed that; within PDL the compression stress in non-vital tooth model were slightly higher than those related to the vial model which increase the risk for associated root resorption this may be due to the removal of neurovascular pulpal system that lead to loss of

neurotransmitters release which in turn results in a decrease in calcitonin gene-related peptide (CGRP-IR) neuropeptides which can affect a role cellular metabolism and external root resorption [8,9].

This study results were show that, within PDL the compression and tensile stress were nearly like within little deformation this may be due to its viscoelastic property, high regenerative capacity, high vascularity and interstitial fluid content which contribute to the equalization of mechanical stress through fluid movement [11].

This study result was plotted in megapascal (MPa) which equivalent 1000 kilopascal (Kpa), we can see for vital teeth only the Translation orthodontic tooth movement resulted in PDL compression stress higher than MTS suggesting ischemic and resorptive risks occurrence. While for non-vital teeth this risk appeared in both Rotation and Translation orthodontic tooth movement. For both vital and non-vital model all remaining orthodontic tooth movement tooth induce no risk for inflammatory resorption snice their compressive stress was lay below the optimal PDL maximum tolerable stress (MTS).

For the four anterior teeth during application of different orthodontic tooth movement, this study was showed that, tensile stress values were higher than compression for both vital and non-vital model within application of different orthodontic tooth movement (Extrusion, Intrusion Tipping, rotation and, translation); since the enamel and dentin are both anisotropic (direction-dependent) and act like brittle materials. Brittle materials (such as ceramics, glass, and enamel) are much stronger in compression than in tension. So, the teeth will resist compression better and the stress appear to be concentrated more in tension zones, making tension stress greater than compression stress and this can lead to microcracks and fractures. Previous Studies showed that, the maximum compressive stresses of the enamel, and dentin, specimens were 62.2 ± 23.8 , and 193.7 ± 30.6 , MPa, respectively [23]. Ultimate tensile strength of dentine was 104 MPa²⁴ while for enamel 46.9 ± 13.7 MPa.²⁵ The all-recorded values in this study were below these optimal values that the tooth can withstand before failure occur. Translation movement produced the highest von Mises stress in both vital and endodontically treated teeth, with vital teeth showing the greatest stress magnitude. Clinically, this suggests that bodily tooth movement may carry a higher risk of PDL ischemia and external root resorption, mainly when applied to endodontically treated teeth. Additionally, even when optimal orthodontic

forces were used; non-vital teeth demonstrated increased susceptibility to potentially harmful PDL compression stresses during both rotation and translation movements.

This study has several limitations inherent to finite element study. Individual anatomical variations, such as differences in root morphology, bone density, and periodontal ligament thickness, were not considered. Moreover, the constructed models assumed to be homogeneous, isotropic, and linearly elastic material properties for dental and periodontal tissues, which may not fully represent their complex biological behavior. Additionally, the simulations evaluated initial stress distribution under static loading conditions and did not account for time-dependent biological responses, force decay, or bone remodeling during orthodontic treatment. Therefore, the results should be interpreted as indicative of relative stress patterns rather than direct predictors of clinical outcomes.

Conclusion

When optimal force was maintained during orthodontic tooth movement, finite element study was showed that; for vital teeth only the Translation orthodontic tooth movement resulted in PDL compression stress higher than MTS suggesting ischemic and resorptive risks occurrence. While for non-vital teeth this risk appeared in both Rotation and Translation orthodontic tooth movement. For both vital and non-vital model all remaining orthodontic tooth movement tooth induce no risk for inflammatory resorption snice their compressive stress was lay below the optimal PDL maximum tolerable stress (MTS). These findings emphasize the importance of careful force selection and biomechanical planning when orthodontic treatment involves endodontically treated teeth. Clinicians should consider using lighter forces, staged or controlled mechanics, and closer radiographic and clinical monitoring—especially during rotation and translation movements—to minimize the risk of adverse periodontal and root responses. Overall, this study supports the need for individualized orthodontic mechanotherapy protocols for endodontically treated teeth to enhance treatment safety and improve long-term prognosis.

Acknowledgement

Authors wish to acknowledge College of Dentistry and College of Engineering, University of Mosul, for the given support.

References

1. Agrawal GN, Marathe S, Rana S, Kaur R, Gandhi P, Jain R. Effect of orthodontic treatment on endodontically treated tooth: a clinical study. **Ann Rom Soc Cell Biol.** 2021;25(6):12671-12674.
2. Chen X, Liu SQ, Wang XX, Liu W, Zhou X, Wang X. Effect of orthodontic treatment on the outcomes of endodontically treated teeth: a cone-beam computed tomography analysis. **J Endod.** 2024;50(8):1091-1099.
3. Pustułka K, Trzcionka A, Dziedzic A, Skaba D, Tanasiewicz M. Radiological assessment of root features and periodontal structures in endodontically treated teeth subjected to forces generated by fixed orthodontic appliances: a prospective clinical cohort study. **J Clin Med.** 2021; 10:2078.
4. Tanaka OM, Leão Filho JCB, Vitral RWF, Bósio JA. Orthodontic treatment in endodontically treated maxillary incisors. **Eur J Gen Dent.** 2013;2(1).
5. Mohankumar K, Parameshwaran TM, Asokan U. An evidence-based review of literature: effect of orthodontic treatment on endodontically treated teeth. **J Adv Med Dent Sci Res.** 2020;8(8):156-162.
6. Wickwire NA, McNeill MH, Norton LA. The effect of tooth movement upon endodontically treated teeth. **Angle Orthod.** 1974; 44:235-242.
7. Spurrier SW, Hall SH, Joondeph DR, Shapiro PA, Riedel RA. A comparison of apical root resorption during orthodontic treatment in endodontically treated and vital teeth. **Am J Orthod Dentofacial Orthop.** 1990;97(2):130-134.
8. Bender IB, Byers MR, Mori K. Periapical replacement resorption of permanent, vital, endodontically treated incisors after orthodontic movement: report of two cases. **J Endod.** 1997;23.
9. AlMogbel AA, Alasmary S, Alfarraj S, Alenazi R, Albuti R, Alenazi RS. Orthodontics and endodontics clinical practice correlation: a narrative review. **Cureus.** 2024;16(3):e.
10. Cheron RA, Marshall SJ, Goodis HE, Peters OA. Nanomechanical properties of endodontically treated teeth. **J Endod.** 2011;37(11):1450-1454.
11. Proffit WR, Fields HW, Sarver DM. **Contemporary orthodontics.** 6th ed. St. Louis (MO): Elsevier/Mosby; 2019.
12. Moga RA, Buru SM, Chiorean CG, Cosgarea R. Compressive stress in periodontal ligament under orthodontic movements during periodontal breakdown. **Am J Orthod Dentofacial Orthop.** 2021;159(3):–.
13. Consolaro A, Consolaro RB. Orthodontic movement of endodontically treated teeth. **Dent Press J Orthod.** 2013;18(4):2-7.
14. Ottolengui R. The physiological and pathological resorption of tooth roots. **Items Interest.** 1914; 36:332-362.
15. Su R, Li S, Zhang C, Hou J. Effective endodontically treated incisors with external root resorption during orthodontic movement: a case report. **Clin Case Rep.** 2023;11(3).
16. Bakkari A, Bin Salamah F. Updated guidelines for the orthodontic management of traumatized and endodontically treated teeth: a review study. **Cureus.** 2022;14(9): e28943.
17. Levander E, Malmgren O, Stenback K. Apical root resorption during orthodontic treatment of patients with multiple aplasia: a study of maxillary incisors. **Eur J Orthod.** 1998;20(4):427-434.
18. Kjaer I. Morphological characteristics of dentitions developing excessive root resorption during orthodontic treatment. **Eur J Orthod.** 1995;17(1):25-34.
19. Reddy H, Singh N, Vaghela J, Sharma S. Effect of orthodontic treatment on endodontically treated tooth: a clinical study. **J Pharm Negat Results.** 2023;1338-1341.
20. Consolaro A, Miranda DAO, Consolaro RB. Orthodontics and endodontics: clinical decision-making. **Dent Press J Orthod.** 2020;25(3):20-29.
21. Yassir YA, McIntyre GT, Bearn DR. Orthodontic treatment and root resorption: an overview of systematic reviews. **Eur J Orthod.** 2021;43(4):442-456.
22. Moga RA, Olteanu CD, Delean AG. Investigating the ability of the tooth and surrounding support tissues to absorb and dissipate orthodontic loads during periodontal breakdown: finite elements analysis. **Appl Sci.** 2024; 14:1041.
23. Chun KJ, Choi HH, Lee JY. Comparison of mechanical property and role between enamel and dentin in human teeth. **J Dent Biomech.** 2014; 5:1758736014520809.
24. Sano H, Ciucchi B, Matthews WG, Pashley DH. Tensile properties of mineralized and demineralized human and bovine dentin. **J Dent Res.** 1994;73(6):1205-1211.
25. Zaytsev D, Panfilov P. Strength properties of the human dentinoenamel junction. **Mater Lett.** 2016; 178:107-110.

Table 1. Elastic properties of materials.

Material	Young's modulus, E (GPa)	Poisson ratio (ν)
PDL	0.0667	0.49
Cortical bone	14.5	0.323
Trabecular bone	1.37	0.3

GPa, Gega pascal.

Table 2. Von mises stress, Compression stress, Tension stress and, Deformation for the four *vital* anterior teeth and their related periodontal ligament during different orthodontic force (Extrusion, Intrusion Tipping, rotation and, translation.

Orthodontic movement	Von mises stress (MPa)		Compression stress (MPa)		Tension stress (MPa)		Deformation (Mm)	
	Teeth	PDL	Teeth	PDL	Teeth	PDL	Teeth	PDL
Extrusion 0.6 N	5.028	0.001803	0.859	0.00433	6.19	0.00474	0.01621	0.00973
Intrusion 0.2 N	1.676	6 ^{*-4}	0.388	0.00129	1.542	0.00195	0.005403	0.00324
Tipping 0.6 N	9.1	0.004324	2.11	0.01423	11.59	0.01624	0.04944	0.02349
Rotation 0.6 N	15.9	0.008753	3.86	0.02287	19.3	0.02941	0.08611	0.0412
Translation 1.2 N	24.36	0.01639	14.33	0.033	39.8	0.063	0.1457	0.078

N, newton. MPa, Megapascal. Mm, millimeter.

Table 3. Von mises stress, Compression principal stress, Tension principal stress and, Deformation for the four *non- vital* anterior teeth and their related periodontal ligament during different orthodontic force (Extrusion, Intrusion Tipping, rotation and, translation.

Orthodontic movement	Von mises stress (MPa)		Compression stress (MPa)		Tension stress (MPa)		Deformation (Mm)	
	Teeth	PDL	Teeth	PDL	Teeth	PDL	Teeth	PDL
Extrusion 0.6 N	4.86	0.001843	0.776	0.00486	6.013	0.00491	0.01703	0.009681
Intrusion 0.2 N	1.62	6.142 ^{*-4}	0.398	0.001318	1.455	0.002155	0.005678	0.003227
Tipping 0.6 N	7.976	0.004461	1.94	0.01448	10.32	0.01644	0.0500	0.02361
Rotation 0.6 N	14.44	0.00765	3.32	0.02856	19.29	0.03228	0.09954	0.04702
Translation 1.2 N	22.3	0.016	9.3	0.04045	29.85	0.07136	0.1666	0.08603

N, newton. MPa, Megapascal. Mm, millimeter.

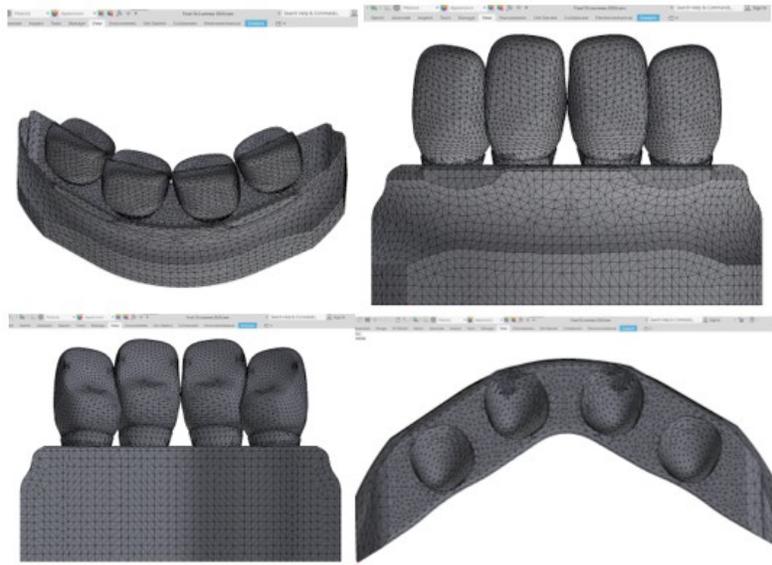


Figure 1. Different view of the 3D model of four maxillary anterior teeth and their related structure, created by Auto CAD (2010) based on CBCT data.

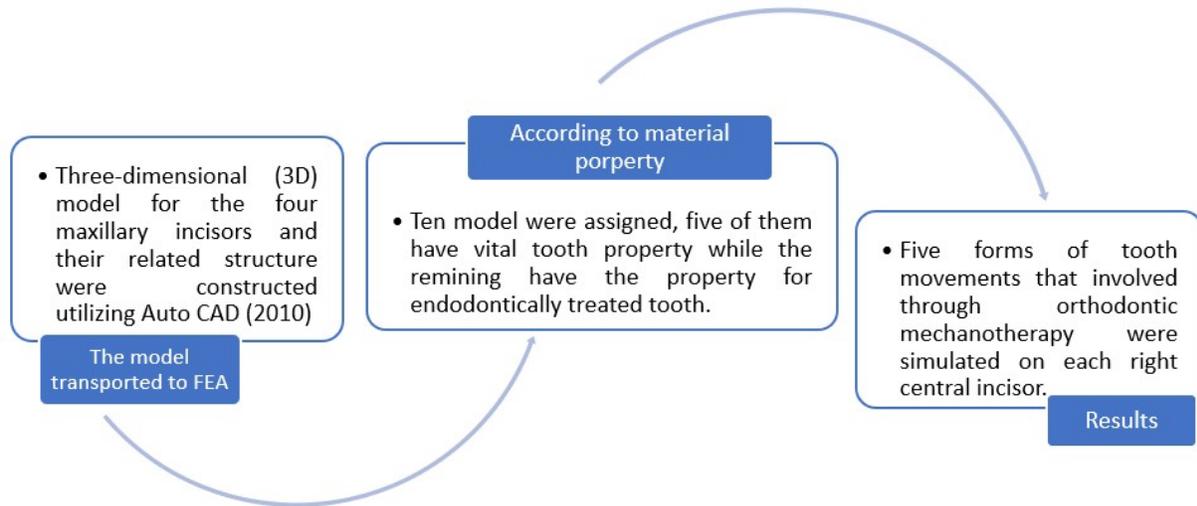


Figure 2. Flow diagram for finite element study protocol, that plot orthodontic force stresses distribution for vital and endodontically treated maxillary central incisor.

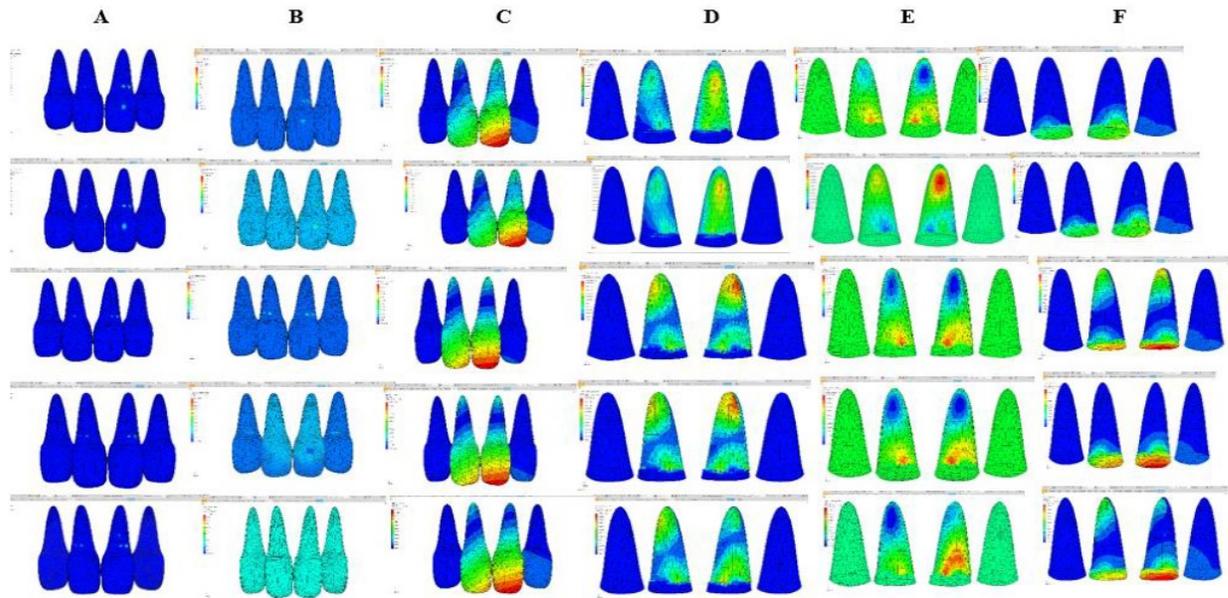


Figure 3. First column (A) represents Von mises stress for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. Second column (B) represents principal stress for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. Third column (C) represents Deformation for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. The fourth column (D) represents Von mises stress for the periodontal ligament for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. The fifth column (E) represents principal stress for the periodontal ligament for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively up to down. The sixth column (F) represents Deformation for the periodontal ligament for the four vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down.

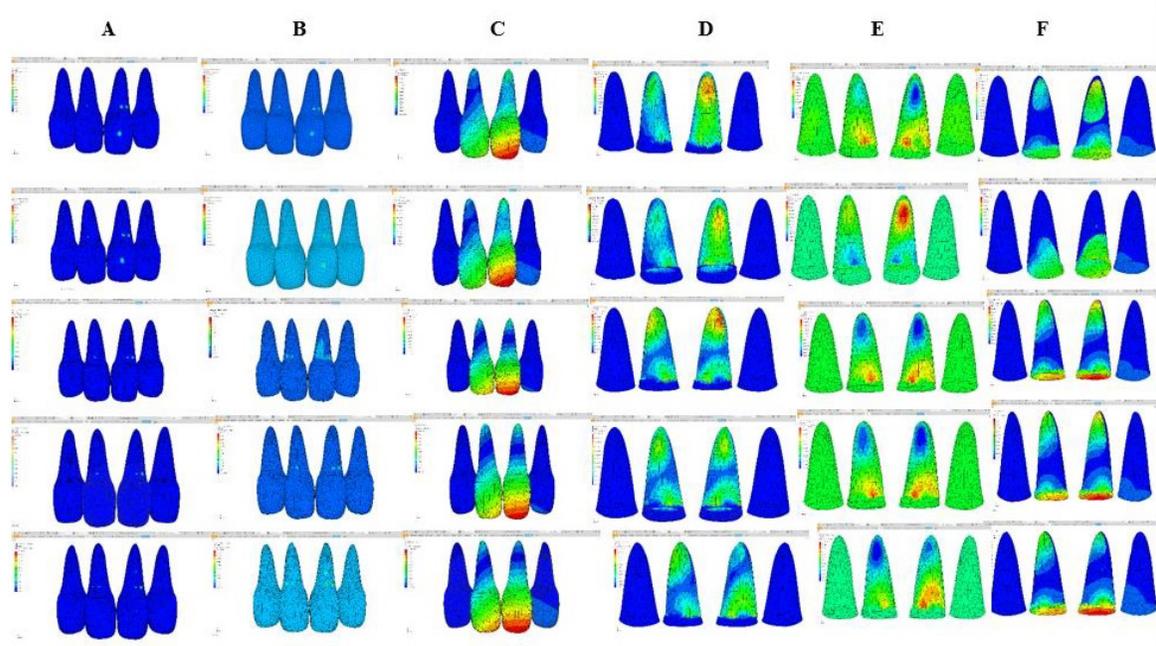


Figure 4. First column (A) represents Von mises stress for the four non-vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. Second column (B) represents principal stress for the four non-vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. Third column (C) represents Deformation for the four non vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. The fourth column (D) represents Von mises stress for the periodontal ligament for the four non- vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down. The fifth column (E) represents principal stress for the periodontal ligament for the four non vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively up to down. The sixth column (F) represents Deformation for the periodontal ligament for the four non vital anterior teeth during different orthodontic tooth movement that are Extrusion, Intrusion, Tipping, Rotation and, Translation respectively from up to down.