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Comparative Stress Evaluation Of Poly Ether Ether Ketone (Peek), Composite And Fibre Posts In Primary Teeth - 3d Finite Element Analysis

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ABSTRACT

Aim and Background: Posts has evolved from Metallic to Fibre posts in Pediatric dentistry. Poly Ether Ether Ketone (PEEK), the newest dental inventory. Therefore, to compare the efficacy of PEEK with Composite and Glass Fibre post as material for post and core in Primary Maxillary Central and Lateral Incisor: A Finite Element Analysis (FEA) was performed.

Methodology: Upon Ethical clearance from the Institutional Ethical Committee (2021/223), FEA was done on Six 3D models with three post materials i.e., PEEK, Composite and Glass Fiber in Maxillary Central and Lateral Incisors. Force of 180 N was applied at angulations 0°, 45°and 90°. Stress Concentration was analyzed using "ANSYS version 18.1" in the form of Von Misses stress values. ANNOVA test for statistical analysis was performed.

Results: Results were non-significant regarding overall stress and stress on luting cement on all models. Stress values on dentin for all the types of Post materials were in a similar range, however, values seen on Central Incisors were higher than those of Lateral Incisors which was statistically significant in Model 2 and Model 4. (P value- 0.047)

Conclusion: There is a non-significant correlation between the types of post used and the overall force dissipated on the tooth model and on luting cement.There are greater chances of fracture in Lateral Incisors when compared to Central Incisors which was statistically significant in our study.

Clinical Relevance: This study has created a base for the Novel use of the existing material PEEK in pediatric dentistry for Posttechniques.

Keywords: *Poly Ether Ether Ketone, Finite Element Analysis, Post and Core Technique, Pediatric dentistry*

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1. INTRODUCTION

Pediatric dentists face a hurdle when it comes to restoring primary maxillary incisors that have been extensively damaged by Early Childhood Caries (ECC) and trauma because of the age and conduct of children. When it comes to a maxillary anterior incisor replacement, it should have the following qualities: it should be durable, have a material color that matches, have adhesive cementation that is biocompatible with pulp, be easy to put quickly, and only take one treatment appointment. [1]Intracanal retention is required in primary incisors treated with endodontic therapy for the composite crown to last. [2]

For the repair of teeth that have undergone significant restorations in the past or have experienced caries, endodontic therapy, fractured teeth, or other dental issues, dental post-core systems are frequently used. [3]In pediatric dentistry, a variety of post types are available for usage, including prefabricated posts, orthodontic wires in the forms of "α," "γ," [4], and "Ω," [5] cast posts with a macro retentive element [6], reverse metallic posts [7], composite resin posts, [8] fiber posts [5], and biologic posts [9].

Composite and Glass fibre posts are in use since 1990's but possess certain disadvantages like retention issues due to polymerization contraction and shrinkage in case of composite posts [10]and technique-sensitive, high cost and time-consuming procedure for glass fibre posts. [11]

Poly Ether Ether Ketone (PEEK) is the latest inventory in dentistry and is proposed to have better properties in comparison with existing materials. Its applications are widely researched in various surgical fields like: spine, orthopedic, maxillo-facial surgeries, prosthesis etc, and dental applications, such as fixed prostheses, removable prostheses and their components, dental implants, individual abutments, maxillary obturator prostheses, & orthodontic wires. As an intraradicular post-core material, PEEK shows high fracture resistance compared with metal and fiberglass post-system in Permanent teeth. [12] The elastic modulus of PEEK is similar to that of dentin, which is a key advantage, that facilitates uniform distribution of forces on the restorations, thereby acting as a stress breaker. [13]

Various methods are practiced to measure the stress-bearing capacity of posts Due to advances in technology, FEA has gained more popularity as it gives Comprehensive result sets and safe simulation of potentially dangerous, destructive, or impractical load conditions and failure modes. Its quick computation times, inexpensive cost, and ability to calculate and visualize a large range of physical parameters simultaneously make it a desirable substitute. [14]

Both the material, PEEK, and the technique, FEA, are unique and the avenues are unexplored concerning the combination in Primary dentition. Therefore, to compare the efficacy of PEEK in comparison to Composite and Glass Fibre Post as post and core material in Primary Maxillary Central and Lateral Incisor FEA was done.

2. MATERIALS AND METHOD

An In- Vitro study was performed upon ethical clearance from the Institutional Ethical Committee. (2021/223)

6 models were made using Soft Edge Version 11 software, named:

Model 1: PEEK post in endodontically treated primary maxillary Central incisors.

Model 2: Composite post in endodontically treated primary maxillary Central incisors.

Model 3: Glass Fiber post in endodontically treated primary maxillary Central incisors.

Model 4: PEEK post in endodontically treated primary maxillary Lateral incisors.

Model 5: Composite post in endodontically treated primary maxillary Lateral incisors.

Model 6: Glass Fiber post in endodontically treated primary maxillary Lateral incisors.

Models were prepared with the ideal preparation style for post and core treatment taking the dimensions from existing literature. The final model included the spongy bone, Cortical bone, Periodontal Ligament (PDL) space, cementum, dentin, Zinc Oxide Eugenol (ZOE) obturating material, Glass Ionomer Cement (GIC) layer, luting cement, Composite for restoration, and respective Posts for the respective models. Each entity was given different colors for easy identification. These models is then transferred to the software "Hypermesh version 11" (Figure -1: different components of Model) for the process of meshing. This mesh was programmed to contain the material properties (Elastic Modulus, Poisson's Ratio), which define how the structure will react to certain loading conditions i.e., with the incorporation of material properties to stimulate the normal model.

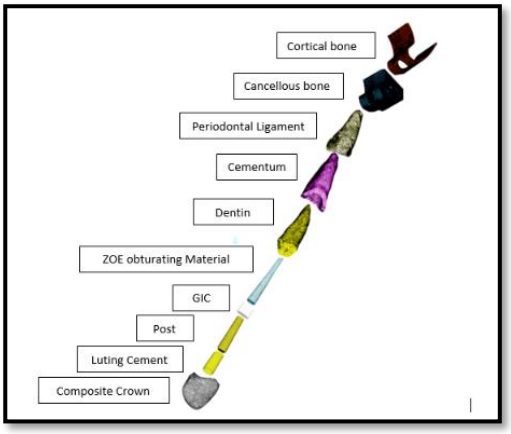

Figure -1: different components of Model

The material properties, Poisson's ratio, and Young's modulus of elasticity of the material were incorporated into the model. The mechanical properties used in the study are given in Table 1(Material properties)[15,16] and the force of 180N [17,18] was been applied on three different angulations i.e.,0°, 45°and 90° on all the 6 models at the lingual portion of the tooth to determine the maximum equivalent Von Mises stress values. [15] The analysis is done using the software "ANSYS version 18.1".

Table:1 – Mechanical properties of all components of the model

Materials	Young's Modulus (MPa)	Poisson's Ratio
Cortical bone	14700	0.30
Spongy bone	490	0.30
PDL	69	0.45
Cementum	18600	0.30
Dentin	19890	0.31
Zinc oxide eugenol	288	040
GIC	10800	0.30
Luting cement	5000	0.30
Composite (core and crown)	11570	0.24
PEEK Post	4200	0.3
Composite post	11570	0.24
Glass fibre post	45000	0.28

ANNOVA (Analysis of Variance) Statistical analysis was performed using R Core Team (2013) Version. A Post hoc analysis was performed whenever ANOVA was found to be showing statistically significant differences in terms of p Value.

3. RESULTS

In the present study, six different model groups were subjected to different forces at various angles and thus the generated stress values and patterns, particularly within the Posts, underlying luting cement, and Dentin were observed. The stresses were visualized in color coding ranging from dark blue (minimum stress) to red (maximum stress) in the models. All the stress values were presented in Megapascals (MPa).

In the inter-group comparison, at all the angles, the least amount of stress was generated at 45° angulation and least at 0°

angulation. Stresses were more in Central Incisors for all models when compared to Lateral incisors.Statistical analysis shows no significant difference between all the models. (P value = 0.337) (Table- 2: statistical comparison for overall stress on all models) (Figure- b: Von misses' representation of overall stress on models)

Table- 2: statistical comparison for overall stress on all models

	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Model 1	116.2335	32.38766	18.69903	90.75	152.68
Model 2	116.0749	31.61906	18.25527	90.72	151.50
Model 3	115.9112	30.43731	17.57299	90.51	149.65
Model 4	84.6725	15.31093	8.83977	67.01	94.21
Model 5	89.0712	19.99296	11.54294	67.01	106.00
Model 6	84.6147	15.26214	8.81160	67.01	94.19

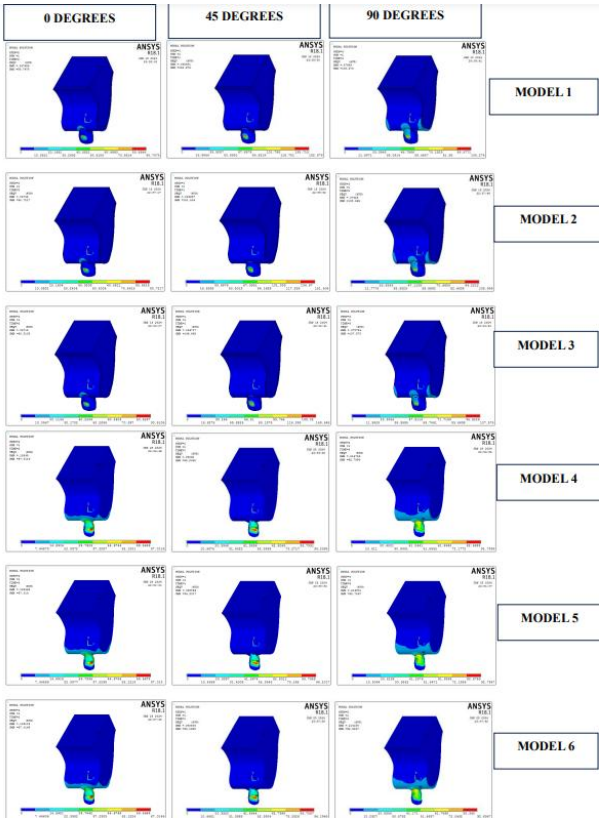

Figure- 2: Von misses' representation of overall stress on models

The study also evaluated the stress generated within the underlying dentin of all the six model groups at the same force and at three different angulations (0°,45°,90°) among which the least amount of force was generated in the Model 3 (17.3556 MPa) and Model 6 (30.680 MPa) (Glass Fibre post) in Central incisors and Lateral Incisors respectively. As the ANOVA test showed a statistically significant difference (P value = 0.042) for dentinal stress among the 6 Models, Post Hoc Analysis (Table-3) using the Bonferroni Test was performed which revealed a statistically significant difference between Model 2 and 4 which signifies there was a significant difference instress distributed in Central incisors and Lateral Incisors. However, there isn't any significant statistical difference between the models for the same teeth.

Table:3- Post Hoc test for dentinal stress

Model	Model	Mean Difference (I-J)	Std. Error	Significance	
Model 2	Model 1	-4.32177	10.45990	1.000	
	Model 3	0.47197	10.45990	1.000	
	Model 4	-24.14927	10.45990	0.019	
	Model 5	-24.03697	10.45990	0.605	
	Model 6	-23.77833	10.45990	0.633	
	Model 5	-24.50893	10.45990	0.558	
	Model 6	-24.25030	10.45990	0.583	
Model 4	Model 1	19.82750	10.45990	1.000	
	Model 2	24.14927	10.45990	0.019	
	Model 3	24.62123	10.45990	0.547	
	Model 5	0.11230	10.45990	1.000	
	Model 6	0.37093	10.45990	1.000	

Evaluation of the stress generated within the luting cement of all the six model groups was also analyzed at the same force, at three different angulations (0°,45°,90°). Among these the least amount of force was generated in Model 2 (4.3392 MPa) (Composite post) and Model 4 (5.78241 MPa) (PEEK post) in Central incisors and Lateral Incisors respectively. Statistically there isn't any statistically significant difference in the Luting cement Stress among the 6 Models. (P value = 0.061)

4. DISCUSSION

In the primary dentition, Maxillary incisors are the most commonly and more severely affected teeth due to S-ECC and Trauma, with a prevalence of 20-50.4% [19,20] The Pediatric dentists encounters challenges which includes the age group's behavioral constraints, tooth structure loss, and the bonding agent's weak adhesion to primary teeth, to name a few. Intracanal posts are a suitable adjunct to create a comprehensive and retentive restoration for teeth that have undergone endodontic treatment. [21]

An In- *Silico* studyperformed by K.S Lee et al, revealed that PEEK and Dentin have similar flexural strength (PEEK, 200 MPa; dentin, 212.9 MPa) but PEEK has the lower elastic modulus (PEEK, 5.1 MPa; dentin, 18.6 MPa). As a consequence, PEEK induces lower stress in the post-and-core components, mainly because of the flexibility of this material. [22] According to Najeeb S et al, PEEK has been claimed to absorb better occlusal stresses because of its low elasticity modulus, therefore stress-based problems in dental restorations could be avoided using PEEK[23] According to Ibrahim et al in 2020,It was reported that compared to post materials with a high elastic modulus, the stress distribution created by the PEEK prefabricated post in intraradicular dentin showed a decreased probability of vertical root fracture. [24] According to Tekin et al, it was stated that PEEK posts cause less stress on dentin compared to glass fiber posts [25]. These results were consistent with our research as PEEK post was equally effective as Composite and glass fibre post in dissipating force on the tooth model.

Boschia et al [26] reported that post materials with a high elastic modulus are not homogenous in dental tissue and transferred destructive tensions. Santos-Filho et al reported the importance of compatibility between the restorative materials used and the biomechanical behavior of dental tissues. [27] Dentinal tension decreased with increasing post-modulus of elasticity during masticatory stress. [28] Because of its ability to soak up and dampen pressures, glass fiber post material is incredibly sturdy. Adanir et al. [29], who studied permanent molars, observed similar results to these. According to Ozarslan et al PEEK posts have high fracture resistance and therefore could survive masticatory stress better than titanium and glass fiber posts. These results were similar to our evaluation where the forces generated on dentin by all three types of posts were similar making them equally efficient.

Furthermore, in the present study, the stress values on dentin for the Lateral Incisors were observed to be higher than that of Central Incisors regardless of type of post. (Table-3) The higher fracture strength of Central Incisors compared to Lateral Incisors may be attributed to larger teeth diameter with more enamel surface available for bond. Similar observations were made in an In vitro study done by Barghi et al in 2023. [30]

The effect of force at different angulations on luting cement was analyzed in all models in the current study. It was observed that all three posts were able to dissipate a lower amount of force on the underlying luting cement leading to decreased chances of failure. The scarcity of literature recording the force dissipation effect of different types of posts on luting cement in primary teeth permits little room for comparison demonstrating a valid gap in research literature.

A flexible complex structure comprising endodontically treated maxillary incisors, post-core restorations, crowns and

supporting structures was modeled using finite elements in this investigation. Every structure was regarded as perfectly bonded, homogenous, isotropic, and linearly elastic. Around the teeth, the gingival line was modeled at a fixed height. In an effort to mimic the most accurate representation of teeth, we have attempted to incorporate every meaningful possibility. However, it could not be universally applicable and seen from a therapeutic standpoint. It was possible in this investigation that the materials and the unique qualities of each material had an impact on the strains that developed after applying force. Therefore, it is suggested that further research be explored, including clinical investigations.

5. CONCLUSION

It can be stated, pending more research and long-term monitoring in a clinical setting, that PEEK posts function just as well as Composite and Glass Fiber posts in primary teeth, offering a unique approach to the more aesthetically pleasing rehabilitation of severely damaged primary incisors.

6. CLINICAL SIGNIFICANCE

In this manuscript we wish to highlight that the new material named PEEK in dentistry has equivalent good properties to the already existing materials and therefore can be used as an alternative for the rehabilitation for severely mutilated primary incisors as a post material.

In In-vitro PEEK post performed equivalent to composite and glass fiber post when compared in the stress analysis.

the effect of force on all three posts and their components were in similar range establishing that PEEK is equivalently effective in all aspects when compared to Composite and Glass Fiber posts in primary teeth and can be considered novel alternative for the rehabilitation of severely mutilated primary incisors in the field of pediatric dentistry.

7. LIST OF ABBREVIATIONS:

PEEK- Poly Ether Ether Ketone

FEA- Finite Element Analysis

ECC-Early Childhood Caries

ZOE- Zinc Oxide Eugenol

GIC- Glass Ionomer Cement

ANNOVA- Analysis of Variance

MPa- Megapascals

ETHICS DECLARATION:declare no conflict of interest.

DATA AVAILABILITY: The data supporting this article can be made available by the corresponding author upon request.

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REFERENCES

[1] Metha D, Gulati A, Basappa N, Raju OS. Esthetic rehabilitation of severely decayed primary incisors using glass fiber reinforced composite: a case report. J Dent Child (Chic) 2012;79.1:22-5.

[2] Seraj B, Ghadimi S, Estaki Z, Fatemi M. Fracture resistance of three different posts in restoration of severely damaged primary anterior teeth: An in vitro study.J. Dent. Res. 2015 ;12.4:372.

[3] Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent 2002;87.4:431-7

[4] Viera CL, Ribeiro CC. Polyethylene fi ber tape used as a post and core in decayed primary anterior teeth: A treatment option. J Clin Pediatr Dent 2001;26.1:1-4.

[5] Mortada A, King NM. A simplifi ed technique for the restoration of severely mutilated primary anterior teeth. J Clin Pediatr Dent 2004;28.3:187-92

[6] Wanderley MT, Ferreira SL, Rodrigues CR, Rodrigues Filho LE. Primary anterior tooth restoration using posts with macroretentive elements. Quintessence Int. 1999 Jun;30.6:432-6.

[7] Eshghi A, Esfahan RK, Khoroushi M. A simple method for reconstruction of severely damaged primary anterior teeth. Dent Res J 2011;8.4:221-5.

[8] Seraj B, Ghadimi S, Estaki Z, Fatemi M. Fracture resistance of three different posts in restoration of severely damaged primary anterior teeth: An in vitro study. J. Dent. Res. 2015;12.4:372.

[9] Romito AC, Wanderley MT, Oliveira MD, Imparato JC, Corrêa MS. Biologic restoration of primary anterior teeth. Quintessence Int. 2000;31.6:405-11.

[10] Judd PL, Kenny DJ, Johnston DH, Yacobi R. Composite resin short-post technique for primary anterior teeth. J Am Dent Assoc. 1990; 120.5:553–555.

[11] Suwarnkar SD, Prasad VN, Khan R, Sirikonda S. Posts in primary teeth-a literature review. J Interdiscip Dent Sci. 2017 Jul;6.2:3.

[12] Bathala L, Majeti V, Rachuri N, Singh N, Gedela S. The role of polyether ether ketone (PEEK) in dentistry–a review. J Med Life. 2019 Jan;12.1:5.

[13] Henriques B, Fabris D, Mesquita-Guimarães J, Sousa AC, Hammes N, Souza JC, Silva FS, Fredel MC. Influence of laser structuring of PEEK, PEEK-GF30 and PEEK-CF30 surfaces on the shear bond strength to a resin cement. J Mech Behav Biomed Mater 2018;84:225-34.

[14] Srirekha A, Bashetty K. Infinite to finite: an overview of finite element analysis. Indian j dent res 2010;21.3:425-32.

[15] J Updates Pediatric Dent. 2022; 1.2: 29-37: A finite element analysis

[16] ÖZARSLAN M, BÜYÜKKAPLAN U, ÖZARSLAN MM, TÜRKER N, ÇELİK HK. Finite Element Stress Analysis of PEEK, Glass Fiber and Zirconia Post-Core Systems in Maxillary Central Incisor. Van Sağlık Bilimleri Dergisi. 2021;14.2:180-90.

[17] Maximum occusal bite force for children in different dentition stages. Eur J Orthod. 2013;35.4:427-33 76

[18] Helkimo E, Carlsson GE, Helkimo M. Bite force and state of dentition. Acta Odontol Scand.1977;35.6:297-303.

[19] Al-Shalan TA, Erickson PR, Hardie NA. Primary incisor decay before age 4 as a risk factor for future dental caries. Pediatr. Dent.1997; 19:37-41.

[20] Manal AM, AlKattan H, ALBukhari L, El Meligy O. Assessment of dental decay in a group of children in jeddah, kingdom of saudi arabia. Int. J. Clin. Pediatr. Dent. 2019;12.5:423.

[21] Talebi M, Parisay I, Khorakian F, Nik E. A simplified method for the restoration of severely decayed primary incisors. J. Dent.(Tehran, Iran). 2015;12.3:177.

[22] Lee KS, Shin JH, Kim JE, Kim JH, Lee WC, Shin SW, Lee JY. Biomechanical evaluation of a tooth restored with high performance polymer PEKK post-core system: A 3D finite element analysis. Biomed Res. Int. 2017.

[23] Najeeb S, Khurshid Z, Matinlinna JP, Siddiqui F, Nassani MZ, Baroudi K. Nanomodified PEEK dental implants: Bioactive composites and surface modification - A review. Int J Dent 2015:381759.

[24] Ibrahim RO, AL-ZAHAWI AR, Sabri LA. Mechanical and thermal stress evaluation of PEEK prefabricated post with different head design in endodontically treated tooth: 3D-finite element analysis. Dent Mater J. 2021;4.2:508-18.

[25] Yildiz S, Tekin S, Kizilkaya AR, Akgün SE, Deger Y. Comparative Stress Analysis of Custom-Made PEEK Dental Post-Cores versus Conventional PostCores in Incisor Restorations: A Finite Element Study. Medical Science Monitor: Int. j. med. sci. clin. res. 2023;29:e940887-1.

[26] Boschia Pest L, Guidotti S, Pietrabissa R, Gagliani M. Stress distribution in a post-restored tooth using the three-dimensional finite element method. J Oral Rehabil 2006; 33:690-697.

[27] Santos-Filho PC, Veríssimo C, Soares PV, Saltarelo RC, Soares CJ, Marcondes Martins LR. Influence of ferrule, post system, and length on biomechanical behavior of endodontically treated anterior teeth. J Endod 2014; 40:119-123.

[28] Trivedi S. Finite element analysis: A boon to dentistry. J Oral Biol Craniofac Res. 2014;4.3:200-3.

[29] Adanir N, Belli S. Stress analysis of a maxillary central incisor restored with different posts. Eur J Dent. 2007;1.2:67-71.

[30] Barghi H, Sharifi S. Comparison of fracture resistance of primary incisor teeth restored with glass fiber post and reversed-oriented metal post–An in vitro study. Dent Res J. 2023;20:29.