Effect of Different Apical Plug Thickness of Calcium Silicate Cements on Fracture Resistance of Simulated Immature Teeth

Abstract:
Aim and Objectives: Treatment goal of traumatized immature teeth is to provide a restoration that reinforces the tooth structure to improve function and esthetics. The present study was conducted to compare and evaluate the effect of different apical plug thickness of calcium silicate cements on fracture resistance of simulated immature teeth.
Materials and Method: Eighty single rooted human teeth were sectioned and divided into eight groups (n=10). In Group I (positive control) no instrumentation was done. In the remaining seventy teeth endodontic access preparation was done and the root canals were instrumented with Peeso reamers. Group 2 (negative control), was filled with calcium hydroxide. In group 3, 4 5; MTA Plus was inserted into root canals to create 3-mm and 6-mm apical plugs and full obturation, respectively. Similarly in Group 6, 7, 8; Biodentine was inserted to create a 3-mm and 6-mm apical plug and full obturation, respectively. The remainder section of the canals in Group 3, 4 6, 7 were obturated with conventional gutta-percha and AH Plus sealer. The fracture testing of each specimen was performed using a Universal Testing Machine and force was recorded in newton (N). The values obtained was statistically analyzed One way Anova and Post Hoc Tukeys tests.
Results: The maximum fracture resistance was seen in Group 3, which showed significantly greater values than Group 1, 2, 5, 6, 7&8 (p<0.05). No significant differences were found between the Group 3 and 4 and between Group 6 and 7 (P > .05).
Conclusion: Up to 6mm thickness of apical plug can be created with MTA Plus and Biodentine without deteriorating the fracture resistance of tooth complex.

Key words: Fracture resistance, MTA Plus, Biodentine, Apical Plug

Introduction:

In our daily practice, we often face challenges with regard to pulp injuries within permanent immature teeth. The conventional endodontic procedure in such teeth represents a real challenge because the dental elements become susceptible to fracture.[1] The calcium hydroxide treatment to induce apical stop has been favorable, but the frail dentinal walls present additional concerns as such teeth are defenseless against fracture from normal masticatory forces and external trauma.[2,3] Unfavorable crown root ratio due to short immature root complicate further post endodontic restoration.4The major drawback reported with the traditional calcium hydroxide treatment is the weakening of the root structure which might due to proteolytic and hydrolytic reactions taking place in the organic matrix.[5,6] According to Rosenberg et al. prolonged dressing with Ca (OH)2(calcium hydroxide) increase the susceptibility of dentinal walls to fracture by lowering fracture resistance.[7] Therefore, suggested treatments should aim to provide a restoration that reinforces the fragile dentinal walls for improved function and aesthetics.[8] Alternatives to calcium hydroxide therapy can be MTA(Mineral Trioxide Aggregate) apexification and revascularization.[9] Clinical success of MTA apexification has been well reported in the literature.[10] It is recommended that MTA can be placed in 2-5mm in thickness as apical plugs.[11] However it has a few shortcomings such as prolonged time for setting, difficulty in handling and the probability of discoloration.[12] Newer materials such like

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MTA Plus (Prevest Denpro Limited, Jammu city, India) and Biodentine (Septodont, Saint-Maur-des-Fosses, France), have been reported to recover the forementioned shortcomings of MTA.[13] MTA Plus is a nanostructural MTA with improved mechanical characteristics.[14] Biodentine is a viable alternative to MTA because of its superior mechanical and handling characteristics.[15] Grech et al in a study found that Biodentine has highest compressive strength compared to other tested materials.[16] However, the adequate thickness of apical plug for single visit apexification is still questionable.

Hence the objective of conducting the study was to evaluate and compare the different thickness of apical plug using MTA Plus and Biodentine on fracture resistance of simulated immature teeth.

Subjects and Methods:

The study was approved by institutional ethics and review board.

Tooth Selection :

Eighty extracted human permanent teeth with single root were collected from the Department of Oral Surgery, as per the norms laid down by the institutional ethics committee. Multirooted, carious and fractured teeth were excluded. Each tooth were sectioned by the use of corborundum disk (Dentsply Maillefer, Tulsa,OK, USA) mounted on slow speed handpiece (NSK, Tokyo, Japan) to obtain a standardized length of 18±1mm.

Sample preparation for fracture testing:

Teeth were randomly divide into eight experimental groups (n=10) and prepared as follows:

Group 1(Positive control): Tooth specimens were prepared from Apical to coronal preparation with Peeso Reamers (No.1-6) (Mani Inc.Tochigi, Japan) without endodontic access cavity preparation to simulate intact immature teeth.

In the remaining 70 teeth endodontic coronal access cavity was prepared using a round bur (Dentsply Maillefer, Tulsa, OK, USA). The root canals were instrumented to ISO No. 80 K file (Dentsply, Maillefer, Tulsa,OK, USA). The canals were prepared with Peeso reamers (No.1-5) (Mani Inc.Tochigi, Japan) to mimic immature teeth followed by irrigation with 5 ml, 3.0% sodium hypochlorite (Comdent, Mumbai, India) .Five milliliter of 0.9% normal saline (Fresenius Kabi, Pune, India) was used as a final rinse. In ten teeth, the canals were filled with Ca (OH)2 (UltraCal XS; Ultradent,South Jordan, UT) and served as Negative Control - Group 2. The endodontic access was restored with a temporary filling material (Orafil G, Prevest Denpro), the prepared specimens were then stored at 37 0C at 100% humidity for 4 weeks.

MTA Plus (Prevest Denpro Limited, Jammu, India, for Avalon Biomed) powder was mixed with the gel provided in a ratio of 3:1 and was inserted with carriers into the root canals from the endodontic access and condensed with pluggers to create 3mm apical plug and 6 mm apical plug in teeth samples in Group 3and Group 4 respectively and full obturation in in Group 5 samples.

All specimens were wrapped in wet guage, placed in incubator and allowed to set for 1 hour at 370C with 100% humidity.

Biodentine (Septodont, Saint-Maur-des-Fosses, France) was mixed according to manufacturer's instruction and was placed with a carrier in the apical portion of the canal and similar groups were created. Group 6(3mm thick apical plug), Group 7(6mm thick apical plug) and completely obturated root canal in Group 8. The uniformity of apical plugs created was confirmed radiographicaly. (Figure 1) The canals in groups 3, 4, 6 and 7 were obturated with gutta-percha and AH Plus (Dentsply DeTrey, Konstanz, Germany) sealer. The endodontic access were restored with resin composite restoration. (Esthet X HD, Dentsply).

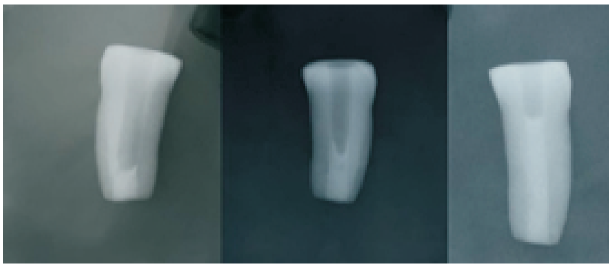

Fig 1: Showing different Apical Plug thickness as 3mm, 6mm and Full obturation.

Samples were stored in 100% humidity at 370C for 4 weeks and then embedded in acrylic for fracture testing. The fracture resistance was tested by mounting the samples in a universal testing machine with a crosshead speed of 1mm/min until fracture. The maximum force required to fracture each sample was recorded in newton (N). The values obtained were subjected to statistical analysis.

Statistical Analysis:

The data collected was distributed normally and subjected to SPSS-20 for statistical analysis. Mean and standard deviations were calculated for each experimental groups by using parametric tests i.e. One way anova for comparing more than two independent groups and Post Hoc Tukeys for pairwise comparison of subgroups. Level of statistical significance was set at p-value less than 0.05.

Results:

The fracture resistance of experimental groups are shown in [Table 1]. The results suggest that the maximum fracture resistance was seen in Group 3(3mm MTA Plus) which showed significantly greater values than Group 1(Positive control), Group 2(Negative control), Group 5(full obturation with MTA Plus), Group 6 (3mm Biodentine apical plug), Group 7(6mm biodentine apical plug), Group 8(full obturation with biodentine). ($p<0.05$). No significant differences were found between the Group 3 and group 4 and between Group 6 and Group 7 ($P > .05$). The fracture resistance of MTA Plus and Biodentine apical plug samples was compared using Independent t test and results were found to be significant at 3mm and 6mm MTA Plus Apical plug samples showed greater fracture resistance than Biodentine apical plug. [Table 2]

GROUPS		MEAN	SD	F value	P value
Group i	Positive control	616.30	62.52	73.962	0.001*,S
Group ii	Negative control	383.40	49.13		
Group iii	MTA Plus-3 mm	837.70	56.29		
Group iv	MTA Plus-6mm	829.90	42.42		
Group v	Full obturation	562.40	66.88		
Group vi	Biodentine-3 mm	753.40	60.98		
Group vii	Biodentine-6mm	747.60	50.48		
Group viii	Full obturation	530.80	77.49		

a One Way Anova test , * Significance of relationship at $p < 0.05$, SD- Standard deviation

Table 1: Comparison of different thickness of apical plug using MTA Plus and Biodentine on fracture resistance of simulated immature teeth

GROUPS	MEAN	SD	MEAN	SD	T value	P value
	MTA Plus		Biodentine			
3 mm	837.70	56.29	753.40	60.98	3.212	0.005*
6 mm	829.90	42.42	747.60	50.48	3.942	0.001*
Full obturation	562.40	66.88	530.80	77.49	0.976	0.342

Table 2: Comparison of different thickness of apical plug using MTA Plus and Biodentine and on fracture resistance of simulated immature teeth.

Discussion:

For strengthening necrosed immature teeth, different materials and techniques have been examined over the years.[17] Essentials for selection of such a material is that it should strengthen the remaining tooth structure , act against stresses, adhere consistently to root dentin, ease of application and removed when necessary and serve as a good apical stop.[18] In the present study reinforcing effect of MTA Plus and Biodentine by using different thickness of apical plug in the root canals of simulated immature teeth was studied. The results indicate that the samples in which 3mm and 6 mm of MTA Plus apical plug has been created along with backfilling done with Gutta Percha showed greater fracture resistance without any significant difference compared to samples in which complete reinforcement was done. This could be due to structural alteration of proteins in the dentinal walls caused by the alkaline nature of MTA that may result in weakening of dentinal structure in short-term .However the Biodentine reinforcement groups showed lesser resistance to fracture compared to the MTA Plus reinforcement samples with significance. The possible explanation for this could be MTA Plus may indirectly induce the expression of dentin metalloproteinase inhibitor, thus preventing the destruction of the dentinal matrix and it may form bond with root dentinal tissue that is initially mechanical and later becomes chemical.[19] Another reason could be due to higher release of Ca ions from Biodentine during crystallization promoting its solubility which may reduce the strength of biodentine over a period of time.[20] AH Plus sealer is shown to form micromechanical bonding with the root dentin leading to long lasting dimensional stability that may amplify the fracture resistance.[21]Also the flexural strength for dentin exposed to biodentine and MTA Plus reduced significantly after 2 and 3 months as reported by Sawyer et al.[22] A Finite Element Analysis study by Ron AC et al found that obturation of the root canal with MTA Plus or Biodentine is not a suitable method of reinforcing an immature tooth with thin dentinal walls.[23] Moreover, the present study also revealed that Calcium hydroxide had deteriorated the resistance to fracture of the tooth root in comparison to MTA Plus, Biodentine treatment groups and intact immature teeth samples with significance. This could be attributed to the weakened root dentine dentin which might have resulted due to changes in organic matrix caused by high level alkalinity of calcium hydroxide.[5] The long term exposure to calcium hydroxide dressing result in proteolytic denaturation of dentinal matrix may affect the physical properties of dentin unfavorably leading to stress propagation and cyclic fatique.[6] Moreover endodontic treatment weakens tooth structure and predisposes teeth to fracture as during removal of dentin through instrumentation, it also showed that permanent teeth are more resistant to fracture as compared to immature teeth and this can be attributed to the deposition of secondary dentin along the canal walls which provides resiliency to the roots. In the vein with our results, it was published that long term treatment of Calcium hydroxide could be deleterious to the dentinal integrity, thus rendering it more prone to fracture by Twati et al.[24]

Conclusion:

The results of the present study indicate that the apical plug thickness of 3mm and 6mm using MTA Plus and Biodentine showed significantly greater resistance to fracture compared to the complete reinforcement with these calcium silicate cements. Henceforth, MTA Plus and Biodentine can be used to build apical plug upto a thickness of 6mm during the single-visit apexification of traumatized immature teeth without deteriorating the fracture strength of tooth structures.

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The fracture testing was performed in the ITS Engineering College, Greater Noida utilizing UTM machine.

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