Conservative restorations of endodontically compromised anterior teeth in paediatric patients: physical and mechanical considerations

ABSTRACT

Aim Objective of this in vitro study was to evaluate the influence of fiber post placement on fracture resistance of pulpless anterior teeth restored with standardised Class III and Class IV resin composite fillings. Materials and Methods One hundred and five human maxillary central incisors were selected and randomly divided into 7 (n=15) experimental groups (endodontic therapy/ endodontic therapy and one Class III resin composite filling/ endodontic therapy and one Class IV resin composite filling/ endodontic therapy and two Class III resin composite fillings/ endodontic therapy, fiber post and one Class III resin composite filling/ endodontic therapy, fiber post and one Class IV resin composite filling/ endodontic therapy, fiber post and two Class III resin composite fillings). Specimens underwent fracture strength test. Means (N) were calculated and data were analysed using 1-way ANOVA and Tukey multiple comparisons tests (p=0.05). Results Concerning teeth with two Class III, fiber post placement significantly increased fracture strength values from 603.59 to 864.24 N. Specimens restored with one Class III (795.21 N without post, 936.68 N with post) showed higher fracture strength values if compared with specimens with two Class III, with significant differences just concerning specimens without a fiber post. Fracture strength was not significantly influenced by fiber post placement in Class IV groups (720.71 N without post, 799.69 N with post). Conclusion Data suggest that fiber post placement may significantly improve anterior teeth fracture strength when at least two Class III composite fillings are associated to the endodontic treatment. No significant effect of fiber post placement could be recorded when just one Class III or one Class IV composite filling were present.

Keywords Composite restoration; Fiber post; Fracture resistance; Incisors.

Introduction

The occurrence of caries on anterior teeth is a common problem in paediatric dentistry, even if social class as well immigrant status have been reported as strong determinants of oral health [Ferro et al., 2010; Ferro et al., 2012]. Restoration of incisors, which have been severely damaged by early childhood caries or trauma, may be a difficult challenge for clinicians. When an aesthetic restoration with minimal tooth reduction is desired, for example in young patients, conservative preparations and resin-based composite restorations are an ideal therapeutic option [Lambert, 2006]. However, the likelihood of survival of a pulpless tooth is directly related to the quantity and quality of the remaining dental tissue [Pereira et al., 2005]. Some of the conditions that may increase the potential of tooth fracture after endodontic treatment were recently summarised [Tang et al., 2010]: they include loss of tooth structure, caries, trauma, post canal preparation, post selection, corrosion of metal posts after restoration, coronal restoration and inappropriate selection of tooth abutments for prostheses [Pereira et al., 2005; Al-Omiri et al., 2010]. Other factors, such as abrasion, erosion, tooth anatomy, dental arch position and patient’s age, are also important [Soares et al., 2008b]. There is some controversy about the necessity of post placement [Schwartz and Robbins, 2004]. Some authors consider the placement of a post an indispensable prerequisite [Wegner et al., 2006], especially before prosthetic rehabilitation. On the contrary, according to other studies, post space preparation may further weaken the abutment tooth and therefore, post placement appears only to be considered if retention for final fixed partial dentures or removable partial dentures is inadequate and does not have the objective of strengthening the endodontically treated tooth [Wegner et al., 2006].

The purpose of this in vitro study was to evaluate the effect of fiber reinforced post placement on the fracture resistance of endodontically treated anterior teeth
restored with standardised Class III and Class IV resin composite fillings. The null hypothesis tested was that the different restorative procedures would not affect the fracture strength.

### Materials and methods

One hundred and five freshly extracted under periodontal indication human maxillary central incisors were selected from adult patients. External debris was removed. Teeth were examined under a stereomicroscope (Nikon SMZ10; Tokyo, Japan) to ensure that they were free of defects and cracks. Coronal height and root length were limited to 10.5 ± 1 mm and 12 ± 1 mm, respectively. Anatomic crowns were similar in dimension, measuring 8.15 ± 0.7 mm mesiodistally and 7.3 ± 0.65 mm buccolingually, at the level of the cementoenamel junction (CEJ). Selected teeth were stored in 0.5% chloramine-T aqueous solution at 4°C until the beginning of experiment, but no longer than 1 week after extraction. Teeth were randomly divided into 7 experimental groups (n = 15) and a one-way ANOVA test was used to confirm that there was no statistically significant difference in mean dimensions among groups. Teeth were then prepared as follows.

**Group 1 (endodontic therapy)**

In Group 1, specimens were submitted to conventional root canal therapy. Through a palatal access, root canals were mechanically enlarged to ISO size 25, 0.06 taper (Revo-S; MicroMega, Besancon-Cedex, France). Irrigants used were 5% sodium hypochlorite (Ogna, Muggiò, Milan, Italy) and 17% EDTA (Pulpdent, Watertown, MA). Enlarged canals were rinsed with distilled water, dried with paper points and sealed with gutta-percha (Lexicon Gutta Percha Points; Dentsply Tulsa Dental, Tulsa, OK) and endodontic sealer (Pulp Canal Sealer EWT; Kerr, Romulus, MI). Pulp chambers were restored with a light-cured hybrid composite and adhesive system, according to the manufacturer’s instructions (Enamel Plus HRi; Micerium).

**Group 2 (endodontic therapy and one Class III resin composite filling)**

In Group 2, each specimen was subjected to standard endodontic treatment, as described above, furthermore a standard Class III direct composite restoration was placed. Silicone molds (Optasil; Heraeus Kulzer, Wehrheim, Germany) were prepared on each tooth before cavity preparation. Class III cavities were carried out on each tooth mesial surface (Fig. 1b), at the level of the middle third, using a cylindrical diamond rotary cutting instrument (#314.141.524.315; Intensiv SA, Grancia, Switzerland) mounted on an air-water cooled high speed handpiece. The bur was kept perpendicular to the tooth long axis and to the labial surface: therefore the internal form of the cavity appeared to be round. Care was taken to keep a standard preparation depth (both on the mesiodistal and on the occluso-gingival dimensions) equal to the bur diameter. A new bur was used after every five preparations. Cavities were etched for 15 seconds with phosphoric acid gel (Ena Etch, Batch no. 2009000632; Micerium, Genova, Italy). The adhesive (EnaBond, Batch no. 2009000475; Micerium, Genova, Italy) was applied and light-cured (LE Demetron I; Sybron/Kerr) for 30 seconds. Teeth were restored using the silicone mold as a guide for resin composite application. Resin composite (Enamel Plus HRi, UD3 and UE2 shades; Micerium, Genoa, Italy) was layered in increments of approx 2 mm each that were light cured for 40 seconds. Polishing was performed using diamond and aluminum oxide pastes (Shiny A, B and C, Micerium, Genoa, Italy).

**Group 3 (endodontic therapy and one Class IV resin composite filling)**

In Group 3, each specimen was subjected to standard endodontic treatment, as described above, furthermore a standard Class IV direct composite restoration was placed. Sample processing procedures were the same as described for Group 2, except for the cavity shape that was designed to include on each tooth the incisal mesial angle. A permanent pen was used on each crown to mark out the middle point on the incisal edge and the middle point between the incisal mesial angle and the mesial cemento-enamel junction. These marks indicated the cavity limits on the incisal edge and on the proximal surface. Subsequently a cylindrical diamond bur (#314.141.524.315; Intensiv SA, Grancia, Switzerland), kept perpendicular to the tooth long axis and to the tooth labial surface, was used to drill out a standard Class IV cavity, up to the above mentioned.
The effects of fiber posts on maxillary incisors


The two cavity walls were one perpendicular to the other and respectively parallel and perpendicular to the tooth long axis (Fig. 1c).

Group 4 (endodontic therapy and two Class III resin composite fillings)

In this Group, specimens were prepared according to the same procedures described for Group 2, but on each tooth two Class III restorations of similar size were carried out both on the mesial and on the distal aspect (Fig. 1d).

Group 5 (endodontic therapy, fiber post and one Class III resin composite filling)

In Group 5, specimens were endodontically treated. Moreover, preformed fiber posts (Endo Light Posts size 2; RTD, St. Egrève, France) were placed in each root canal, according to the following procedures. After the root canal therapy, teeth were temporised for 24 hours using a light-curing free-eugenol cement (Fermit N; Ivoclar Vivadent, Schaan, Liechtenstein). Then, gutta-percha was removed with warm endodontic pluggers (Sybron Dental Specialties, Romulus, MI). Post spaces were prepared to a depth of 15 mm measured from the incisal edge using Torpan drills ISO 100 Yellow (RTD, St. Egrève, France). Post-space preparations were rinsed with 5% NaOCl. A final irrigation was accomplished with distilled water, and post spaces were dried with paper points. Every canal was etched for 60 seconds with 37% phosphoric acid, introduced into the spaces with a needle, rinsed using a water syringe, and then gently dried with paper points. XP Bond (Batch n. 1007001752; Dentsply DeTrey, Konstanz, Germany) and Self-Cure Activator (Batch n. 090519; Dentsply DeTrey) were mixed for 2 seconds and applied to the root canal for 30 seconds with a microbrush. The luting agent (Core-x-Flow, Batch n.091021, Dentsply DeTrey) was injected into the root canal by a tube with a needle and the appropriate plug (KerrHawe SA, Bioggio, Switzerland) using a specific Composite-Gun (KerrHawe SA) [D’Arcangelo et al., 2008a]. Posts were then seated to full depth in the prepared spaces using finger pressure. Excess luting agent was immediately removed with a small brush. After initial chemical polymerisation, the resin luting agents were light cured for 40 seconds with a light intensity of at least 1000 mW/cm² (Optilux 501; Demetron/Kerr Co.). Exceeding posts were cut 2 mm coronally to the lingual CEJ using a cylindrical diamond bur mounted on a high-speed handpiece (Bora L; Bien-Air, Bienne, Switzerland) under water-spray cooling. Subsequently, pulp chamber was restored as described in Group 1 and standard Class III resin composite restorations were placed on each mesial surface, as in Group 2.

Group 6 (endodontic therapy, fiber post and one Class IV resin composite filling)

In Group 6, after the root canal therapy, fiber posts were placed as described for Group 5 and Class IV composite fillings were applied as in Group 3.

Group 7 (endodontic therapy, fiber post and two Class III resin composite fillings)

In this Group, after the root canal therapy, fiber posts were placed as for Group 5 and two Class III composite fillings were applied on each sample as in Group 4.

Fracture strength testing

All specimens underwent 10,000 thermal cycles between 5°C and 55°C, with a 30-second dwell time and a 5-second transfer between temperature baths. Specimens were then preserved in a saline solution at room temperature for 1 week. Afterward, teeth were embedded in acrylic resin blocks up to 1 mm from the buccal CEJ and submitted to the fracture strength test at a constant speed of 0.5 mm/min using a Universal Testing Machine (Lloyd LR 30K; Lloyd Instruments Ltd, Fareham, UK). The force was applied at a 45° angle to the long axis of the tooth by means of a 1.5 mm rounded loading tip located on enamel between the middle and the cervical third of the crown palatal aspect. Failure loads were recorded. The modes of failure were determined under an optical microscope (Stemi 2000 CS; Carl Zeiss, Jena, Germany) with low-power (50 X) stereo magnification and classified as follows: root fractures, involving just the root; facial fractures, involving just the crown in its facial aspect; longitudinal fractures, involving the crown and extending into the root; and cervical fractures, at the level of the CEJ. Modes of failure were also subdivided into restorable (facial and cervical fractures) and unrestorable (root and longitudinal fractures). After having checked that data were normally distributed (Kolmogorov-Smirnov test), 1-way ANOVA was performed to analyse the influence of the different treatments on failure load. Post hoc multiple comparisons were performed using the Tukey test, with the significance level set at α = 0.05.

Results

Concerning the maximum load (newtons), specimens on which fiber posts were placed (Groups 5, 6 and 7) achieved higher mean values compared with teeth that were simply restored with Class III and Class IV fillings (Groups 2, 3 and 4), although the differences were significant just between groups 4 and 7. Statistically significant differences were also registered between groups 2 and 4, where specimens with one Class III restoration showed higher mean fracture strength value compared with specimens with two Class III restorations. Fracture strength test results and the observed modes of failure are summarised in Table 1.

Discussion

The results of the present investigation showed a
general trend of fracture strength reduction when complex and extended cavities (Group 4: two Class III restorations) were compared with less invasive designs (Group 3: Class IV restoration; Group 2: one Class III restoration). In addition, an increase in fracture resistance mean values was registered when resin composite restored endodontically treated teeth (Groups 2, 3 and 4) were compared with corresponding specimens restored using fiber reinforced posts (Groups 5, 6 and 7). The differences were statistically significant just as far as the most complex cavity designs were concerned (Group 4 vs. Group 7): this result may be due to the relatively high standard deviation values achieved, still in accordance with the present results that showed a relatively low number of unrestorable failures in Groups 5, 6 and 7. Moreover, the use of FRC posts led to a decrease in cervical fractures and to an increase in facial fractures, which are generally easier to be managed by the clinician. This is in accordance with a recent study [Sorrentino et al., 2007] aimed to compare the fracture resistance and failure patterns of endodontically treated premolars with MOD preparations restored using different material combinations. The Authors concluded that the teeth restored with posts predominantly showed restorable fractures, while teeth restored without posts mostly displayed unrestorable failures. Some other published studies evaluated the effects of different restoration techniques for non-vital premolars with Class II defects [Mohammadi et al, 2009; Scotti et al, 2011]. Mohammadi et al. [2009] suggested that root-filled maxillary premolars, restored with direct resin composite with or without fiber post and cusp capping, have similar fracture resistance under static loading. A recent in vitro study [Scotti et al, 2011] confirmed these findings, showing that endodontically treated premolars with MOD cavity preparations restored with direct resin composite with fiber post or cusp capping demonstrate similar fracture resistance. However in the case of anterior teeth, the flexural behavior of posts should be

### TABLE 1 Distribution of population according to sex.

<table>
<thead>
<tr>
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<th>GROUP1</th>
<th>GROUP2</th>
<th>GROUP3</th>
<th>GROUP4</th>
<th>GROUP5</th>
<th>GROUP6</th>
<th>GROUP7</th>
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</thead>
<tbody>
<tr>
<td><strong>Maximum Load [N] (SD)</strong></td>
<td>780.83a,b,c</td>
<td>795.21a,b</td>
<td>720.71b,c</td>
<td>603.59c</td>
<td>936.68a</td>
<td>799.69a,b</td>
<td>864.24a,b</td>
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<tr>
<td><strong>Facial fractures</strong></td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>12</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td><strong>Cervical fractures</strong></td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Longitudinal fractures</strong></td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Root fractures</strong></td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
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*SD = standard deviation. Same superscripted letters indicate no significant differences (P > 0.05).
The results of the present study are in accordance with Salameh et al. [2008], who reported that the use of fiber posts in endodontically treated incisors increases their resistance to fracture and improves the prognosis in case of fracture. Soares et al. [2008a] showed that even though fracture resistance might decrease with major loss of dental structure, the combination of the fiber post with an adhesive restoration created a higher incidence of more favourable failure types. Moreover, a finite element analysis study [Coelho et al., 2009] showed that fiberglass and carbon fiber posts presented a more homogeneous stress distribution compared to metallic posts, which was close to that produced in an intact tooth. In other words, the authors suggested a lower risk of catastrophic failure for flared root canals if the teeth were restored with fiberglass or carbon fiber posts. According to Grandini et al. [2005], fiber posts associated to direct resin restorations is a faster therapeutic option that conserves remaining tooth structure. The authors evaluated the longevity of fiber posts associated to direct resin restorations by 6, 12, 24 and 30-month recall and satisfactory results were found although no comparison with teeth without posts had been made.

In the present study a 45-degree angle of load was chosen to be in accordance with previous static load protocols [D’Arcangelo et al., 2010; D’Arcangelo et al., 2008b; Baratieri et al., 2000] and to simulate a worst-case scenario. However, the resistance of teeth in the oral environment is not determined by failure load alone. The quasi-static load to failure applied to the test specimens did not model cyclic mechanical fatigue, which is widely believed to be a dominant cause of failure for restored endodontically treated teeth; hence, additional factors should be further considered, such as cyclic mechanical loading conditions [D’Arcangelo et al., 2010; D’Arcangelo et al., 2008b].

Conclusion

Within the limitations of an in vitro study, the present results suggest that, for endodontically treated anterior teeth, fiber post placement seems advisable in terms of fracture resistance to static load in cases with cavity designs that may determine extensive loss of coronal tissues (two Class III cavities).

References


EFFECT OF FIBER POSTS ON MAXILLARY INCISORS