

Intracoronar reinforcement and coronal coverage: A study of endodontically treated teeth

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Techniques to reinforce endodontically treated teeth have been available for more than 100 years. However, few dentists have questioned the rationale that dictates automatic dowel reinforcement and coronal coverage of pulpless teeth.

The difficulties of in vivo studies have motivated investigators to increase the number of in vitro studies of endodontically treated teeth. Although findings from in vitro studies provide guidelines, direct application of tensile, torque, and shear tests on experimental models or extracted teeth are questionable. This is particularly true if the elasticity of tooth structure, alveolar bone, and periodontal ligament is considered.

The purpose of this study was to correlate clinical and laboratory studies of 1273 endodontically treated teeth in retrospect and determine the clinical significance of post reinforcement and coronal coverage. The location of the tooth in the arch and how it modifies the restorative requirements of an endodontically treated tooth are evaluated.

LITERATURE REVIEW

Substantiated clinical studies of desiccation and increased susceptibility to fracture after endodontic therapy are sparse.¹ Many in vitro studies that describe variables significant to the longevity of endodontically treated teeth appear in the literature.²⁻¹² The studies indicate that the major variables to consider are (1) intracoronar reinforcement,²⁻¹⁰ (2) coronal coverage,^{4, 5, 7, 9, 10} and (3) arch position of the tooth.^{2-6, 8, 11, 12}

In impact studies that simulate trauma to maxillary central incisors, Trabert et al.² found no significant differences in resistance to fracture between untreated and endodontically treated teeth. However, endodontically treated central incisors restored with parallel-

sided stainless steel posts recorded significantly higher resistance to fracture.

Kantor and Pines³ subjected pulpless teeth to compression and shearing stress and determined that a cemented stainless steel stabilizing rod nearly doubled resistance to fracture. The cemented post tooth possessed the highest strength, followed by the control (nonreinforced) tooth and the cast dowel and core tooth while the composite resin core registered the lowest strength.

Lovdahl and Nicholls⁴ measured resistance to a load applied lingually at an angle of 130 degrees to the long axis of the tooth. Under the test conditions, endodontically treated maxillary central incisors with natural crowns demonstrated greater strength than teeth treated with either a cast dowel and core or pin-retained amalgam cores. Parallel-sided stainless steel post reinforcement was not included in this study, nor were the build-up techniques tested with coronal coverage.

Guzy and Nicholls⁵ applied forces at 130 degrees to maxillary canine and central incisors. The study demonstrated no statistically significant difference in reinforcement by cementing a Kerr Endo-Post No. 100 (Sybron/Kerr, Romulus, Mich.) into a sound endodontically treated tooth. The Kerr Endo-Post No. 100 is a smooth-surface, tapered dowel while the Para-post system (Whaledent International, New York, N.Y.) uses a serrated, parallel-sided stainless steel dowel design.

The amount of tooth structure that remains after endodontic treatment and post space preparation is an important consideration in the restoration of endodontically treated teeth.^{6, 11} In their investigation of simulated trauma, Trabert et al.² found that pulpless teeth restored with small diameter stainless steel posts provided increased resistance to fracture in comparison with larger post sizes. Furthermore, varying dowel diameter has no significant affect on the retentive abilities of dowels.¹³ Overpreparation of the post space

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and larger posts produce no greater reinforcement but actually decrease the resistance to fracture.^{2,11}

The risk of irreversible damage to the endodontically treated tooth from failure of the post system must be weighed against the anticipated advantages of intracoronar reinforcement.^{2,6,11} Judgment must be exercised in each instance, rather than automatically placing a post in every endodontically treated tooth. For example, in mandibular anterior teeth coronal coverage alone may suffice to ensure longevity.

Despite the numerous techniques in the literature, scientifically tested criteria for reinforcement of endodontically treated, multirouted posterior teeth are few. The techniques range from cast gold dowels and cores fabricated with direct wax or acrylic resin patterns to amalgam cores.^{7,14-17}

Nayyar et al.⁸ suggested that amalgam be condensed 2 to 4 mm into each canal, pulp chamber, and coronal portion of the tooth. During 4 years of observation, approximately 400 posterior teeth treated with amalgam coronal-radicular dowel and core and cast crown did not show evidence of failure attributable to the amalgam technique.

In an *in vitro* study, Christian et al.¹² compared the resistance of horizontal forces of amalgam core buildups. This study, which evaluated endodontically treated mandibular molars, demonstrated that the control teeth withstood approximately double the force that the teeth with amalgam cores did. A post in the distal canal and an amalgam core well-condensed around the post provided the greatest resistance to fracture against a horizontal force.

Studies suggest that the location of the tooth in the arch^{2-5,8,12} and the amount of remaining tooth structure^{2,4-6,11} necessitate different restorative requirements to ensure the longevity of endodontically treated teeth.

Dentists have routinely prepared endodontically treated teeth for crowns. The need for coronal coverage of pulpless teeth with minimal tooth structure or large multiple restorations has been commonly accepted. On the other hand, coronal coverage of pulpless teeth with nearly intact coronal structure has prompted controversy. Some dentists advocate merely filling the access preparation of intact endodontically treated teeth,^{4,5,7} while others insist on coronal coverage.^{9,10}

A diversity of opinion exists regarding post reinforcement in endodontically treated teeth. Investigators have drawn conclusions in favor of^{2,3,6,9,10} and against^{4,5,7,8} the retention and protection provided by dowels.

In summary, a review of intracoronar reinforcement

and coronal coverage of endodontically treated teeth indicates that a substantial number of *in vitro* studies but relatively few clinical studies have been conducted.

METHODS

This study incorporates selected findings of *in vitro* studies to determine whether similar factors are clinically significant to the longevity of endodontically treated teeth.

Over 6000 patient records of nine dentists engaged in general practice were examined for teeth that had undergone endodontic therapy. The endodontically treated teeth were present for 1 to 25 years. With endodontically treated teeth used as the unit of analysis, data were collected for the following independent variables.

Location of the tooth in the arch

Six groups of teeth were classified according to arch position because of similar root structure, periodontal support, amount of tooth structure, and comparable function as follows:

1. Maxillary anteriors: teeth Nos. 6, 7, 8, 9, 10, 11
2. Maxillary premolars: teeth Nos. 4, 5, 12, 13
3. Maxillary molars: teeth Nos. 1, 2, 3, 14, 15, 16
4. Mandibular anteriors: teeth Nos. 22, 23, 24, 25, 26, 27
5. Mandibular premolars: teeth Nos. 20, 21, 28, 29
6. Mandibular molars: teeth Nos. 17, 18, 19, 30, 31, 32

Coronal coverage

Endodontically treated teeth were placed in the coronal coverage category if they possessed an onlay, partial or complete veneer crown, or ceramometal crown. Teeth with restorations that ranged from amalgams and composite resin fillings to pin coronal buildups were placed in the noncoronal coverage category.

Intracoronar reinforcement

Endodontically treated teeth with cast dowels and cores, and prefabricated and threaded posts, were placed in the intracoronar reinforcement category. Teeth with no intracoronar reinforcement included pin amalgam and pin composite resin fillings, amalgam and pin composite resin fillings, amalgam and composite resin fillings, and temporary fillings.

Treatment reported in patient files was verified radiographically. Endodontically treated teeth were not included if present for less than 1 year, although failures were noted from the day of root canal therapy.

Table I. Descriptive data and statistical analysis*

Location of teeth in arch	Intracoronar reinforcement								Coronal coverage							
	Post				No post				Crown				No crown			
	Success		Failure		Success		Failure		Success		Failure		Success		Failure	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Maxillary anteriors	178	89.4	21	10.6	171	84.7	31	15.3	273	87.5	39	12.5	76	85.4	13	14.6
Statistical significance	No significant difference															
Maxillary premolars	69	93.2	5	6.8	114	87.0	17	13.0	169	93.9	11	6.1	14	56.0	11	44.0
Statistical significance	No significant difference $\chi^2 = 29.06, df = 1, p < .001$															
Maxillary molars	23	92.0	2	8.0	161	93.1	12	6.9	174	97.8	4	2.2	10	50.0	10	50.0
Statistical significance	No significant difference $\chi^2 = 55.34, df = 1, p < .001$															
Mandibular anteriors	23	95.8	1	4.2	50	96.2	2	3.8	39	97.5	1	2.5	34	94.4	2	5.6
Statistical significance	No significant difference															
Mandibular premolars	50	89.3	6	10.7	80	90.9	8	9.1	120	93.8	8	6.3	10	62.5	6	37.5
Statistical significance	No significant difference $\chi^2 = 12.46, df = 1, p < .001$															
Mandibular molars	41	97.6	1	2.4	189	91.7	17	8.3	215	96.8	7	3.2	15	57.7	11	42.3
Statistical significance	No significant difference $\chi^2 = 47.35, df = 1, p < .001$															

*Presence of statistically significant difference by chi square analysis.

Endodontically treated teeth that failed because of periodontal pathosis or carious involvement were excluded. Based on these delimitations, 1273 endodontically treated teeth were selected from 6000 patient records.

Records were reviewed for information from office visits subsequent to endodontic therapy and last recorded examination. The definition of clinical success (longevity) was based on the absence of a negative finding from the last examination. Recorded failures of endodontically treated teeth included dislodgment, fracture of tooth or root structure, vertical root fracture, and iatrogenic root perforation. The patient's report that the endodontically treated tooth was asymptomatic and functioning comfortably was noted. Data are presented in Table I indicating the number of successes and failures. An analysis was performed to determine whether (1) the location of the tooth in the arch, (2) the presence of intracoronar reinforcement, and (3) coronal coverage had an effect on the success or failure of endodontically treated teeth. Chi square analysis was used to determine whether significant differences existed.

RESULTS

The data in Table I indicate that several statistically significant interactions existed among the variables. Because of the complexity of the results, the findings are presented according to the anatomic position of the teeth.

Maxillary anterior teeth

The placement of a post and a crown on this group of endodontically treated teeth did not affect the success

rate. The success rate of endodontically treated maxillary anterior teeth ranged from 84.7% with no intracoronar reinforcement to 85.4% with no coronal coverage, 87.5% with coronal coverage, and 89.4% with placement of a post.

Maxillary premolars

While the placement of intracoronar reinforcement did not significantly affect the success rate of maxillary premolars, the placement of a crown did have a significant affect. Chi square analysis demonstrated a significantly higher success rate in maxillary premolars with crowns when compared with maxillary premolars without crowns ($\chi^2 = 29.06, p < .001$). The success rate of endodontically treated maxillary premolars ranged from 56.0% without coronal coverage to 87.0% with no intracoronar reinforcement, 93.2% with placement of a post, and 93.9% with coronal coverage.

Maxillary molars

Post placement did not significantly affect success rate, while placement of a crown did have a significantly higher success rate in maxillary molars with crowns than maxillary molars without crowns ($\chi^2 = 55.34, p < .001$). The success rate of endodontically treated maxillary molars ranged from 50.0% without coronal coverage to 92.0% with placement of a post, 93.1% with no intracoronar reinforcement, and 97.8% with coronal coverage.

Mandibular anterior teeth

The placement of a post and a crown in this group of endodontically treated teeth did not significantly

improve the success rate. The success rate of endodontically treated mandibular anterior teeth ranged from 94.4% without coronal coverage to 97.5% with coronal coverage.

Mandibular premolars

While the placement of a post did not significantly affect the success rate, a comparison of mandibular premolars with crowns and mandibular premolars without coronal coverage showed highly statistically significant differences. Chi square analysis demonstrated a significantly higher success rate in mandibular premolars with crowns than in mandibular premolars without crowns ($\chi^2 = 12.46$, $p < .001$). The success rate of endodontically treated mandibular premolars ranged from 62.5% without coronal coverage to 89.3% with placement of a post, 90.9% without intracoronar reinforcement, and 93.8% with coronal coverage.

Mandibular molars

The placement of a post did not significantly affect the success rate of this group of teeth. However, a comparison of mandibular molars with crowns and mandibular molars without coronal coverage demonstrated significant differences. Chi square analysis demonstrated a significantly higher success rate in mandibular molars with crowns than in mandibular molars without crowns ($\chi^2 = 47.35$, $p < .001$). The success rate of endodontically treated mandibular molars ranged from 57.7% without coronal coverage to 91.7% without intracoronar reinforcement, 96.8% with coronal coverage, and 97.6% with placement of post.

DISCUSSION

A summary of the findings indicates that intracoronar reinforcement did not significantly increase the clinical success rate of any of the anatomic groups of endodontically treated teeth and coronal coverage significantly improved the clinical success rate of endodontically treated maxillary premolars, maxillary molars, mandibular premolars, and mandibular molars. It did not significantly affect maxillary anterior or mandibular anterior endodontically treated teeth.

The fact that there was not a significant increase in resistance to fracture or dislodgment gained with a post is diametrically opposed to accepted treatment. A closer inspection of the results reveals that three of the six anatomic groups of teeth had greater clinical success rates without a "reinforcing" post. However, the observed differences were not statistically significant.

The results of this study indicate a need for a reevaluation of the rationale for restoration of endo-

dontically treated teeth. Dentists should focus less on factors that influence retention and concentrate more on factors that affect resistance to root fracture. In vitro studies^{2,6,7} confirm the importance of the bulk of tooth structure in strength and resistance to fracture. Therefore, excessive removal of tooth structure during preparation of post space and restorative techniques should be avoided.

The motivation for placement of a post should not be for reinforcement. When insufficient tooth structure exists to prepare a tooth for coronal coverage, a technique must be used to restore lost dentin. A post facilitates the retention of restorative materials for fabrication of a foundation in both posterior and anterior teeth. However, an amalgam or composite resin coronal-radicular core appears to be just as appropriate as a post and core buildup in the restoration of posterior teeth.^{13,14,18}

Indiscriminate placement of a post in every endodontically treated tooth is unrealistic. Consideration must be given to the variables involved: remaining tooth structure, periodontal support, root and pulp morphology, and occlusion. A mandibular anterior tooth with compromised coronal tooth structure is a good example. Rather than risk removal of an inordinate amount of tooth structure or perforation of the root during post space preparation, a composite resin filling could be placed in the pulp chamber. Restoration of the coronal portion of the tooth may be sufficient to ensure a favorable prognosis for success. In fact, although not statistically significant, mandibular anterior pulpless teeth demonstrated a slightly higher success rate without a post.

Coronal coverage of anterior maxillary and mandibular endodontically treated teeth conferred no significant improvement on their longevity. The findings were confirmed by in vitro studies that demonstrated the greater strength of natural crowns in maxillary central incisors.^{4,5} Therefore, a filling in the access preparation of coronally intact maxillary and mandibular anterior teeth is as viable a treatment alternative as coronal coverage. It is the prerogative of the dentist to select coronal coverage because of large existing multiple restorations or esthetics.

The prognosis of pulpless maxillary and mandibular premolars and molars is significantly increased with coronal coverage. Depending on the remaining tooth structure, a variety of techniques that range from a cast dowel and core to an amalgam coronal-radicular core can provide a foundation for crown preparation.

After comparing the success and failure of the groups, it appears that some teeth are more prone to failure regardless of restorative technique. Maxillary

anterior teeth are more susceptible to trauma than premolars or molars because of arch position.

The difference in direction of forces during function in maxillary anterior teeth vs. mandibular anterior teeth may also account for the discrepancy in the failure rate between the two. Mandibular anterior teeth are subject to more vertical forces closer to their long axis, while maxillary anterior teeth receive more angular forces. Significant loss of tooth structure while obtaining canal access during endodontic therapy may sufficiently weaken the maxillary anterior teeth despite the restoration that is placed.

In light of the disparity of results between in vitro studies and this retrospective clinical investigation, there is a need to examine the clinically significant factors in dowel and core design.

CONCLUSIONS

The records of 1273 endodontically treated teeth suggest:

1. There was no significant increase in resistance to fracture or dislodgment gained with intracoronal reinforcement for the six anatomic groups of teeth.

2. Coronal coverage did not significantly improve the rate of clinical success for maxillary and mandibular anterior teeth.

3. The rate of clinical success was significantly improved ($p < .001$) with coronal coverage of maxillary and mandibular premolars and molars.

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