

Evidence-Based Review of Clinical Studies on Restorative Dentistry

The restoration of the endodontically treated tooth represents a key factor during treatment planning because of its impact on the long-term prognosis. Here we provide an analysis of clinical studies evaluating outcomes of various restorative treatments applied to endodontically treated teeth.

Analysis of Article #1

Three-Year Clinical Comparison of Survival of Endodontically Treated Teeth Restored With Either Full Cast Coverage or With Direct Composite Restoration

Mannocci F, Bertelli E, Sherriff M, Watson TF, Pitt Ford TR—*J Prosthet Dent* 2002;88:297-301.

Study Overview

Level of Evidence: Level 2

Purpose / Question: The purpose of this study was to evaluate the clinical success rate of endodontically treated premolars restored with fiber posts and direct composite restorations and compare that treatment with a similar treatment of full coverage with metal-ceramic crowns.

Source of Funding: None designated

Type of Study / Design: Randomized controlled clinical trial—low level

Title: The Clinical Outcomes of Endodontically Treated Premolars Restored With Adhesive Techniques and Fiber Posts Were Comparable to Similar Teeth Restored With Full Coverage Metal-Ceramic Crowns

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Summary

Subjects

Subjects included in this study had 1 maxillary and 1 mandibular premolar for which root treatment and a crown build-up were indicated and met specific inclusion/exclusion criteria. Only premolars with Class II carious lesions and preserved cusp structure were included.

Procedures

Patients were assigned randomly to 1 of 2 experimental groups: (1) tooth root treated and restored with carbon fiber post, adhesive techniques, and composite (60 teeth); or (2) tooth root treated, restored with adhesive techniques and composite, and then restored with full-coverage metal-ceramic crowns (57 teeth); no posts were used. All root canal procedures were performed by using standardized techniques under dental dam isolation. Teeth in group 1 received a carbon fiber post (Composipost) and were restored with Composite Z100 with no

composite cuspal coverage. Teeth in group 2 received a composite core build-up, were prepared for a crown, and were restored with a metal-ceramic crown. One clinician performed all restorations.

Subjects were re-examined and cases were evaluated by 2 calibrated clinicians (other than the operator) at intervals of 1, 2, and 3 years. At each time period the restorative margins were examined clinically under $3\times$ magnification, the teeth were probed for periodontal breakdown, and colored slides were made. Re-examination radiographs were made by using a paralleling technique, followed by radiograph projection and evaluation.

Main Outcome Measure

Causes of failure were categorized as root fracture, post fracture, post decementation, clinical and/or radiographic evidence of marginal gaps between the tooth and restoration, and clinical and/or radiographic evidence of secondary caries contiguous with restorative margins.

Main Results

Failure rates and failure modes are listed in Table 1. At 1-year re-examinations there were no failures. At 2- and 3-year re-examinations, the failure modes that occurred were decementations of posts and clinical and/or radiographic evidence of marginal gaps between the tooth and restoration. There was no difference in the failure frequencies of the 2 groups, and there was no difference between the number of failures caused by post decementation and presence of marginal gaps in the 2 groups.

Conclusions

Within the limitations of the study design, clinical success rates of endodontically treated premolars restored with fiber posts and direct composite restorations after 3 years of clinical service were equivalent to a similar treatment of full coverage with metal-ceramic crowns.

Statistical Analysis and Commentary

A Newman-Keuls multiple comparison test was used to determine statistical differences in the failure rates between the 2 test groups, and 95% confidence intervals were reported. No statistically significant differences in failure rates were found. The pooled results after 2 and 3 years showed a total of 4 failures in the composite group; 3 of these failures were due to marginal gaps, and 1 was due to decementation of the post. There were only 3 failures in the crown group, 2 as a result of decementation of the post and 1 as a result of a marginal gap. Because the number of failures is so small, the confidence intervals are relatively large. A larger "n" size might have provided a better pool of subjects from which to determine significance at the highest level possible.

If this study could have been designed to use match-pairs of teeth, bias might have been reduced. Using adhesives in this type of study allows for maximum retention of tooth structure and greater predictability, especially in premolars (1). The results of this study cannot be compared with others that used post crowns or composite restorations because previous studies have been retrospective (2, 3).

No root fractures or post fractures were found in this study. These types of fractures are often elusive and cannot be readily identified

Table 1. Failure rate and failure modes at the 1-, 2-, and 3-year re-examinations

| Year | | Composite post only, group 1 | Composite and crown, group 2 | Δ | 95% Confidence interval |
|------|--|---------------------------------|---------------------------------|-------|----------------------------|
| 1 | Sample size | 60 | 57 | | |
| | Recall | 55 | 57 | | |
| | Failure | 0 | 0 | | |
| 2 | Recall | 48 | 57 | -0.99 | -17.5 to 12.6 |
| | Failure | 3 | 3 | | |
| | (Decementation of post) (Marginal gap formations) | 1 2 | 2 1 | | |
| 3 | Recall | 50 | 54 | -2.0 | -14.9 to 8.89 |
| | Failure | 1 | 0 | | |
| | (Marginal gap formations) | 1 | | | |

Δ, Difference in percentage failures between group 1 and group 2; 95% CI, exact 95% confidence about Δ. Reproduced with permission from Mannocci F, Bertelli E, Sherriff M, Watson TF, Pitt Ford TR. Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. *J Prosthet Dent* 2002;88:297-301.

clinically or radiographically and might require longer examination periods for their occurrence. Furthermore, the marginal gaps and post decementations must be viewed as restorative failures and not endodontic failures, for which the latter is too often erroneously identified when restorative or periodontal failure is present.

Restoration of selected endodontically treated teeth by using fiber posts and composite without any crown coverage might be considered as an economic and tooth-saving alternative to the more expensive and less conservative crown coverage. Remaining tooth structure and patient function will often dictate this alternative.

Analysis of Article #2

Clinical Evaluation of Teeth Restored With Quartz Fiber-Reinforced Epoxy Resin Posts

Malferrari S, Monaco C, Scotti R-Int J Prosthodont 2003;16:39-44.

Study Overview

Level of Evidence: Level 4

Purpose / Question: The purpose of this prospective clinical follow-up was to evaluate the survival rate of 180 endodontically treated teeth restored with quartz-fiber posts and composite resin material and finalized with metal-ceramic or all-ceramic crowns during a 30-month period.

Source of Funding: None designated

Type of Study / Design: Cohort study—low level

Title: Restoration of Endodontically Treated Teeth Using Quartz Fiber-Reinforced Posts Provides a High Level of Long-Term Stability

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Summary

Subjects

One hundred eighty endodontically treated teeth in 132 patients (age, 18–65 years) were restored by 13 different clinicians (Table 2).

Procedures

All teeth required a crown, and root canal treatment was performed at least 3 months before final restoration. There were no signs or symptoms of pathosis clinically or radiographically. Radiographs

were taken by using a long-cone technique and were examined under magnification.

Teeth were restored with *Æstheti-Plus* quartz-fiber posts that were available in 3 sizes, have a cylindrical, double-section shape, and were 22 mm in length. Post diameters varied in sizes from the coronal to apical extent (1.4–1.0 mm, 1.8–1.2 mm, and 2.1–1.4 mm). All single-rooted teeth received 1 post; in 14 premolars and 11 molars 2 posts were placed. Seventy-nine percent of the canals had a round shape, 19% had an oval shape, and 2% had a c-shaped anatomy. The restored teeth were opposed to natural tooth structure in 53% of the cases, 19% occluded with metal-ceramic crowns, 16% opposed dentures, 11% occluded with metal-resin crowns, and 1% were not in occlusion.

All restorations were placed by using standardized technique. C&B resin Cement was used to place the posts, and core build-ups were done with *Core-Flo* or *Bis-Core* (all products from Bisco, Schaumburg, IL). Teeth were re-examined at 6, 12, 24, and 30 months. Three dentists evaluated the clinical outcomes; however, the examiners were not blinded.

Main Outcome Measure

Outcomes were considered successful if the post and core were in situ with no displacement or detachment of the post, no crown or prosthesis decementation, and no post, core, or root fracture. Subjective symptoms were recorded as potential signs of failure.

Main Results

Three failures occurred, 1 cohesive and 2 adhesive in the temporary phase of treatment. No crown or prosthesis decementations or post, core, or root fractures occurred. The periodontal tissues were healthy, and no caries or subjective symptoms were noted.

Conclusions

Within a 30-month period, 205 *Æstheti-Plus* quartz-fiber posts were used to restore 180 teeth. Only 1.7% represented failure during that time period. All failures occurred during temporary phases of treatment (1 cohesive and 2 adhesive failures), and no roots or posts were fractured. When failure did occur, the teeth were amenable to retreatment.

Table 2. Distribution of treated teeth according to type

| Jaw/arch | Central incisors | Lateral incisors | Canines | Premolars | Molars |
|----------|------------------|------------------|---------|-----------|--------|
| Maxilla | 43 | 17 | 28 | 24 | 8 |
| Mandible | 9 | 11 | 16 | 8 | 16 |
| Both | 52 | 28 | 44 | 32 | 24 |

Reproduced with permission from Malferrari S, Monaco C, Scotti R. Clinical evaluation of teeth restored with quartz fiber-reinforced epoxy resin posts. *Int J Prosthodont* 2003;16:39-44.

Statistical Analysis and Commentary

After 30 months, there were only 3 failures among the 180 teeth treated with quartz-fiber reinforced posts, for an overall success rate of 98.3%. The inclusion of a Kaplan-Meier survival curve added little additional information. The authors also provided data on the distribution of teeth in the study.

Although the data obtained would tend to provide support for this restorative entity, the level of evidence in this case series study is not as strong as if it had been designed as a randomized controlled clinical trial. With the number of clinicians providing treatment and the limited “n” size that might be ascribed to each clinician, the results might be questioned, because standardized techniques do not necessarily equate with highly calibrated operators.

Analysis of Article #3

Randomized Clinical Comparison of Endodontically Treated Teeth Restored With Amalgam or With Fiber Posts and Resin Composite: Five-Year Results

Mannocci F, Qualtrough AJE, Worthington HV, Watson TF, Pitt Ford TR—Oper Dent 2005;30:9-15.

Study Overview

Level of Evidence: Level 1

Purpose / Question: The purpose of this study was to evaluate the clinical performance of endodontically treated premolars without crown coverage when restored with amalgam compacted into the root canals compared with endodontically treated premolars restored with fiber posts and composite.

Source of Funding: None designated

Type of Study / Design: Randomized controlled clinical trial—high level

Title: Five-Year Clinical Outcomes of Root-Treated Premolars Restored With Amalgam Were Similar to Root-Treated Premolars Restored With Fiber Posts and Composites

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Summary

Subjects

Subjects included in this study had 1 maxillary and 1 mandibular premolar for which root treatment was indicated. Only premolars with Class II carious lesions and preserved cusp structure were included. Teeth were required to be in occlusal function after restoration, and none were to be used as abutments for fixed or removable prostheses. Teeth were excluded if the periodontal attachment loss was >40% of the root length and if the gingival index score was greater than 1 (4). The patient pool included 116 women and 103 men (age, 32–63 years; mean age, 45).

Procedures

Patients were assigned randomly to 1 of 2 groups on the basis of a coin flip: (1) tooth root treated and restored with amalgam (109 teeth) or (2) tooth root treated, restored with a fiber post and composite (110 teeth). The distribution among the maxillary and mandibular first and

second premolars was similar for each group. All root canal procedures and restorations were performed by one clinician with standardized techniques under dental dam isolation. All restorations were placed 1 week after root treatments. Teeth in group 1 received an amalgam restoration (Valiant PhD) that was also packed into the coronal 1/3 of the root canal. In 70 teeth the amount of cuspal structure on either the buccal or lingual was considered insufficient, and minimal amalgam cuspal coverage was placed (3 mm). Teeth in group 2 received a carbon fiber post (Composi-post) and were restored with Composite Z100 with no composite cuspal coverage.

Subjects were re-examined and cases were evaluated by 2 calibrated clinicians (other than the operator) at intervals of 1, 3, and 5 years. At each time period the restorative margins were examined clinically under 3× magnification, the teeth were probed for periodontal breakdown, and color slides were made. Re-examination radiographs were made by using a paralleling technique, followed by radiograph projection and evaluation.

Main Outcome Measure

The main outcome measurements were tooth retention with or without recurrent caries and/or fractures.

Main Results

The only failure modes were due to fracture or recurrent caries. No significant differences were found between amalgams and restorations with fiber posts and composites at the 1-year and 3-year re-examinations. At 5 years there were significant differences between the number of failures caused by fractures ($P = .029$) and the number of failures caused by caries ($P = .047$), with more root fractures in the teeth restored with amalgam and more caries in the teeth restored with fiber posts and composites. There were no significant differences for any mode of failure when an analysis was conducted for the maxillary and mandibular teeth separately. The retention rate for the amalgam groups was 91.3%; for the fiber post and composite it was 90.0%.

Conclusions

Within the limitations of the study design and during a period of 5 years, root-treated premolars restored with fiber posts and composite were more stable in preventing root fractures but less effective in preventing secondary caries than root-treated premolars restored with amalgam. The overall failure rate was not significant for the 2 clinical interventions.

Table 3. Defined experimental groups

| Group* | Characteristics |
|--------|--|
| 1 | All the coronal walls were present (Fig. 1A) |
| 2 | Three coronal walls were retained (Fig. 1B) |
| 3 | Two coronal walls were preserved (Fig. 1C) |
| 4 | Only one coronal wall was left intact (Fig. 1D) |
| 5 | Ferrule effect: no coronal wall was retained, although a collar of dentin at least 2 mm in height, as measured with a periodontal probe, was preserved |
| 6 | No ferrule effect: no coronal wall was retained, and less than 2 mm of dentin was present circumferentially |

*Within each group, 3 equally sized subgroups (n = 20) were randomly formed; subgroup A, no root canal post was placed; subgroup B, DT Light Posts were used to provide retention to the coronal restoration; and subgroup C, Ever Stick fibers were adapted into the post space to obtain a customized FRC post. Reproduced with permission from Cagidiaco MC, García-Godoy F, Vichi A, Grandini S, Goracci C, Ferrari M. Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars. *Am J Dent* 2008;21:179-184.

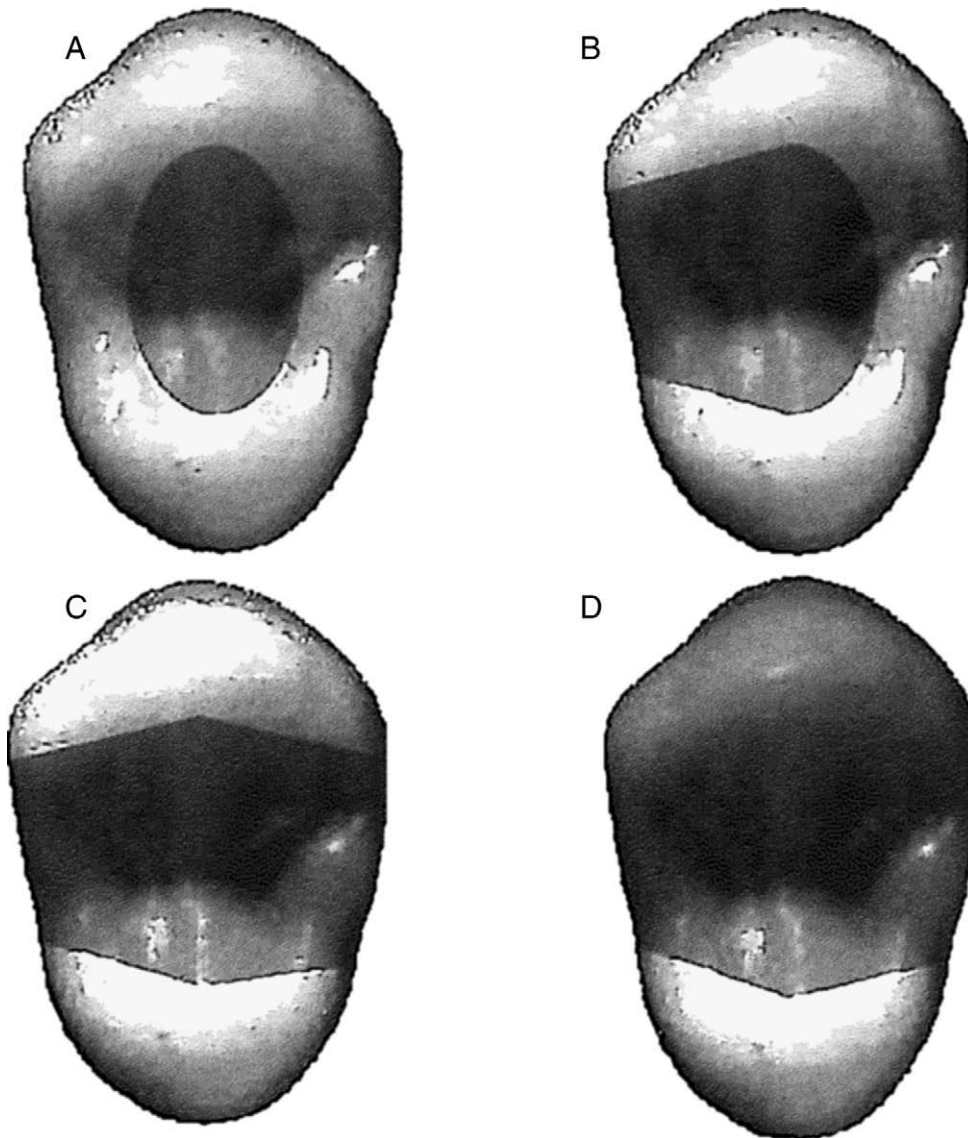


Figure 1. Schematic representation of the varying degrees of hard tissue loss within the specific 6 groups specified in Table 1. The darker area represents the area of tooth loss. Reproduced with permission from Cagidiaco MC, García-Godoy F, Vichi A, Grandini S, Goracci C, Ferrari M. Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars. *Am J Dent* 2008;21:179-184.

Statistical Analysis and Commentary

A Fisher exact test was used to determine statistical differences in failure rates between the 2 test groups, and confidence intervals were also calculated. A Fisher exact test was chosen for statistical analysis because failures are relatively rare compared with the number of cases.

Overall failure rates were not statistically significantly different between the amalgam group and the post/resin composite group. However, there were statistically significant differences between the types of failures. Amalgam restorations were more likely to fracture, and post/resin composites were more likely to have recurrent caries.

Table 4. Frequencies, percentage, and mode of the failure that occurred during the 3-year follow-up

| Groups, residual coronal dentin | No post (subgroup A) | DT Light Post (subgroup B) | Ever Stick (subgroup C) | Total |
|---------------------------------|----------------------|----------------------------|-------------------------|----------------|
| 1. Four coronal walls | 0/20 | 0/20 | 0/20 | 0/60 |
| 2. Three coronal walls | 4/20 (20%) | 0/20 | 2/20 (10%) | 6/60 (10%) |
| 3. Two coronal walls | 7/20 (35%) | 0/20 | 4/20 (20%) | 11/60 (18.3%) |
| 4. One coronal wall | 8/20 (40%) | 1/20 (5%) | 6/20 (30%) | 15/60 (25%) |
| 5. Ferrule effect | 12/20 (60%) | 4/20 (20%) | 7/20 (35%) | 23/60 (38.3%) |
| 6. No ferrule | 14/20 (70%) | 6/20 (30%) | 9/20 (45%) | 29/60 (48.3%) |
| Total/subgroup | 45/120 (37.5%) | 11/120 (9.1%) | 28/120 (23.3%) | 84/360 (23.3%) |

Reproduced with permission from Cagidiaco MC, García-Godoy F, Vichi A, Grandini S, Goracci C, Ferrari M. Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars. *Am J Dent* 2008;21:179-184.

Decementation of crowns, as seen in other studies, does not occur with the bonded posts and cores. The less rigid post/composite restorations might wear more than if a crown were placed, but they also might transfer less stress to the fiber post and the remaining tooth structure. This might account for the absence of the post-core decementations and absence of root fractures in these restored teeth when left uncovered (no crown).

These findings must be taken into consideration in the restoration of endodontically treated teeth at the treatment planning stage of care. These findings should also encourage the clinician to assess carefully any failures that do occur and the circumstances surrounding them. Finally, the patient should have a careful examination at each re-examination period for teeth with fiber posts and composite restorations for the presence of secondary caries.

Analysis of Article #4

Placement of Fiber Prefabricated or Custom Made Posts Affects the 3-Year Survival of Endodontically Treated Premolars
Cagidiaco MC, García-Godoy F, Vichi A, Grandini S, Goracci C, Ferrari M—Am J Dent 2008;21:179-184.

Study Overview

Level of Evidence: Level 2

Purpose / Question: The purpose of this study was to assess whether the amount of residual coronal dentin and the placement of a prefabricated post (DT Light Post [LP]) or customized fiber post (Ever Stick Post [ES]) have a significant influence on the 3-year survival of root-treated premolars.

Source of Funding: None designated

Type of Study / Design: Randomized controlled clinical trial—low level

Title: The Placement of Prefabricated or Customized Fiber Posts Provide a Significant Contribution to the Survival of Root-Treated Premolars in the Presence of at Least One Coronal Tooth Wall

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Summary

Subjects

The subjects consisted of 345 patients who provided 6 groups of 60 premolars that needed root canal treatment. Patients' ages ranged from 18–76 years, with an average of 58 years. All teeth had to be in occlusal function, with a natural tooth in interproximal contact with 2 adjacent natural teeth. If the teeth were not already root-treated, they must have been symptom-free, with a minimum of a 4-mm apical seal, and no radiographic periapical lesion.

Procedures

Each of the 6 groups was defined on the basis of the amount of dentin left at the coronal level after root treatment and before abutment build-up (Table 3, Fig. 1). Within each group, teeth were randomly divided into 3 subgroups ($n = 20$). All teeth were restored with a single unit metal-ceramic crown. Clinical procedures were all performed by one operator. Patients were re-examined clinically and radiographically at 1, 6, 12, and 24 months. All evaluations were performed by examiners other than the operator, and findings were subjected to statistical analysis.

Main Outcome Measure

The main outcome measurements were tooth retention without evidence of post debonding, post fracture, vertical or horizontal root fracture, failure of the core requiring anew restoration, displacement of the crown, endodontic and periradicular conditions requiring endodontic revision.

Main Results

Data in Table 4 report the frequencies and percentages of the failures during a 36-month period, and data were not affected by any loss of patients to re-examination. The overall survival rate was 76.7%, with subgroup A having the lowest survival rate. Teeth in subgroup B had the highest survival rate (90.9%), with those in subgroup C having a survival rate of 76.7%.

In the presence of a post, no root fracture or failure of the abutment portion was recorded; all the failures were due to post debondings and occurred in teeth that presented with a reduced amount of residual dentin, with 1 wall at the most remaining coronally. All teeth with 4 walls of dentin survived the 3 years of clinical assessment. Thirteen root fractures and 32 crown displacements were observed.

Conclusions

During a period of 3 years, the placement of a prefabricated or customized fiber post was shown to provide significant support to the survival of root-treated premolar teeth. Preservation of at least 1 wall of coronal dentin significantly reduced the fracture of these teeth. Longer-term data will provide further evidence on the protective role of the ferrule in this type of restorative intervention.

Statistical Analysis and Commentary

To assess the influence of restoration type, amount of residual coronal dentin, and the interaction of the 2 variables on failure rate, a Cox regression model was applied. Cox regression implements the proportional hazards model or duration model and is designed for analysis of time until an event (the failure of the endodontic procedure). In addition, Kaplan-Meier plots were constructed by subgroup within each group for descriptive purposes. Teeth with the presence of some form of root canal retention had a statistically significantly higher survival rate. A statistically significantly higher survival rate was also found in teeth that had at least 1 intact dentinal wall.

No power analysis was provided that would indicate the "n" for a high level of significance. Once teeth were broken into subgroups, the sample sizes were small, which might not provide evidence for this finding at the highest level. However, the clinical application of techniques within would seem to be reliable and should be considered by clinicians when clinical options present themselves. Furthermore, the restorative evaluation of each tooth on the basis of remaining sound dentin is essential in all treatment planning schemes, along with the patient's occlusion and functional relationships.

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