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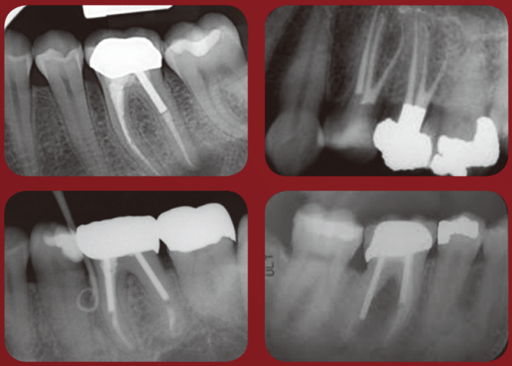

Restoration of Endodontically Treated Premolars and Molars: A Review of Rationales and Techniques Page 4

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Editorial

Traditionally, dentists' awesome responsibility is to keep patients' teeth as long and as many as possible. Therefore, caries prevention, proper defect filling, endodontic and periodontal treatment have been the main daily practice of a general dentist. Prosthodontists, especially fixed prosthodontists, are dental reconstruction providers, who restore the missing areas with sufficient supporting teeth. They look for proper ways to keep as many as possible supporting teeth for stronger and stable artificial dentition. Dental colleagues who paid much attention and effort on treating endodontically and periodontally compromised teeth are highly appreciated.

The introduction of implantology and the high success rate of implant supported dentition in recent 20 years raised a new trend of thinking that keeping teeth with relatively poor prognosis is much worthless than replacing them with implants. Although there is a wide grey zone of treatment philosophy between keeping a natural tooth with technique-dependent endodontic and/or periodontal approaches and remove that tooth and replaced with an implant, some implant-oriented dentists often discourage patients from taking long time conservative treatment, and take away that tooth to have better "bone preservation" for future implant insertion. This type of treatment philosophy seems to have some conflict with "tooth preservation" traditional thinking.

In this issue, two papers talked about endodontic treatment of teeth prepared to be abutments of a fixed bridge or a removable denture. They demonstrated that a careful evaluation and way of management with sufficient medication will preserve teeth and used as abutment teeth for a fixed bridge. The demand of implant will then be reduced. The authors emphasized the importance of preserving natural teeth even with longer treatment time and more energy consuming effort. I believe, the notion they put forth deserves the attention and consideration of prosthodontists and general practitioners.

Yuh-Yuan Shiau, DDS, MS. FICD
Editor in Chief

Review Article

Restoration of Endodontically Treated Premolars and Molars: A Review of Rationales and Techniques

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Abstract

Restorations of endodontically treated premolars and molars can be very different from restorations of anterior teeth. The complex root canal anatomies, limited interocclusal spaces and occlusal loads involved make premolar and molar restorations more challenging than those for anterior teeth. This article discusses the rationales and techniques of post/core fabrication, and a novel application of bonded ceramic restoration for posterior teeth.

Keywords: **post and core, fracture strength, endodontically treated teeth, resin cement**

Introduction

There are a variety of post and core related research studies in the literature discussing the effect of ferrule length, post type, length and diameter[1-3]. However, the sample or study models used in those studies often had a single root and straight canal. As such, information about the curved canals or multiple canals of premolars and molars is very limited. The complex root canal anatomies of posterior teeth, as well as the intensities and directions of the occlusal loads affecting them, make it difficult to utilize the same rules as are used for anterior teeth when fabricating posts and cores for posterior teeth restorations. Nevertheless, endodontic sealers, irrigants, intracanal medications, the grease of temporary cements and fit checkers have been found to negatively affect the bond between resin cement and root dentin surface. As such, it has been recommended that clinicians pretreat root dentin surfaces before post cementation to enhance the longevity of resin-dentin bonds[4]. This article will review the studies concerning post-core foundations for premolars and molars and the effects of root dentin treatment before post cementation.

The Complex Root Canal Anatomies of Posterior Teeth

The most common problems affecting the restoration of endodontically treated posterior teeth are as follows:

a. Multiple root canals with curvature
b. Intensity and direction of occlusal loading force
c. Limited interocclusal space
d. Accessibility

e. Difficulty in moisture control
f. Retention and resistance form
g. Tilting, supraeruption or crossbite
h. Occlusal interference

These specific factors in posterior areas can potentially negate the prognosis of the post and core. Thus, teeth with multiple root canals require a different treatment approach.

To build up an appropriate protocol for posterior teeth, there are many questions that need be answered:

1. Does root canal treatment alone weaken the fracture resistance of posterior teeth?
2. Does an endodontically treated tooth need a crown or onlay?
3. Do the post and core reinforce the tooth structure?
4. Can adhesive techniques influence fracture resistance?
5. What types of post materials make a difference?
6. What factors affect the cement-post interface?
7. Should pre-cementation surface treatment be applied to root canal dentin?
8. Should the same rules used for the post length for anterior teeth be applied for posterior teeth?
9. Should the post/core always be retrieved and the root canal retreated before remaking the crown?
10. What are the survival rates and prognoses for posterior posts and cores?

The removal of an old crown or fixed partial denture does not always validate the removal of an old post and core. There are indications for keeping the existing post and core foundation. First, the past root canal treatment must remain asymptomatic and imperviously sealed. One clinical investigation showed that a previous treatment that remained asymptomatic for more than 4 years did not require retreatment. Moreover, the previous fixed prostheses were stable without signs of loosening or marginal caries and prevented the core material from immersing in saliva. And most importantly, the post length and core morphology were appropriate and could provide retention/resistance form for fixed prostheses. However, in a case in which any of the aforementioned characteristics is uncertain, removal of the existing post/core is indicated.

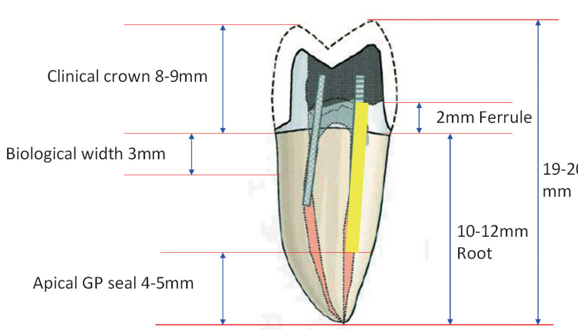


Fig. 1: Illustration of a premolar with root canal treatment and post length determination.

On the other hand, there are risks in post and core retrieval: loss of sound tooth structure, vertical root fracture, coronal leakage of the root canal filling and breakage of the post. As such, the patient should be carefully informed of these risks before commencing the procedure.

Premolars

The root canals of the maxillary premolars are relatively small and short compared with those of maxillary anterior teeth. More than two-thirds of maxillary first premolars and approximately half of maxillary second premolars have two canals. However, there is limited information provided in the literature about post and core foundations for teeth with more than one canal. The following discussion will review the classic studies and their clinical relevance in root canal treated (RCT) premolar restorations.

Post Length Determination

In a review, Goodacre[2] listed a number of opinions from earlier studies regarding what length the post should be, although some are in conflict with each other:

a. Equal to the clinical crown (Harper et al[5] 1976; Mondelli et al6 1971; Rosenberg[7] 1971)
b. Longer than the crown (Silverstein[8] 1964)
c. Equal to 1 1/3 of the crown length (Dooley[9] 1967)
d. 1/2 of the root length (Jacoby[10] 1976; Baraban[11] 1967)
e. 2/3 of the root length (Dewhirst[12] 1969; Hamilton[13] 1959; Larato[14] 1966; Christy[15] 1967; Bartlett[16] 1968)
f. 4/5 of the root length (Burnell[17] 1964)
g. Terminated halfway between crestal bone and apex (Perel[18] 1972; Stern[19] 1973)
h. 4-5 mm of gutta-percha to ensure apical seal (Goodacre[2] 1995)

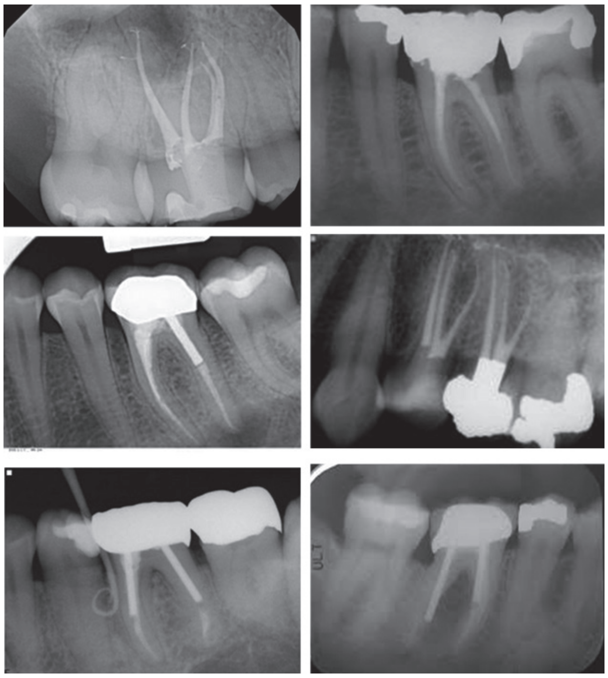


Fig. 2: The root canals of posterior teeth are usually curved. Placing a straight post passing through the middle of the root may result in canal stripping or perforation.

The most commonly quoted rule is that 4-5 mm of gutta-percha should remain to ensure the apical seal. However, keeping suitable apical seal does not always guarantee post retention and resistance. Thus, some clinicians prefer a length of 2/3 of the root length or equal to the clinical crown, while others feel that more than one rule should be followed.

The author found that some of the rules are corresponding and indicate a range of post lengths for premolars. Figure 1 illustrates a two-canal premolar with a 2-mm ferrule and post. In a regular length of premolar (19-20 mm), the root is often 10-12 mm long and the clinical crown above the cemento-enamel junction is approximately 8-9 mm. Subtracting 4-5 mm of gutta-percha length, the distance from the top of the ferrule to the bottom of the post space ranges from 7 to 10 mm. This number is about the length of the clinical crown (8-9mm) and also 2/3 of the anatomic root length. It may be safe to state that the post length in a normal size premolar is approximately 8-9 mm counting from the ferrule. This length can be a starting reference for preparing the post space before radiographic confirmation.

When dealing with some posterior teeth with curved root canals (Fig. 2), one must be cautious in preparing the post space. The potential complications are as follows:

a. Straightening/stripping of the curve canals
b. Over-enlargement
c. Loss of apical seal
d. Coronal microleakage
e. Perforation or weakening of the root canal wall
f. Debris/bacteria trapped at the end of the post
g. The edge of the core interferes with the fit of the crown margin to the tooth structure

Therefore, following the previously mentioned rules to create a long post space in these cases could jeopardize the strength and integrity of the canal system. In the worst situation, the post compromised the prognosis by causing root fracture and apical pathosis. Some clinicians try to place a very short post or screw post with active engagement force into root dentin. These approaches may lead to catastrophic failure of restorations, microleakage, caries or root/furcation damage to posterior teeth. A proper post length and the appropriate type of post/core material to use may vary from one patient to another. One must evaluate all potential risk factors in each individual.

Generally, a straight post can only extend to the start of the root canal curvature. Otherwise, it could weaken the root strength. For premolars and molars, pulp chamber space becomes important for assisting the retention of core material. The use of resin or ceramic core bonded to the residual dentin wall can further reinforce the retention.

Fracture Resistance

Various researchers have previously investigated the change of dentin strength after root canal treatment. Gutmann[20] (1992) concluded that the three major factors identified in the past research as contributing to tooth structure weakening are as follows: (1) the loss of approximately 9% of moisture; (2) decreased dentin strength; (3) changes in collagen cross-linking.

However, there was no scientific assessment of the accuracy of these changes. At present, architectural changes and the loss of structure integrity are considered the major factors affecting the fracture resistance of endodontically treated teeth.

Reeh[21] (1989) pointed out endodontic procedures reduced stiffness by only 5%, whereas MOD cavity preparation reduced it by 63% in premolars. Panitivisai and Messer[22] (1995) performed a similar study on molars. Endodontic access led to two- to three-fold increases in cuspal flexure as compared to the flexure resulting from MOD cavity preparation in molars. These two studies showed the differences between premolars and molars in terms of tooth structure loss and changes in fracture strength resulting from endodontic procedures. The occlusal load and caries risk may contribute to the damage of root canal treated molars. A full coverage crown or an onlay seems to be more necessary in molars compared with premolars.

Another important question has also been asked: "Can a post improve the fracture resistance of a root canal treated tooth?"

Trope[23] et al (1985) determined that preparing a post space weakened endodontically treated teeth compared with ones in which only an access opening, but no post space, was made. Fernades[24] et al (2001) and Heydecke[25] et al (2002) reviewed the literature and concluded that the use of a post and core does not strengthen RCT teeth; rather, it may contribute to the weakening of tooth structure as the forces placed upon the prosthetic crown are transmitted into the root canals and remaining coronal dentin. Therefore, preservation of the remaining tooth structure is the most critical factor. Post shape plays a significant role in the etiology of the root fracture. Vertical root fractures are a common complication in teeth with snugly fitted posts.

Crown after RCT?

There is convincing evidence that cuspal coverage increase the survival of posterior teeth (Schwartz & Robbins[26], 2004). Endodontically treated molar teeth should receive cuspal coverage, but in most cases, do not require a post. Unless the destruction of the coronal tooth structure is extensive, the pulp chamber and canals provide adequate retention for a core buildup.

Molars must resist primarily vertical forces. In those molars that do require a post, the post should be placed in the largest, straightest canal, which is the palatal canal in the maxillary molars and a distal canal in the mandibular molars. Rarely, if ever, is more than one post required in a molar.

Aquilino and Caplan[27] (2002) studied factors affecting RCT teeth survival and found that, controlling for tooth type and caries, teeth which were not crowned after RCT were lost at a rate 6.0 times greater than those that were crowned.

Scotti et al[28] (2013) evaluated the influence of adhesive techniques on fracture resistance. In specimens with a cavity wall thickness >2 mm, direct intracuspal composite resin restorations supported by a fiber post achieved comparable fracture resistance with that of unprepared teeth. With a residual wall thickness of less than 2 mm, only cuspal coverage with or without a fiber post provided satisfactory fracture resistance.

The remaining wall thickness could be an important clinical parameter in deciding how to restore endodontically treated premolar teeth.

Post Selection

There are three major types of posts, each consisting of different materials:

- Metal posts consisting of casting alloy or stainless steel
- Fiber posts consisting of carbon fiber, glass fiber or quartz fiber reinforced with resin composite
- Ceramic posts consisting of zirconia

Metal posts, including casting or prefabricated posts, have a long history of success. Their high mechanical strength and rigidity can withstand occlusal loads and maintain retention and stability in the root canal. However, the modulus of elasticity for such posts is significantly higher than that of dentin and so this type of post transfers stress along the root and may cause vertical fractures.

In contrast, the elastic modulus and mechanical properties of fiber posts are similar to those of dentin. Some authors claim that the assembly of a fiber post and resin core bonded to remaining tooth structure can form a "monoblock." It is believed that a monoblock provides functional integrity in occlusion. The occlusal stress can be homogeneously distributed inside the restoration and RCT teeth. However, a monoblock relies on a durable post-core-dentin bond and this bond must be sustained against occlusal force and moisture. Further investigations are still needed to determine the clinical relevance of the monoblock concept.

Zirconia posts with glass ceramic cores have been introduced recently. It has been reported that zirconia posts are very brittle and require substantial post space preparation to maintain the optimal diameter and strength. A broken zirconia post is very difficult to retrieve. As such, it is recommended that such posts only be used in esthetic areas without intensive occlusal loads.

Post Cementation

Post retention is a critical factor in the prognosis of fixed prostheses. Except for mechanical retention provided by the post length and shape, the use of resin cement bonding to the post and to the root dentin has been advocated to enhance the chemical and micro-interlocking retention (Fig.3). It seems the resin matrix of fiber posts can optimally bond to resin cement without any adhesive or pretreatment. However, some types of fiber posts have an epoxy resin matrix (e.g., RelyX post, 3M ESPE), and do not chemically bond with the methacrylic bases of most resin cements. Others have a highly polymerized and cross-linked dimethacrylate matrix which may not retain much functional double bond residue (e.g., FRC-Plus post, Ivoclar-Vivadent). There are several ways to increase the shear bond strength between resin cement and a fiber post. One of them is blasting the fiber post with a Cojet system (3M ESPE) to roughen the surface so that the embedded ceramic layer enables silane coupling with the resin composite for a true chemical bond.

Self-etching resin cements and self-adhesive cements have been advocated in post cementation recently for their excellent strength and clinical convenience. Self-adhesive cements eliminate the procedure of etching and bonding adhesive application. Phosphate monomers and silane coupling agents are added in the cement base to enhance the bond strength to the root dentin, ceramic or metal substrate. Two of the most commonly added phosphate monomers in the primer or cement base are 10-methacryloxydecyl dihydrogen phosphate (10-MDP) and 6-methacryloyloxyhexyl phosphonoacetate (6-MHPA) (Fig. 4,5). The phosphate group bonds to metal oxide, zirconia, alumina and porcelain glass matrixes (Table 1).

It has been reported that the quality of the resin-dentin bond may not be homogeneous along all portions of the root canal. Pereira et al[29] (2013) tested the push-out bond strength of different luting agents used to cement fiber posts. The roots were sectioned to upper, middle and lower segments. Dual-polymerizing resin cements provided significantly lower mean bond strength compared to self-adhesive cements and glass ionomer cements. Dual-

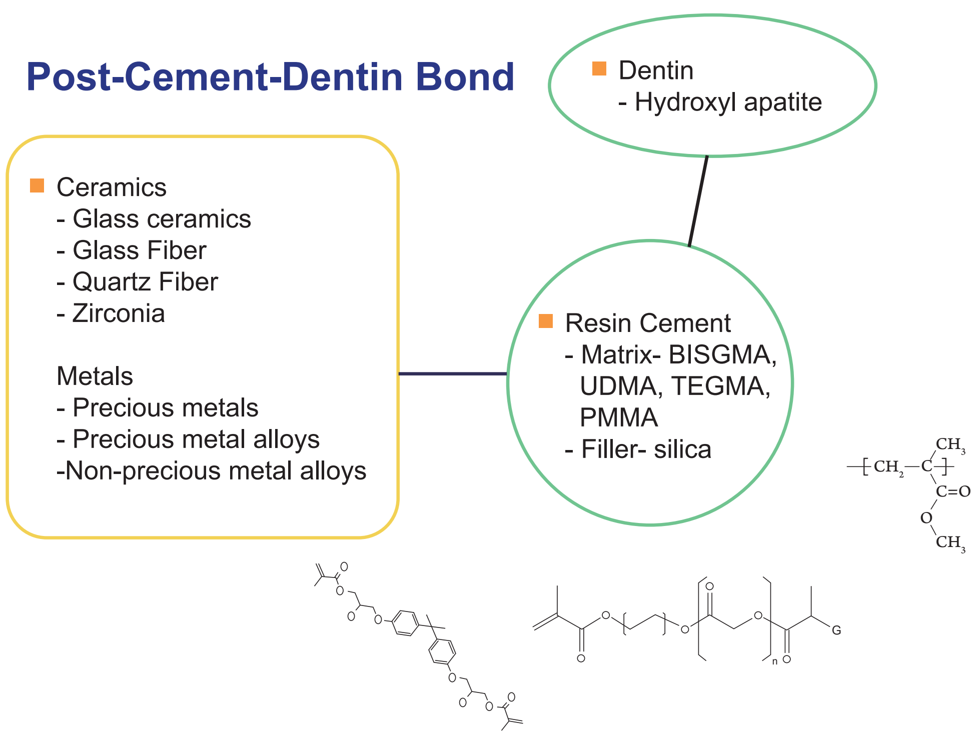


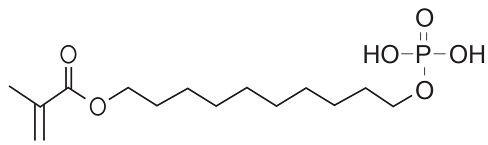
Fig. 3: Post-cement-dentin bond

Table 1: A list of commercial resin cements with phosphate groups

Primer	Self-adhesive Cement
Metal / Zirconia Primer (Ivoclar Vivadent) Monobond Plus (Ivoclar Vivadent) Clearfil Ceramic Primer (Kuraray) Signum Zirconia Bond (Heraeus) AZ Primer (Shofu) ZPrime Plus (Bisco) Alloy Primer (Kuraray) Estenia Opaque Primer (Kuraray) Single Bond Universal (3M)	Panavia 21 (Kuraray) BisCem (Bisco) G-Cem (GC) Clearfil SA Cement (Kuraray) RelyX Unicem/U-100/U-200/Ultimate (3M ESPE) MaxCem (Kerr)

Phosphate monomers

- 10 - Methacryloxydecyl Dihydrogen Phosphate (10-MDP)



- 6 - Methacryloyloxyhexyhexyl Phosphonoacetate (6-MHPA)

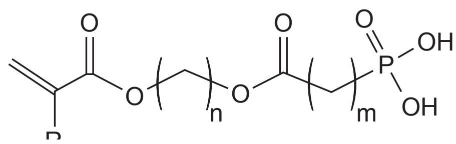
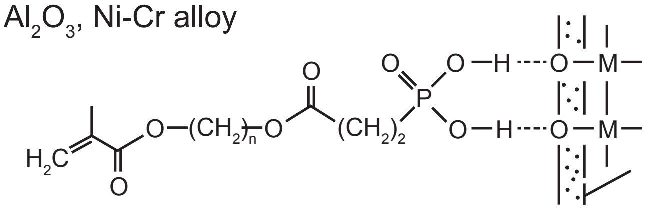


Fig. 4: Two of the most commonly used phosphate monomers in adhesive systems: 10-MDP and 6-MHPA.

Phosphate monomers

- The phosphate group bonds to metal oxides
  -ZrO, Al_2O_3, Ni-Cr alloy



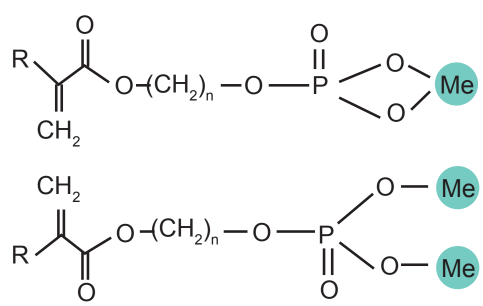


Fig. 5: Phosphate group bonds to metal oxide or ceramic oxide.

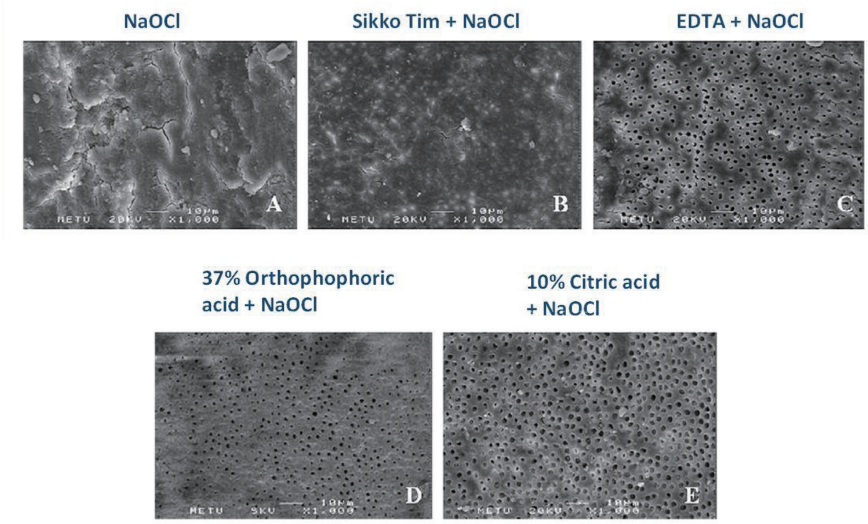


Fig. 6: SEM photographs of root dentin treated with various surface treatments. Quoted from Demiryürek et al[30] (2009).

polymerized resin cements (e.g., Duo-Link) demonstrated decreasing bonding quality from the upper segment (11.5±7.3MPa) to the lower segment (3.1±2.1MPa). This may have been due to the difficulty in obtaining a reliable adhesive interface, even with a systematic 3-step adhesive system. On the contrary, resin-reinforced glass ionomer (RelyX Luting, 3M ESPE) showed increasing bonding strength from the upper (8.2±5.8MPa) to the lower segment (12.8±4.8MPa). Therefore, these results raise some interesting questions:

- "How should the root canal dentin be treated and cleansed before post cementation?"
- "Does the irrigation solution used in the root canal treatment affect the resin-dentin bond?"
- "Does resin cement give better post retention than glass ionomer cement?"

The dentin surface in the root canal is often smeared by canal sealer, gutta-percha, temporary cement, and the grease of an impression material or fit checker. It seems reasonable that phosphate etching and sodium hypochloride or chlorhexidine irrigation can be helpful to remove contamination and any smear layer before post cementation. However, some investigations have demonstrated that pretreatment with etching or irrigation may negatively influence the resin cement bond efficacy.

Demiryürek et al[30] (2009) evaluated the push-out bond strength (MPa) of fiber posts to root dentin after four surface treatments. Sikko Tim (16.5±1.7) was the most effective surface treatment agent compared with EDTA (4.1±0.8), orthophosphoric acid (12.2±1.8), citric acid (12.1±2.4), and a control (3.9±1.7); however, it could not remove the smear layer and sealer remnants effectively on radicular dentin surfaces (Fig.6). The researchers concluded that removal of the smear layer and opening of dentinal tubules are not recommended when a self-etching/self-priming adhesive system is used. For a self-etching system, the additional application of phosphate or citric acid on root dentin was found to decrease the bond strength in this study.

Another study[31] evaluated the effect of traditional irrigants on the bond strength of self-adhesive cement. Snowlight glass fiber posts were luted with self-adhesive resin cement (Clearfil SA Cement, Kuraray Medical Inc., Japan). The push-out bond strengths of pretreatment with phosphate (6.96±2.44 MPa) and diode laser (8.93±1.81MPa) were significantly higher than those of pretreatment with sodium hypochlorite (3.00±1.53 MPa) or EDTA (4.45±0.92 MPa).

Di Hipolito et al[32] (2012) pointed out that the microtensile bond strengths of self-adhesive luting cements (RelyX U100, 3M ESPE ; Multilink Sprint, Ivoclar Vivadent) to dentin pre-treated with 2.0% and 0.2% concentrations of chlorhexidine (CHX) solutions were significantly lower than those found for both of the control groups in their study. Pre-treatment of dentin with 0.2% or 2.0% CHX adversely

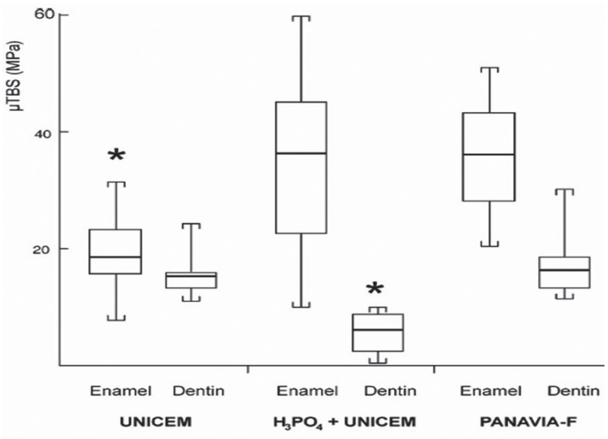


Fig. 7: Surface treatment with phosphoric acid significantly reduced the dentin bond strength of self-adhesive cement. Although acid etching increased enamel bond, there is little benefit to post cementation in the root canals. Quoted from De Munck et al[33], 2004.

affects the bonding efficacy when associated with the self-adhesive cements tested. EDS/SEM analysis exhibited varied concentrations of chlorine ions and crystal-shaped precipitates, depending upon the CHX concentration.

De Munck et al[33] (2004) found that acid etching prior to the application of RelyX Unicem raised the enamel microtensile bond strength to the same level as that of the control, but was detrimental for the dentin bonding effectiveness (Fig.7). The latter must be attributed to inadequate infiltration of the collagen mesh as revealed by field-emission scanning and transmission electron microscopy. Morphological evaluation additionally revealed that RelyX Unicem only superficially interacted with enamel and dentin, and that application using some pressure is required to ensure close adaptation of the cement to the cavity wall.

Erdemir et al[34] (2004) treated root canal dentin walls of the extracted single-rooted teeth with 5% sodium hypochloride (NaOCI), 3% hydrogen peroxide (H_2O_2), a combination of H_2O_2 and NaOCl, or 0.2% chlorhexidine gluconate for 60 seconds. The root canals were obturated using C&B Metabond (Parkell), a conventional etch/priming adhesive cement. The results indicated that NaOCI, H_2O_2, or a combination of NaOCl and H_2O_2 treatment decreased the microtensile bond strength to root canal dentin significantly. The teeth treated with chlorhexidine solution showed the highest bond efficacy. It was concluded that chlorhexidine is an appropriate irrigant solution to maintain the bonding effectiveness of etch-and-rinse resin adhesives[3].

The clinical implications extracted from these previous studies are as follows:

- For conventional three-step adhesive resin cements, sodium hypochloride (NaOCl) irrigation negatively influenced the bond strength, while chlorhexidine (CHX) rinsing was considered to be an appropriate irrigant.
- For self-etching or self-adhesive cement:

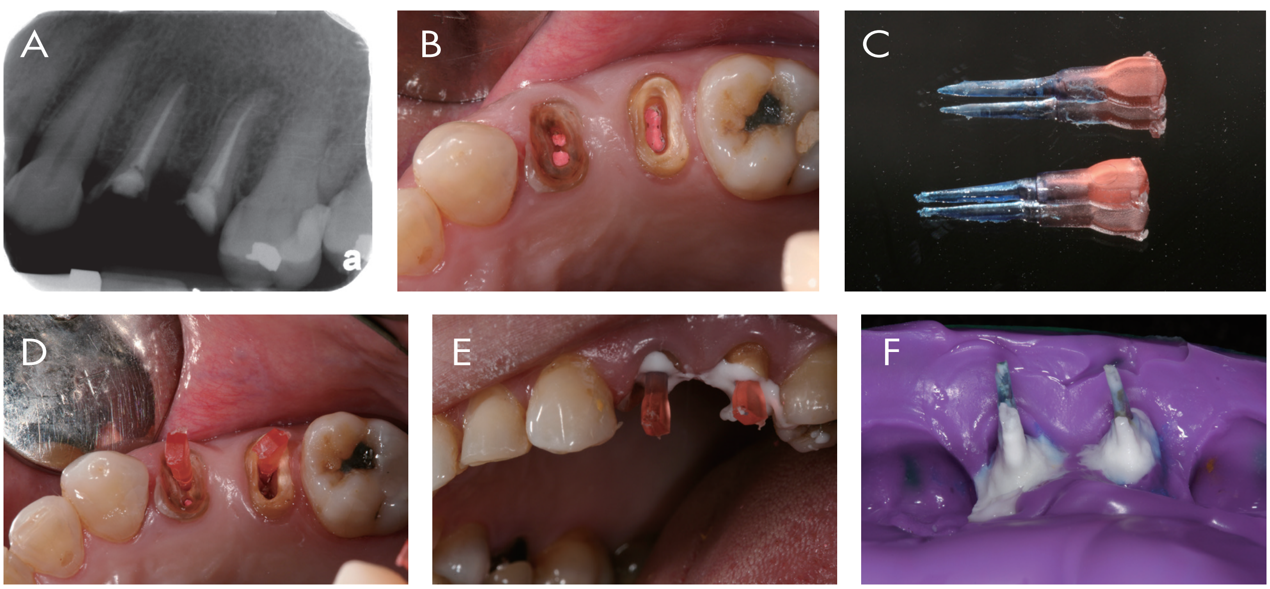


Fig. 8: Indirect technique for multiple cast posts fabrication on maxillary premolars: After tooth preparation A, B, plastic posts (C) were used for canal impression with light-body PVS or Fit Checker (GC), (D-F).

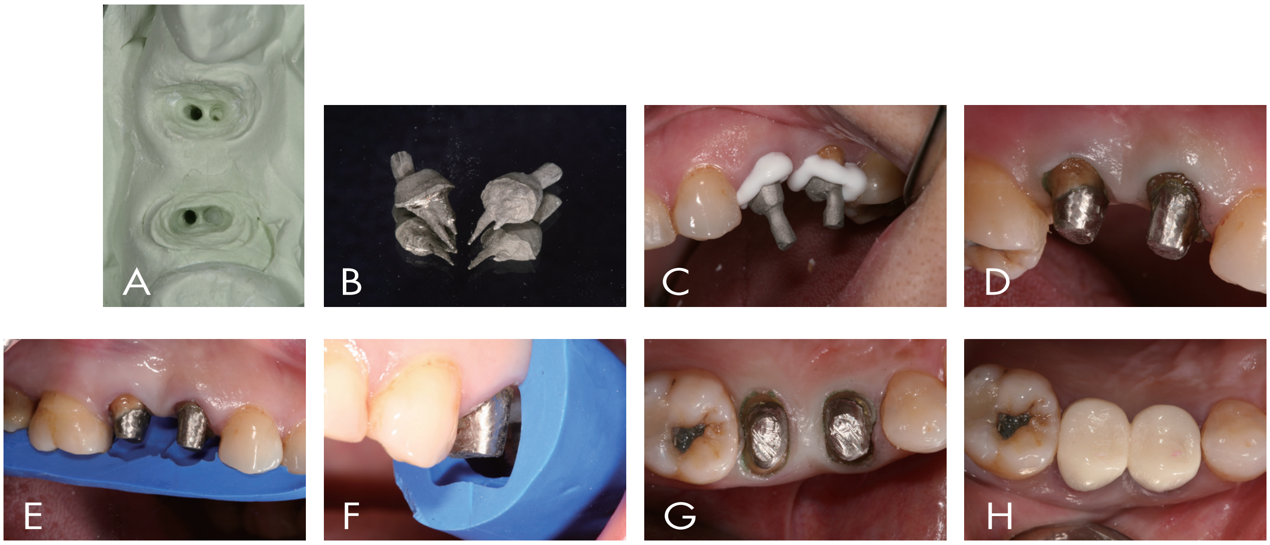


Fig. 9: Indirect technique for multiple cast posts fabrication: The impression was poured with die stone. (A) Resin patterns were made on the master cast. (B) It should be noticed that long post only fully extended to one canal and half length or shorter in the other canal for stability and antirotation. (C-D) The cast posts and cores were inserted and examined for the adaptation clinically. (E-H) Restorative space was evaluated with putty matrix before final cementation.

- CHX irrigation decreased the microtensile bond strength.
- Acid etching to remove the smear layer and open the dentinal tubules did not improve the bond efficacy and must be performed with caution.

Figures 8A-F and 9A-H illustrate the fabrication of multiple cast posts with indirect methods including impression with PVS or fit checker with pins or plastic posts, patterns made on a master cast and cast post cementation.

In summary, the strategy to restore premolars with two canals generally follows the principles described in the post and core studies. A post should never be placed over the curvature of a canal. The optimal length is approximately 8-9 mm counting from the 2-mm ferrule. A post and core does not reinforce the RCT teeth and a crown or onlay is suggested in RCT premolars or molars. Pretreatment of the root canal before post cementation significantly affects the bond strength of resin cement.

Molars

Anterior teeth and premolars with coronal destruction generally require a dowel. However, RCT molars normally have three or more root canals. These narrow and curved canals make it difficult to place a dowel into an optimal length. On the other hand, there is usually sufficient depth and width of the pulp chamber to provide adequate retention and resistance of the core foundation without a post (Nayyar et al[35] 1980; Kane et al[36] 1990; Hunter et al [37,38]1988,1989; Goodacre et al[40] 1994; Schwartz et al[26] 2004). The root canals of molars are anatomically more complex and narrow than those of anterior teeth and premolars. So, the insertion of a post with an appropriate length is likely to strip or weaken molar root canals during the insertion. In situations in which post insertion is attempted to improve core retention, only maxillary palatal canals or mandibular distal canals are suitable for post cementation. In most RCT molars, direct core material buildup with the use of the pulp chamber works well without posts.

A maxillary first molar with endodontic access and one to four axial wall defects is shown in Fig.10-16 as a visual reference for discussing treatment strategies for molar posts and cores:

- 3-wall:
  - Direct core buildup (Fig.10A-F)
  Even with one wall missing, the 2-3 mm pulp chamber depth can provide good retention and resistance form (Fig.11).
- 2-wall:
  - With 2 opposing walls: Direct core buildup (Fig.12)
  - Without 2 opposing walls: Direct core buildup or a post cementation in the largest canal (Fig.13)
- 1-wall:
  - Direct core buildup with a post cement-

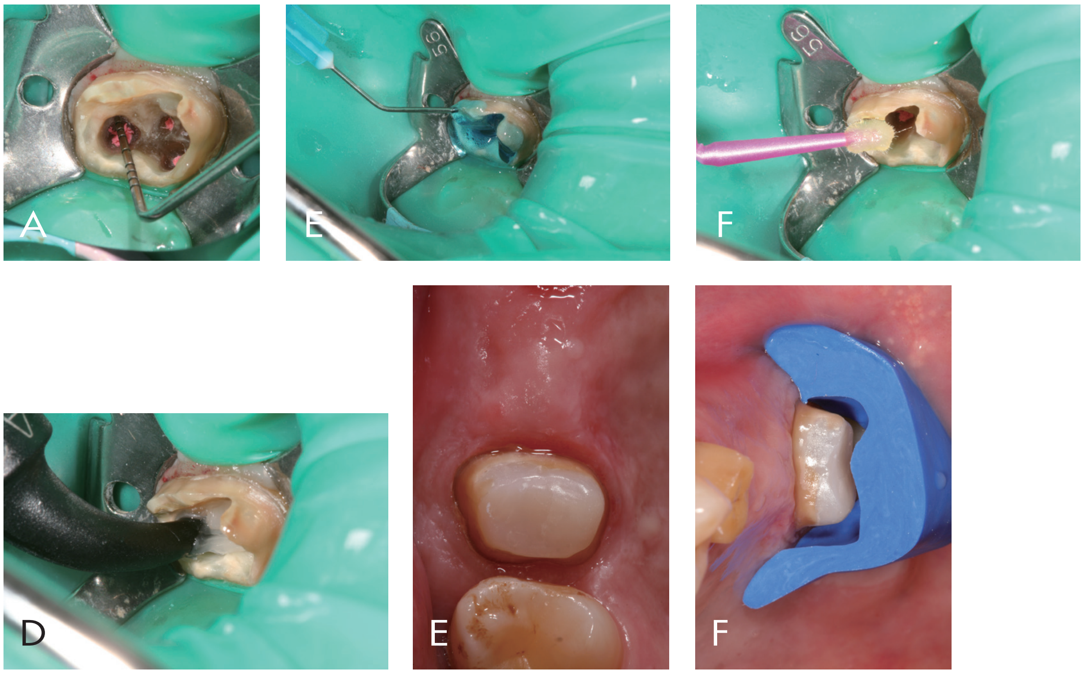


Fig. 10: In situations in which all the walls have been destroyed, a post with bonded resin core or a cast post and core are treatment options. Under rubber dam isolation, the molar was etched, rinsed and coated with adhesive. SonicFill (Kerr) bulk-fill resin composite core was built up.

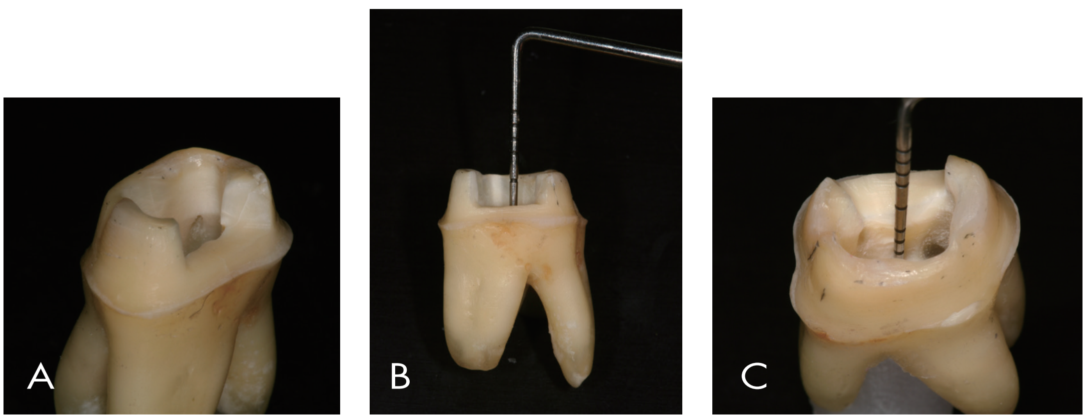


Fig. 11: The depth of pulp chamber from CEJ is approximately 2-3 mm

ed in the largest canal (Fig.14)
- Direct core buildup for molars with short clinical crown
- Cast post and core

- 0-wall:
  - Direct core buildup with a post cemented in the largest canal (Fig.15)
  - Cast post and core with a post/pin (Fig.16A-G)

For adequate crown retention, the height of a prepared molar generally ranges from 3-6 mm. The 2-3 mm depth for a pulp chamber can usually assist another 2-3 mm buildup from the top of residual axial walls. Therefore, for 0-wall RCT molars with relatively short clinical crown heights, direct core buildup with or without a prefabricated post is recommended.

If all four axial walls of RCT molars have been destroyed and there is no sufficient chamber space, a cast post and core assisted with a post can provide adequate retention and stability (Fig.16A-G).

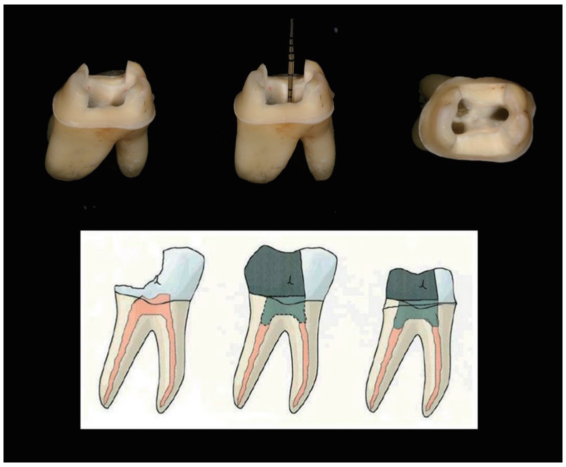


Fig. 12: Two-wall defect with the remaining two walls opposing to each other: amalgam or resin dowel and core is indicated. No post is needed.

Fig. 13: Two-wall defect without opposing walls: a prefabricated post cemented in the largest canal can be considered.

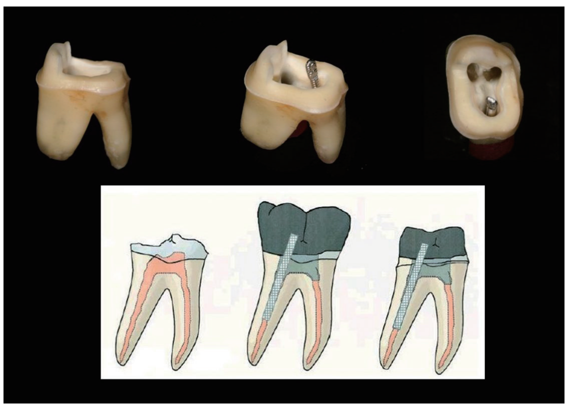


Fig. 14: One-wall defect: A post placement in the canal against the remaining wall.

Fig. 15: 0-wall defect: To assist the retention of core material, a post is placed in the largest palatal canal. For the other two canals, approximately 2-4 mm gutta percha should be removed from the canal orifice.

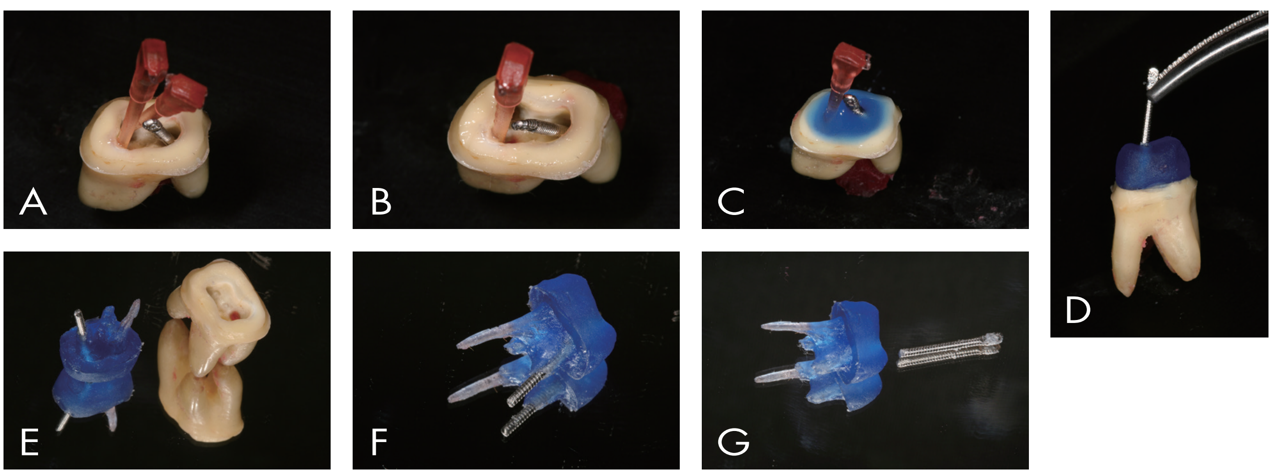


Fig. 16: Demonstration of procedures to make a cast post and core pattern with a pin or prefabricated post.

Core Materials for Molars

Traditionally, there are three major types of direct core materials:

- Amalgam: Adequate strength, good sealing, delayed preparation.
  Appropriate for use in high stress areas and areas with minimal remaining tooth structure.
- Composite resin: Adequate strength, rapid set, immediate preparation, bond to dentin, polymerization shrinkage, hydrophilic, requires strict isolation.
  Appropriate for use in esthetic areas and areas in which substantial coronal tooth structure remains.
- Glass ionomer: Poor strength and high rate of defects.

Amalgam is a core material with long history of success. Although some clinicians have questioned the safety of mercury, there has been no sufficient evidence or report of its toxicity in dental use. Nayyar et al[35] (1980) advocated an amalgam coronal-radicular dowel and core technique. They recommended that two criteria be met:

1) The size of the remaining pulp chamber should be of sufficient width and depth to provide for adequate bulk of amalgam and for retention.
2) Adequate dentin thickness in the area of the pulp chamber is required for rigidity and strength.

The amalgam dowel and core can be completed at the end of the obturation appointment. All gutta-percha should be removed from the pulp chamber and to a depth of 2-4 mm into each canal. If needed, a matrix band or copper band should be placed. Amalgam is condensed into the canals with a periodontal probe or root canal plugger and into the pulp chamber and remaining cavity by conventional methods. The procedures should be performed under rubber dam isolation or strict isolation from saliva and bacteria. If fast-setting amalgam is used, the tooth may be prepared for a cast restoration immediately after hardening, and a final impression can be made at the same appointment.

Over a four-year period, approximately 400 restorations of this type had been placed by Nayyar et al without any failures attributable to the amalgam dowel and core reported.[35]

Resin composite cores have gained in popularity over the last decade for their relative safety and ease of buildup. The bonding procedures of a composite core are similar to those for a cavity filling. The residual sealer, gutta-percha or temporary restorative materials should be removed with diamond burs and EDTA. The dentin of the pulp chamber and root canal is then etched and primed carefully. Adhesive application, incremental buildup and sufficient light polymerization are critical.

A sonic-activated bulk fill composite resin (SonicFill, Kerr) has been introduced that enables cavities to filled up to 5 mm. The change in viscosity under ultrasonic vibration and the component of shrinkage stress reliever were claimed to improve the marginal adaptation and reduce polymerization stress. Figure 10A-F demonstrates the clinical procedure of resin core buildup with SonicFill.

Resin-Bonded Ceramic Post Crown

It is not uncommon to see RCT molars with a very short crown height (<3mm) and limited restorative space, e.g., second molars with thick and dense periodontal soft tissue or a severely worn dentition. After tooth preparation, the remaining axial wall is too short to provide crown retention. Except for clinical crown lengthening procedures, a post and core crown integrating the post, core and crown as one unit is another treatment option. By expanding the crown into the pulp chamber and root canal, the retention, stability and bulk strength are improved. However, a previous investigation raised concerns about poor adaptation and long-term survival rates. The major problem of a post-core crown restoration is the casting inaccuracy. A full-coverage crown is generally made to have some expansion to compensate for alloy shrinkage and ease of insertion. This expansion also made the post portion of a post crown difficult to fit into the pulp chamber.

The author of the present review has demonstrated a novel technique of a resin-bonded lithium disilicate post-core crown. With the use of heat-pressing (Fig.17A-I) and CAD/CAM (Fig.18A-I) techniques, the volumetric change of restorative materials was decreased. The coefficient of thermal expansion (CTE) of lithium disilicate (Emax, Ivoclar Vivadent) is 10.2×10^{-6}, compared with a CTE of 13.8-15.2 $\times 10^{-6}$ for high gold alloy. The pressing temperature of emax is 920℃, which is also lower than the casting temperature of ceramic alloy (1450℃). With a decreased temperature gradient and controlled cooling contraction, the internal adaptation and marginal integrity were

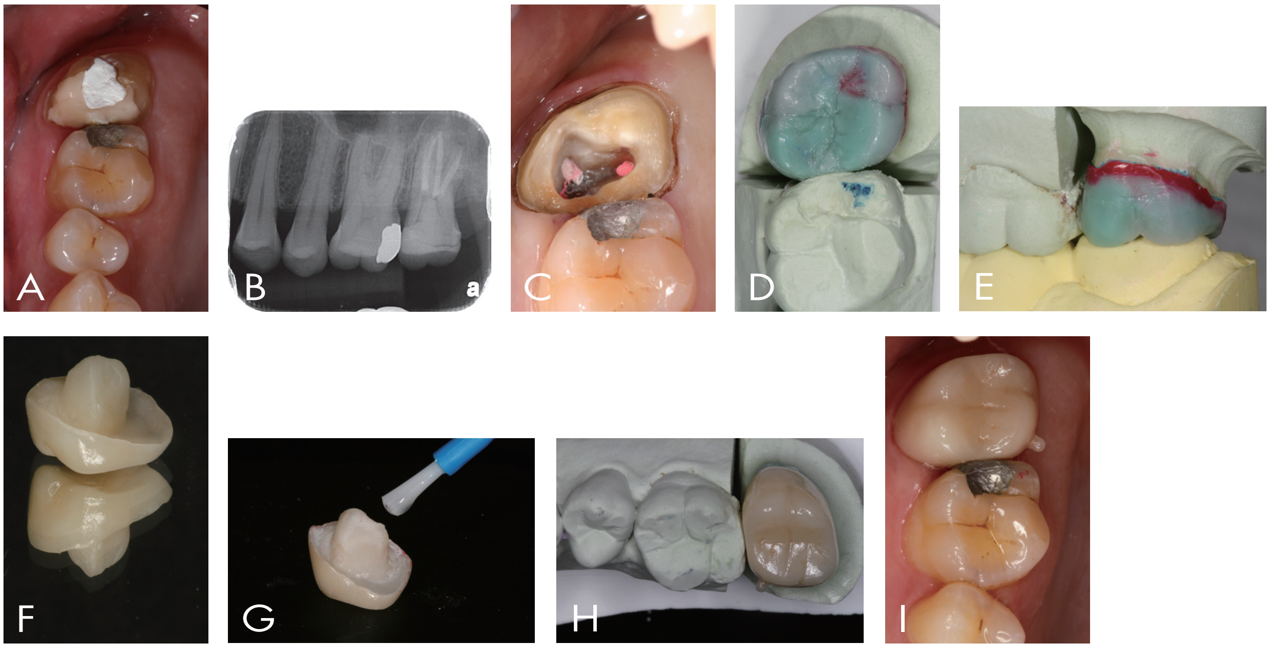


Fig. 17: (A-B) A maxillary RCT second molar with insufficient crown height. (C)The restorative material and gutta percha in the pulp chamber were removed and impression was taken. (D-E) Post and crown wax pattern was made to evaluate the retention, occlusion and morphology. (F) The pattern was invested and heat-pressed with lithium disilicate. (G) Inner surface was etched with hydrofluoric acid and treated silane coupling agent. (H-I) Final restoration and clinical insertion.

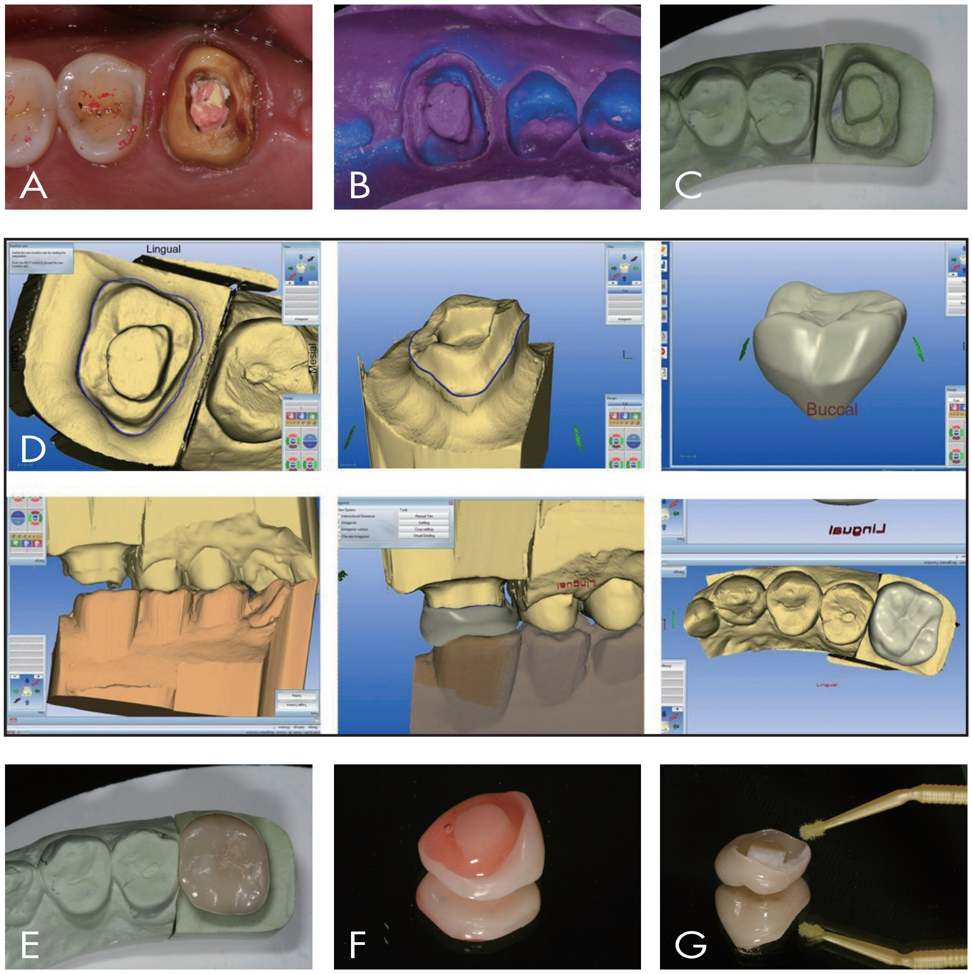
improved. As for CAD/CAM manufacturing, concerns regarding dimensional change can be ignored as the ceramic ingots were milled at room temperature. However, scanning accuracy and meticulous tooth preparation to eliminate any sharp edges are critical.

In the case presentation of ceramic post-core crown(Fig.17A-I, Fig.18A-I), the endodontic access of RCT molars were first opened and restorative material in the pulp chamber were removed. It is not necessary to remove the gutta-percha in the root canals. Engaging the root canal may create a large undercut and the micromechanical bond to pulp chamber structure is sufficient to this crown design. The teeth were prepared and final impressions with polyvinyl siloxane were taken. A wax pattern on the working cast was made for occlusal and morphologic evaluation. For heating-pressing methods, the wax pattern was invested following the manufacturer's instructions (Fig.17). For the CAD/CAM technique, the cast and the wax pattern were both scanned to assist ceramic block milling. Lithium disilicate post-core crowns were then fabricated and etched with hydrofluoric acid for 90 seconds before cleansing in an ultrasonic water bath. The molar was then conditioned with phosphoric acid and thoroughly rinsed. Single Bond Universal adhesive(3M ESPE) was applied on the teeth and the internal surfaces of post-core crowns. The silane coupling agent and phosphate monomer in this adhesive can enhance the bond between emax and resin cement. The final restorations were finished, cemented and adjusted for occlusion.

Monolithic lithium disilicate was selected as crown material because its glass matrix enables the acid etching and chemical bonding. Clinical studies also recognized its optimal strength and long-term survival. This technique offers a solution to insufficient retention for extremely short RCT molar crowns. It also avoids the need of resective surgery and the delay of wound healing.

Conclusions

- The optimal post length of two-canal premolars generally ranged from 8 to 9 mm, including 2 mm ferrule and the root canal space deducting 4-5mm of apical gutta-percha.
- Root canal pretreatment with acid etching, sodium hypochlorite or chlorhexidine irrigation may negatively affect the resin cement bond strength.
- In RCT molars, there is usually sufficient depth and width of the pulp chamber to



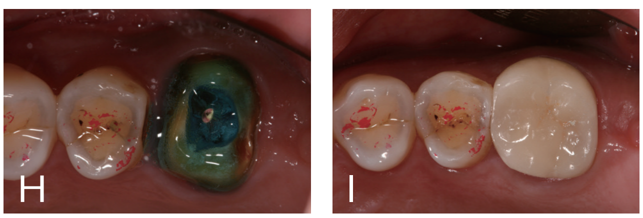


Fig. 18: (A-C) Presented a RCT maxillary first molar with limited interocclusal space. The pulp chamber was prepared and final impression was taken. (D-E)The core-crown was fabricated with Cerec 3D system (Sirona). (F-I) Final restoration was pretreated and cemented with self-adhesive resin cement.

provide adequate retention and resistance of the core foundation without a post.

- Resin-bonded lithium disilicate post and core crowns were demonstrated as an alternative technique to restore RCT molars with limited clinical crown height.

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Original Article

The Influence of Implant Surface Characteristics on Stress Distribution in Areas of Poor Quality Bone Under Lateral Loading: An in Vitro Study of Machine-Thread and Sintered Porous Surface Texture

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Abstract
The purpose of this study was to examine the influence of implant surface characteristics on stress distribution in areas of poor quality bone under lateral loading. Comparisons were performed with porous surface implants and machined-surface implants with strain gauges on the in vitro bone analog. The results suggest that porous surface implants have the advantage of distributing stress to bone around the implant more evenly than machined-surface implants, especially in the case of poor quality bone.

Key words: implant, surface characteristics, stress distribution, in vitro study

Introduction

The advantages of a rough surface over a machined surface include increases in the surface area, the initial bone-implant contact, the rate of bone formation, and the initial stability for immediate loading.[1] Deporter et al[2] suggested that rough surfaces have a better prognosis than machined surfaces with functional loading; however, few studies have examined the biomechanical influences involved.

Unlike other features of implants such as diameter and length, it is not possible to simulate the microstructure of rough surfaces using three-dimensional finite element models. In vitro models that simulate bone analogs should therefore be considered when examining the biomechanical significance of such implants under unfavorable loading configurations. The purpose of this study was to examine the influence of implant surface characteristics on stress distribution in areas of poor quality bone under lateral loading.

Materials and methods

Two types of (12 × 4mm) implants, one with a porous surface without thread (Group I)(Endopore; Innova, Toronto, Canada) and the other with a machined surface with thread (Group II) (GC; Tokyo, Japan), were embedded in a (20 × 20 × 17mm) block constructed with auto-polymerizing resin material to simulate poor quality bone.[3] Healing

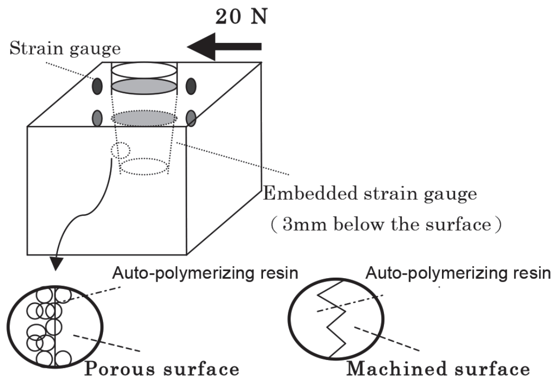

Fig. 1: Illustration of the measurement model and test conditions. Left: porous-surface implant Right: machined-surface implant. Major stress concentration around the neck area was measured using strain gauges placed 3mm away from the edge of the implant. A lateral force of 20N (arrow) was applied to the tip of the abutment.

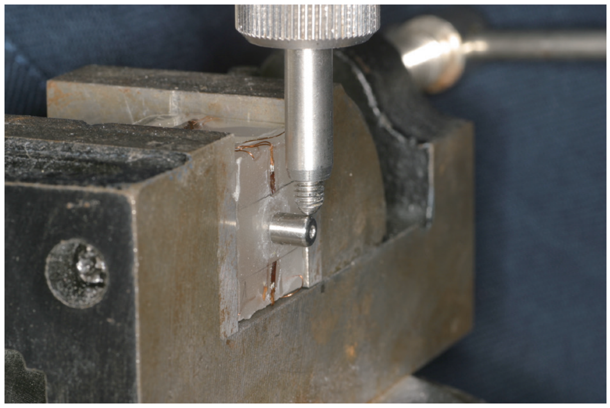

Fig. 2: A model mounted on a lever-type testing machine. Non-impact lateral force of 20N was applied perpendicular to the superstructure, and static strain was recorded for 30 seconds.

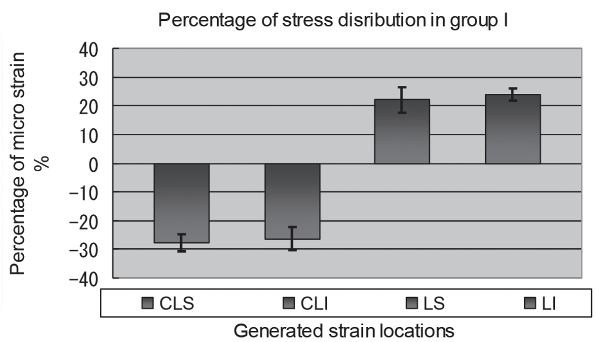

Fig. 3: Stress distribution in Group I.

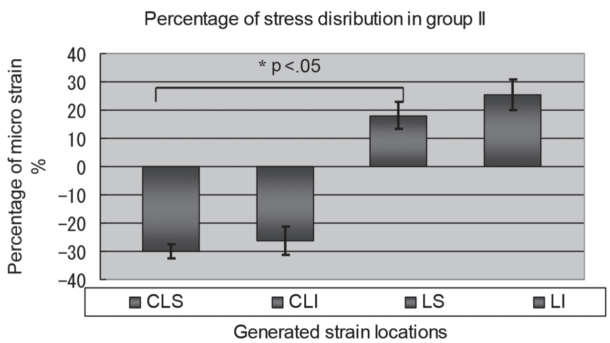

Fig. 4: Stress distribution in Group II.

abutments of 5 mm in height were connected to the implants (Table 1). Strain gauges (Type KFG-1N-120-C1-11, Kyowa, Japan) were then attached on the bone surface 3mm away from the edge of the fixture platform and embedded in the block 3mm below the surface and 3mm away from the edge of the implant on both the loading side and the contralateral side (total: n=4). Three samples were prepared for each implant type. Outputs from the strain gauges were transferred to an A/D converter through an amplifier (PCA-300, Kyowa) with purpose-built software (PCD-30A, Kyowa) (Fig. 1). Strain gauge outputs of each model were calibrated with known loads, and linearity with an error of less than 5 % was confirmed. The occlusal load consisted of an axial and a horizontal load. To simplify the clinical condition, a static horizontal load of 20N was then applied to the tip of the abutment simulating the occlusal force (Fig. 2). Strain data obtained on the surface of the loading (LS) and the contralateral side (CLS) and on the inside of the loading (LI) and contra lateral side (CLI) for each model were normalized as a percentage of the sum of the above following our previous report.[4] Results of both groups were analyzed with one-way analysis of variance (ANOVA) ($p<0.05$), and those of the 4 different areas within each group were compared using a 2-tailed t test ($p<0.05$).

Results

In both groups, tensile strain was observed on the loading side and compressive strain was observed on the contralateral side. In Group I, there were no significant differences between the loading side and the contra-lateral side (LS vs. CLS, LSI vs. CLI) or between the surface and inside of the bone (LS vs. LI, CLS vs. CLI) (Fig. 3). In Group II, there was a significant difference between the surface strains on the

Table 1 Characteristics of the implants and abutment

	Characteristics	Product name	Dimensions	Number examined
Group I	Porous surface without thread	Endopore implant Innova, Toronto, Canada	Diameter: 4mm Length: 12mm	3
Group II	Machined-surface with Thread	GC implant system Tokyo, Japan	Diameter: 4.1mm Length: 12mm	3
Abutment		Endopore implant Innova, Toronto, Canada	Height: 5.0mm	Used in all tests

loading side and on the contra lateral side (LS vs. CLS; $p<0.05$). Most of the strain was concentrated at the level of the fixture platform on the compression side (CLS). There were no significant differences between the surface and inside of the bone (LS vs. LI, CLS vs. CLI) in Group II (Fig. 4).

Discussion

Hansson and Norton[5] indicated that rough-textured threaded implants have larger resistance to shearing force during functional loading than machined-surface implants. Moreover, the resistance of osseointegration to tensile stress might be more critical with soft or poor quality bone when a dense cortical layer of bone is missing, as shown in this study with auto-polymerizing resin material.

Our results indicate that porous surface implants have the advantage of distributing stress more evenly, minimizing the risk of bone resorption and exfoliation both on the compression side and tension side. However, the geometries of rough surface thread implants might not always significantly improve the ability of implants to resist tensile forces caused by transverse force components. The effects of surface roughness and pore size should therefore be further examined in relation to bone formation as well as resorption. In the present study, the macro-architecture of a porous surface without thread and a machine surface with thread were evaluated. However, there are still other important factors, such as rough surface with thread, different thread designs, which might also influence the results. These factors should be evaluated in the further studies.

Conclusions

Within the limitations of this in vitro study, porous surface implants were shown to have the advantage of distributing stress to bone around the implant more evenly than machined-surface implants, especially in the case of poor quality bone.

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Literature Review

Endodontically Treated Teeth : Considerations to Restore Them

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Abstract

The restoration of endodontically treated teeth is a topic that is extensively studied and yet remains controversial. This article discusses the characteristics of endodontically treated teeth and some principles to be observed when restorations of these teeth are planned. The best current approach for restoring endodontically treated teeth seems to minimize structure sacrifice, especially in the cervical area, use post with physical properties close to the dentin and use adhesive procedures.

Keywords: **Endodoontically treated teeth, restoration, dentin, tooth structure, irrigant**

Introduction

What is endodontology, or what, in other words, is encompassed by the practice of endodontics? The definition may be modified from the definition provided by the American Association of Endodontists. Endodontics is that branch of dentistry that is concerned with the morphology, physiology and pathology of the human dental pulp and periradicular tissue. For more than 200 years, various methods for restoring pulpless teeth after root canal therapy have been reported. Gillen et al[1] used a meta-analysis method to determine the impact of the quality of coronal restoration and root canal fillings on the success of root canal treatment. The result from 9 selected studies indicated that the odds of healing in cases of apical periodontitis increase with both adequate root canal treatment and adequate restorative treatment. The finding that adequate restoration and root canal treatment produce better treatment outcomes reinforced the fundamental biologic principle of preventing bacteria ingress via the concerted efforts of endodontists and restorative dentists, indicating that such combined efforts provide the highest quality of care in saving functional teeth.

Should Crowns and Posts Be Placed on Endodontically Treated Teeth?

One study compared the clinical success of 1273 teeth treated endodontically in the preceding 1 to 25 years[2]. It was determined that coronal coverage crowns did not significantly improve the outcomes for endodontically treated anterior teeth. This finding supports the use of a conservative restoration such as an etched resin restoration in the access opening of otherwise intact or minimally restored anterior teeth. Crowns are indicated only on the teeth when they are structurally weakened or require significant form or color changes. Scurria et al collected data from 654 general dentists regarding endodontically treated teeth[3]. The results indicated that 67% of endodontically treated anterior teeth were restored with- out a crown. These data support the concept that anterior teeth are being satisfactorily restored without crowns.

When endodontically treated posterior teeth were compared, a significant increase in clinical success was noted when cuspal coverage crowns were placed on molars and premolars[2]. Placing a crown on an endodontically treated posterior tooth enhances survival[4]. In contrast, Nagasiri's study indicated that when endodontically treated molars are completely intact except for a conservative access opening, they can be restored successfully by using composite resin restorations[5]. In addition, Mannocci et al evaluated the success rate of endodontically treated premolars with and without crown coverage, and found that both approaches had a similar success rate[6].

Endodontically treated dog teeth have been found to have 9% less moisture than vital teeth[7]. This dehydration increases stiffness and decreases the flexibility in teeth. However, dehydration does not account for the physical property changes in dentin[8]. Endodontic procedures reduce tooth stiffness by 5%, and this reduction is attributed primarily to the access opening[9]. Restorations that encompass the cusps of endodontically treated posterior teeth have been found to increase the longevity of these teeth. Therefore, crowns should be placed on endodontically treated posterior teeth that have occlusal intercuspation with opposing teeth that places expansive forces on the cusps[10].

Laboratory and clinical data have failed to support the concept that posts strengthen endodontically treated teeth. Therefore, the purpose of a post is to provide retention for a core. A wide range or recommendations have been made regarding post length. To minimize stress in the dentin and in the post, the post should extend more than 4 mm apical to the bone. Therefore, the key question is how much gutta-percha should be retained to preserve the apical seal. There is greater leakage when only 2 to 3 mm of gutta-percha is present. Four to 5 mm should be retained apically to ensure an adequate seal[11-14]. Solano et al found a less significant difference in apical leakage between teeth whose post spaces were prepared at the time of the obturation and 1 week later using warm gutta-percha condensation and AH plus sealer[15]. However, several studies have indicated that there is no difference in the leakage of the root canal filling material when the gutta-percha is removed immediately after root canal treatment[16,17]. Rubber dam isolation is necessary for post space preparation. Using a rubber dam can prevent bacterial contamination, and such contamination is the key factor in the outcomes of root canal treatments.

Following root canal therapy, post space preparation should be performed and a post definitively cemented as soon as possible. Both rotary instruments and hot hand instruments can be safely used to remove adequately condensed gutta-percha when 5 mm is retained apically. The prepared tooth should then be restored with a provisional restoration with good marginal seal and occlusion. The definitive crown can be cemented in as short a time as possible.

Reports regarding the mechanical properties of zirconia posts have stated that these posts are very stiff and strong with no plastic behavior[18,19]. Kaya and Ergun evaluated the effect of different core materials and post length on the fracture strength of different posts[20]. The fracture patterns observed in teeth restored with fiber posts were more favorable than those for teeth restored with zirconia posts. A higher restoring success rate can be achieved by fiber posts rather than zirconia posts, since the failure mode for these posts would be restorable. From the viewpoint of endodontics, retreatment is made more difficult by a zirconia post, to the extent that the use of a zirconia post might change the treatment plan. For example, if the removal of a zirconia post will sacrifice more dentin structure, apical surgery will be the choice instead of retreatment.

The loss of marginal ridges and pulp chamber roof, the enlargement of root canal orifices, coronal flaring and preparation of the root canal, the use of disinfectants and intracanal medicaments, the selection of the sealer and obturation technique, and finally the type and quality of coronal restoration (including occlusal adjustment) implemented form a chain of treatment steps with a cumulative effect on the remaining root and tooth tissues and their chemical and physical properties. The main aspects of the effect of the most frequently used irrigants on radicular dentin and surrounding tissues will be presented and discussed.

The Effect of Irrigants

Chemical treatments have been reported to affect both the physical and bonding properties of dentin, and are more closely related to clinical procedures involving coronal and root dentin.

Sodium hypochlorite (NaOCl) is a well-known, non- specific proteolytic agent that is capable of removing organic material and bacteria from the canal space. Dentin is composed of approximately 20% organic material, so it is not surprising that exposure to sodium hypochlorite influences the physical properties and chemical structure of this substrate. Several studies have demonstrated that NaOCl compromises the bond strength between adhesive agents and dentin[21-23]. Exposure of dentin to sodium hypochlorite affects the organic components of dentin and alters its chemical and mechanical properties (flexural strength and elasticity). These effects are time-dependent and concentration-dependent[24-27].

Chlorhexidine shows good antibacterial efficacy against a broad spectrum of microorganisms, making it a good solution for endodontic irrigation. Unfortunately, it does not dissolve tissues, either organic or inorganic. It does not affect the collagen present in the organic dentin matrix[28]. Chlorhexidine has an inhibitory effect on MMPs (matrix metalloproteinases), thereby suppressing collagenolytic processes and preventing degradation of the bond[27]. The use of chlorhexidine during the bonding procedure to increase the longevity of dentin bond strength is recommended for clinical practice. This is good for post cementation.

Calcium hydroxide has been widely used in endodontics as an intra-canal medicament between appointments. In an aqueous solution, calcium hydroxide dissociates into calcium and hydroxyl ions. Various biological properties have been attributed to this substance, such as antimicrobial activity[29], tissue-dissolving ability[30], inhibition of tooth resorption[31], and induction of repair by hard tissue formation[32]. In an in vitro study conducted by Andreasen et al., immature mandibular sheep incisors were medicated with calcium hydroxide ($Ca(OH)_2$) for 0.5, 1, 2, 3, 6, 9, or 12 months[33]. Within 1 year, the fracture resistance decreased to one-half of the initial value. After only 2 months, a clear reduction from 16.9 MPa to 12.1MPa was observed. These results were confirmed in Andreasen's other study[34]. The results showed a decrease in the fracture resistance of the incisors with $Ca(OH)_2$ in the root canals after 100 days of storage, compared to teeth stored in intracanal saline, and teeth with $Ca(OH)_2$ placed in the canals for 30 days and then filled with MTA. These results supported the conclusion that $Ca(OH)_2$ significantly reduces dentin microhardness and strength. Accordingly, prolonged exposure should be avoided.

As outlined above, the use of irrigants and intracanal medicaments will alter the properties of root dentin. One sequela of these alterations is reduced bond strength between root dentin and obturation materials. This is important when new materials applied with dentin adhesives are used for obturation or restoration of endodontically treated teeth, or during the adhesive insertion of root posts. The influence of the sequence of use of medicaments and irrigants on the adhesion to dentin has thus far not been sufficiently investigated. Clinical evidence on this topic is still lacking.

In the future, strategies and techniques should be developed toward reducing or neutralizing these unwanted negative effects and maintaining or improving the strength of endodontically treated teeth.

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Case Report

電腦輔助植牙技術與立即負荷之上顎全口改良式全氧化鋯植體固定贗復物: 病例報告

Maxillary Full Arch Implant Rehabilitation with Modified Monolithic Zirconia Fixed Dental Prostheses Utilizing Computer-Guided Implant Placement and Immediate Loading Protocol : A Clinical Report

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摘要

氧化鋯相較於陶瓷具有良好的機械性質，所以近年來被大量地使用在製作固定義齒。然而臨床上發現氧化鋯固定義齒主要的問題在於容易產生瓷鑲面碎裂。為了減少併發症的發生以及維持美觀，因此有頰側燒瓷的改良式全氧化鋯義齒設計的研發。本病例報告為上顎全部缺牙的患者接受電腦輔助無翻瓣植牙手術並立即負荷，以植體支持改良式全氧化鋯完成固定贗復物。詳述術前、手術、技工室操作以及贗復物各個時期的過程以及追蹤四個月的結果。

關鍵詞： 電腦輔助、改良式全氧化鋯、立即負荷、非翻瓣

Abstract

Zirconia has become widely used for crown and fixed dental prostheses (FDPs), which exhibits superior mechanical properties compared with other ceramics. However, fracture of the veneering ceramics is a major complication for the zirconia-based implant-supported FDPs. Modified monolithic zirconia has been introduced to reduce porcelain chipping and to preserve the esthetics. This clinical report presents a case receiving computer-guided flapless implant surgery with immediate loading protocol and reconstruction with modified monolithic zirconia implant-supported FDPs in fully edentulous maxilla. The pre-surgical, surgical, laboratory, prosthetic stages and 4 months follow-up outcomes are illustrated for complete arch rehabilitation.

Keywords: **computer-guided, modified monolithic zirconia, immediate loading, flapless**

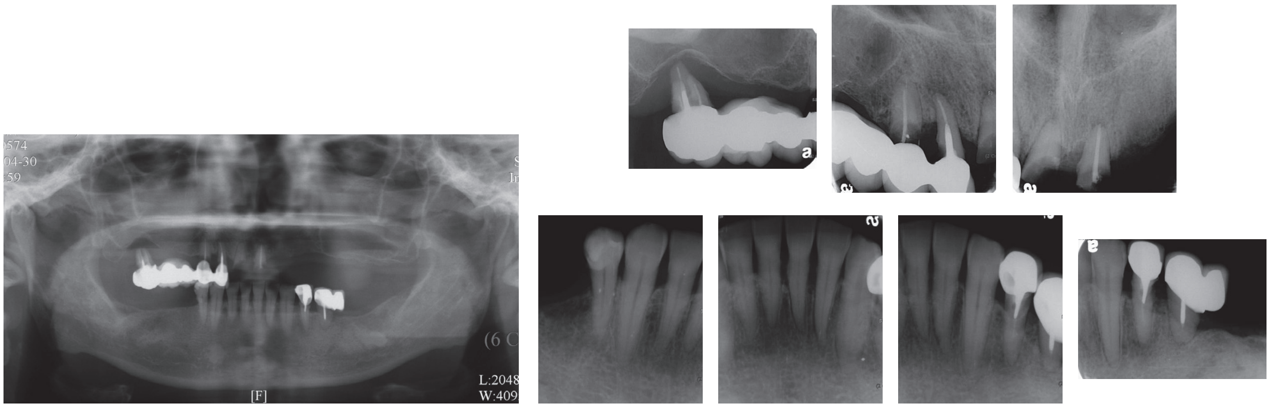

圖1：患者就診時的全口放射線檢查

傳統的植牙手術到贗復物完成，需要經過好幾個步驟。在植入植體以後，等待骨整合期間，病人通常沒有任何贗復物或是需要配戴活動義齒。且因為術後傷口照護的關係，贗復物常需要調整，在這樣的狀況下，會增加病人功能和社交上的許多不便。

直到90年代，發展出手術同次在植體裝上臨時義齒，且有立即性的功能負載（immediate function）[1]，讓病人無牙的時間從數月可以縮短到一天。製作立即性功能負載的義齒，常見的方式是將全口義齒改成固定臨時義齒，這種方式稱為轉換性的義齒（conversion prosthesis）[2]，另外一種是利用傳統印模方式製作出臨時義齒。但這些方法的缺點是臨床上需要花費許多時間，且不容易達到良好的美觀。於是2002年van Steenberghe等學者提出LITORIM（Leuven information technology-based oral rehabilitation by means of implants），透過電腦斷層掃描（computerized tomography scan）、電腦輔助治療計畫訂定、以及兩次掃描（ double scan）方式，讓手術醫師在術前可以透過3D影像了解軟組織與硬組織的關係，精確的計畫出植牙的位置，並且在術前經由電腦模擬出來的植牙位置翻製出臨時義齒[3]。在2005年van Steenberghe等學者研究利用電腦斷層掃描製作臨時義齒以及手術模板做無翻瓣（ flapless）手術的準確度，結論認為利用電腦輔助3D植牙技術做無翻瓣的手術是一項值得信賴的治療選擇[4]。

為了達到重建咬合功能、美觀以及牙齦外型（gingival architecture）的需求，植體義齒材質的選擇目前常使用的是金屬陶瓷義齒（metal ceramic prostheses）以及全瓷義齒（all-ceramic prostheses）。Pjetursson等學者系統性回顧的研究發現，植體支持金屬陶瓷固定局部義齒（metal-ceramic implant-supported FDPs）5年的存活率是96.4%，出現併發症的機率是33.6%，其中陶瓷碎裂（porcelain chipping）占了13.5%[5]。相較於金屬陶瓷贗復物，全瓷贗復物在後牙單冠以及固定局部義齒（fixed partial denture）會有較高的失敗率。常出現的機械性併發症（mechanical complication）是支架斷裂（framework fracture）以及陶瓷碎裂（porcelain chipping）[6,7]。 Y-TZP（ yttria-stabilized tetragonal zirconia polycrystal）氧化鋯因為有較高的機械性質（mechanical properties）所以被應用在製作固定局部義齒。3~5年的臨床研究發現氧化鋯支架斷裂約在0%到2.2%之間[8-11]。然而牙齒支持氧化鋯贗復物陶瓷碎裂的機率約15.2%到25%之間[8,9,12]。改善陶瓷碎裂有多種方式，如電腦輔助設計與製造（computer-aided design/computer-aided manufacturing）製作瓷面（veneer）[13,14]，燒製瓷面時減緩加熱以及冷卻的時間[15]等。另一種則是將瓷面省略，利用電腦輔助設計與製造全氧化鋯（monolithic zirconia）義齒[16,17]。但全氧化鋯透光性不高，沒有辦法達到理想的美觀，所以發展出改良式全氧化鋯（modified monolithic zirconia），在義齒的支架以及咬合面利用氧化鋯材質製作，並且在頰側燒瓷，達到良好美觀以及減少陶瓷碎裂的機會[18]。

本篇病例報告是利用電腦輔助植牙技術進行手術，並製作上顎全口立即負荷的臨時固定義齒。正式義齒採用改良式全氧化鋯設計，應用電腦輔助設計與製造方式，製作氧化鋯義齒支架並在頰側燒瓷，藉此達到良好美觀以及減少機械性併發症。

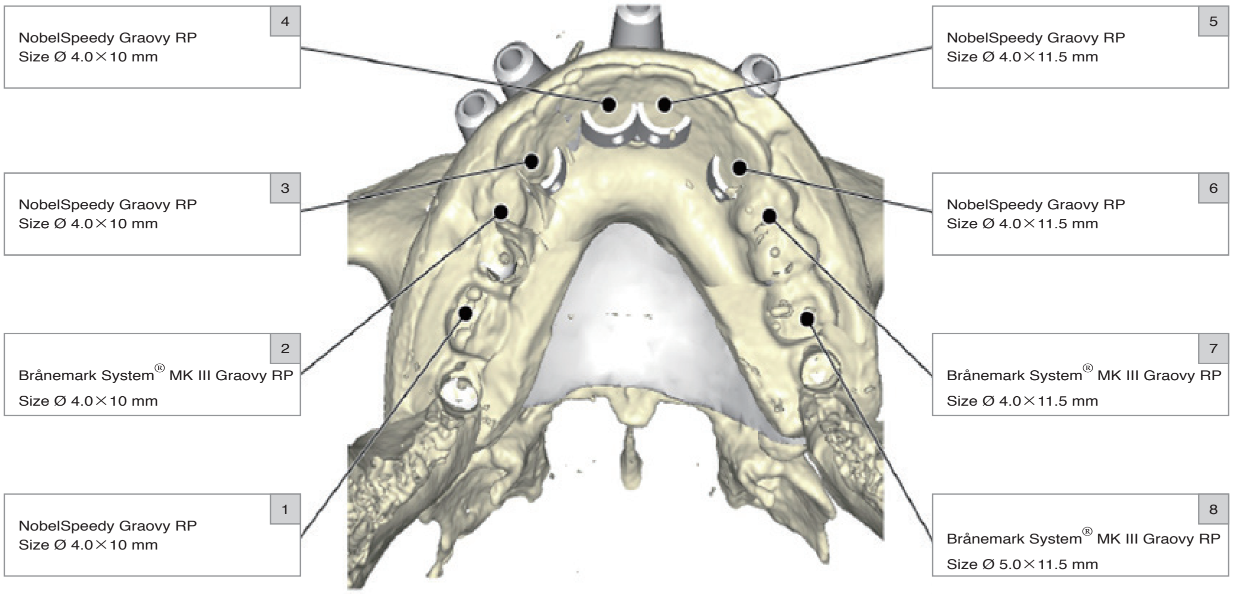

圖2：根據電腦斷層影像，計劃在上顎植入8顆植體

病例報告

檢查診斷及治療計畫

本篇病例報告為53歲女性，就診主訴為希望進行全口重建。經過臨床及X光檢查後（圖1），發現11, 13, 21為殘留牙根，12, 34有牙齦下的齲齒，17, 35有嚴重牙周骨頭缺損，上顎兩側後牙區骨頭高度不足，前牙區骨頭寬度不足。由於患者希望以固定義齒贋復，所以計畫將上顎剩餘的牙齒以及34, 35拔除後，於下顎34, 35, 37, 45, 47植入5顆植體。上顎先進行植牙區的準備（implant site development），然後預定利用電腦引導植牙定位系統（ computer-guided implant placement system）於11, 13, 14, 16, 21, 23, 24, 26植入植體並製作立即負荷（immediate loading）的臨時固定式義齒，最後以改良式全氧化鋯設計完成植體贋復物。

治療過程

拔除患齒3個月後，請病患接受電腦斷層掃描以分析缺牙區骨嵴條件。由於上顎前牙以及後牙區骨嵴嚴重萎縮，建議先進行上顎鼻竇增高術（ maxillary sinus augmentation）及上顎前牙區的引導骨再生術（ guided bone regeneration）。

等待上顎復原期間，於34, 35, 37, 45, 47植入五顆植體（ Brånemark System® Mk III TiUnite, Nobel Biocare, Gothenburg, Sweden）。兩個月後製作臨時固定義齒。上顎方面，將全口臨時活動義齒翻模製作放射線用模板（radiographic stent），並進行美觀試戴。使用NobelGuideTM（Nobel Biocare）軟體，把病人戴著放射線用模板跟單獨只有模板的兩次掃描資料彙整，根據電腦斷層影像計劃在11, 13, 14, 16, 21, 23, 24, 26植入8顆植體（圖2），並製作出手術導板（stereolithographic surgical template, Nobel Biocare）。

技工室操作部分，將上顎放射線用模板翻製成臨時義齒（Alike, GC Japan），並利用手術模板接上植體仿體（implant analog）灌模翻印出上顎模型，在模型植體上裝上臨時支台體，並預先在臨時義齒和橡皮障上鑽好孔洞。

手術在局部麻醉下進行，先將手術導板利用預先製作的定位裝置（silicone occlusal index）定位植入四支定位釘（anchor pin）固定。固定手術導板後，進行無翻瓣植牙手術。在11, 13, 14, 16, 21, 23, 24, 26的位置分別植入八顆植體（Brånemark System® MKIII or NobelSpeedy™ Groovy, Nobel Biocare）（圖3），同時測量植體的植入扭力（insertion torque），由於26植體的植入扭力僅有10-15Ncm，而其他植體皆超過30Ncm，所以26排除在立即負荷臨時固定式義齒外。將預先準備好的橡皮防濕障隔離手術區域，在手術同次製作螺絲

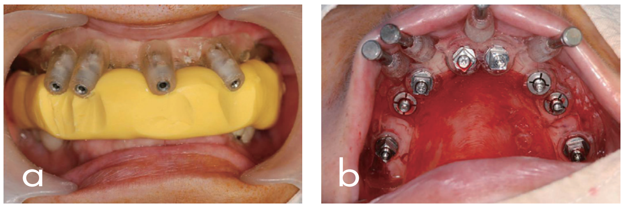

圖3：上顎植入8顆植體

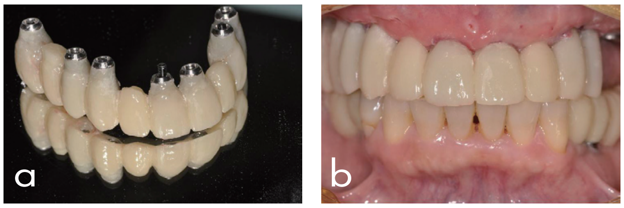

圖4：螺絲固定式臨時固定義齒

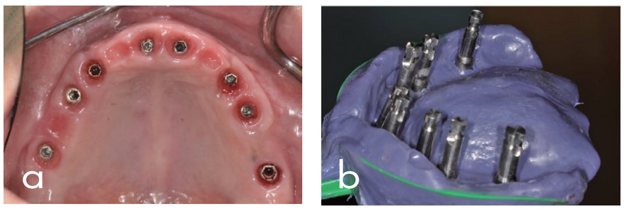

圖5：手術後4,5個月，以開放式牙齒印模

固定式臨時固定義齒（screw-retained interim fixed prostheses）（圖4），建議病人先以流質飲食兩週，之後吃軟質食物兩個月，並定期回診檢查。

在術後4.5個月以後，以開放式牙托（open tray）方式印模（Impregum, ESPE, Seefeld, Germany）（圖5），灌模後以臨時義齒在主模型上轉印出軟組織的型態（Panasil, light body, Kettenbach Dental, Eschenburg, Germany）。並利用臨時義齒將上下顎模型置位於半調節咬合器（Hanau Modular Articulator System 190; Whip Mix Corp, Louisville, Ky）。正式義齒採用分段改良式全氧化鋯設計，應用電腦設計輔助修形方式製作氧化鋯義齒支架（Ceramill zi; Amann Girrbach AG）。支架試戴調整咬合後，進行頰側燒瓷（Vita VM9;Vita Zahnfabrik, Bad Sackingen, Germany）。臨床上進行美觀試戴並精修咬合，兩側側向運動的設計皆給予群體功能（group function）（圖6）。上下顎螺絲固定式義齒鎖緊到35Ncm，螺絲孔洞以馬來膠（Temporary stopping, GC）及光聚合樹脂（Filtek Z250, 3M ESPE）填補。X光檢查顯示所有義齒

圖6：頰側燒瓷後的氧化鋯義齒具群體功能側向運動的義齒咬合

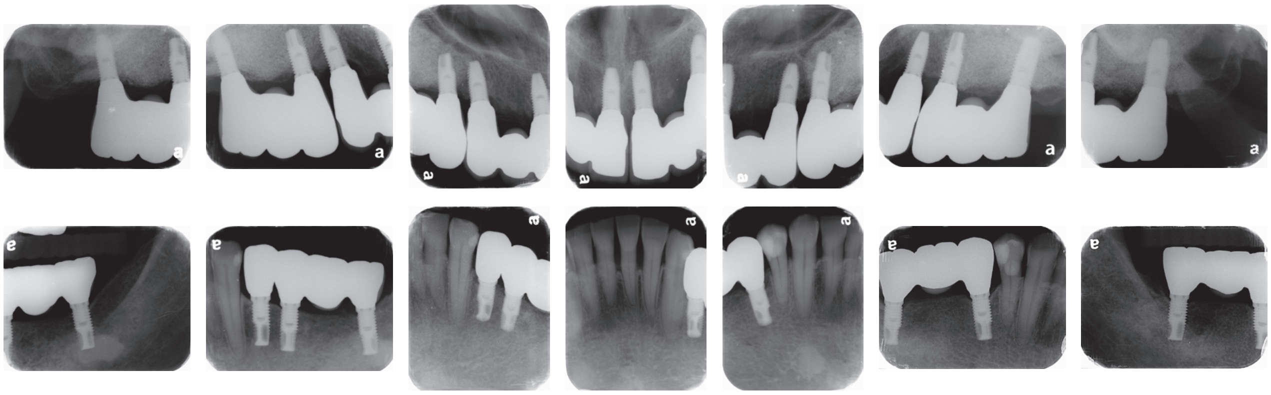

圖7：X光檢查顯示植體植入後，所有義齒都有良好的邊緣密合性

圖8：完成的氧化鋯固定義齒

都有良好的邊緣密合性（marginal adaptation）（圖7）。四個月後的回診檢查並沒有發現任何生物性（biological）或是機械性的併發症（mechanical complication）（圖8）。

討論

與傳統電腦斷層掃瞄相比，利用3D軟體計畫植牙位置及手術導板的製造，可以得到更精確的位置，減少手術時間及傷害到鄰近組織的機會[19-21]。不過電腦輔助植牙技術還是有限制性的，例如需要額外的花費、需要製作手術導板等。另外，因為手術沒有翻瓣會受到限制，如果角化牙齦不足或是需要做骨頭成形（osteoplasty）就不適合。所以這樣的手術，適合用於有足夠的角化牙齦寬度與骨頭條件的病例。而本病例因為初次評估結果顯示上顎兩側後牙區骨頭高度不足，及前牙區骨頭寬度不足，所以在進行電腦引導植牙定位手術前，需先補骨頭以利後續手術進行。

而另一項值得討論的是，即使是在手術導板的引導下，也不能完全精確的植入植體到預定的位置及深度[22]，術前計畫和術後植體位置平均會有0.9mm和4.5度左右的誤差[23-25]。影響準確度的因素有影像取得和重組產生的誤差、電腦製作出手術導板的誤差、手術導版穩定度、手術操作者本身的誤差等[24,26]。所以預先製作的臨時義齒並不能完全符合植入的位置，臨床上需在口內利用臨時義齒樹脂和預先製作的臨時義齒，將臨時支柱（temporary abutment）取出（pick-up）以得到最終正確的位置。

對於全口無牙的病人在植牙同時製作立即受力的臨時義齒，已經有很多的研究，大部分都認為可達到良好的成功率[27-31]。相對於局部臨時固定義齒，全口臨時固定義齒會有較高的併發症（complication），例如螺絲鬆動（screw loosening）、臨時義齒斷裂、承受過大壓力（over loading）等，可能導致植體骨整合失敗[32]。所以臨時義齒的設計必須連接跨過兩側的牙弓，以達到良好的穩定性，分散咬合力量並且做成螺絲固定，除了方便移除臨時義齒之外，也可以減少細微的移動（micromovement）[28]。正式義齒設計方面，近期的系統性回顧文章指出，全口植體固定義齒（complete-arch implant-supported FDPs）在

生物性和技術性上會出現較高的併發症[33]。分段式的義齒設計，可以降低贗復物製作困難度以及容易維持口腔清潔[34,35]。

雖然全氧化鋯義齒設計可以增加強度以及減少瓷面碎裂的機會[16]，但如果沒有適當的拋光可能會造成對咬牙的磨耗。而磨耗會因為材質、構造、表面粗糙度以及強度而有所不同。近期的體外實驗都顯示相對於陶瓷，經過拋光後的氧化鋯反而對對咬牙有較低的磨耗[36,37]。此外，在燒結完成的全氧化鋯咬合面做咬合調整，會讓表面產生單斜晶相轉變（monoclinic transformation），減少四方晶相（tetragonal phase）的比例，所以當贗復物產生裂縫時，可能無法產生相變韌化機制（transformation toughening mechanism），阻止裂縫的延伸[38,39]。本病例利用臨時固定義齒取代咬合蠟堤，得到較精確的上下顎間關係，減少臨床上調整咬合的機會，並且做適當的拋光減少對咬牙之磨耗[40]。

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Case Report

有關早年衰老症候群牙科治療的臨床考量
Clinical Considerations for Hutchinson-Gilford Progeria Syndrome in Dental Treatment

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摘要

早年衰老症候群屬於罕見疾病，臨床特徵包括發育停滯、頭髮稀少以及臉部、口腔與鼻子狹小。其中，顎骨的發育停滯及口腔狹小的問題，使得牙科治療有異於正常病患。本報告的目的提出早衰症的病例，針對其臨床的特性，探討在牙科治療所需要注意的事項。

關鍵字：早衰症、張口受限、口顏面障礙、牙科處理

Abstract

Hutchinson-Gilford Progeria syndrome（ HGPS ）is a rare genetic disorder in which the individual suffers from various afflictions similar to an aged one. HGPS individuals exhibit many dentofacial disorders. These manifestations may affect dental treatment. The purpose of this report presented a case of HGPS. Clinical considerations in dental treatment were emphasized.

Key word: **Hutchinson-Gilford Progeria syndrome, mouth open limitation, dentofacial disorder, dental treatment.**

引言

早年衰老症候群（Hutchinson-Gilford Progeria syndrome, HGPS），簡稱早衰症。早衰症是一種極端罕見的先天遺傳性疾病，臨床特徵是患者的老化過程比一般快速。在新生兒發生的機率，大約每八百萬分之一。97% 的病例出現在白人，而男生發生的比率大約為女生的1.5倍。罹患此病孩童的壽命很少超過13歲，在早衰症患者的血液當中，由於低密度脂蛋白及膽固醇的增加，常常造成高血脂的現象，因此，死亡的原因大部分是來自動脈粥樣硬化（atherosclerosis）[1]。

幼年時期的早衰症包括了發育遲緩、局部性硬皮病。隨著年紀的增長，其他的症狀會變的更明顯。例如發育停滯、頭髮稀少以及臉部、口腔與鼻子狹小，都是早衰症患者的獨特表徵。早衰症患者通常具有小而虛弱的身體，就像老人一樣。

至於有皺摺的皮膚、動脈硬化、心血管疾病等則屬於比較晚期才會出現的症狀[2]。

圖1：病患就診時的正面觀、微笑及側面觀

圖2：病患的胸腔X光片

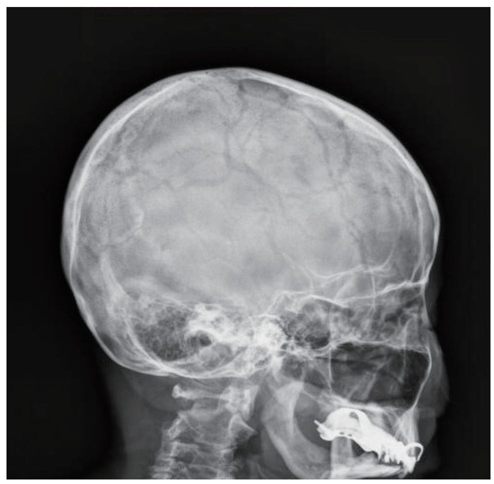

圖3：病患的測顱X光片

早衰症最早是在1886年發現的。正常的情況下，人體第一對染色體LMNA（Lamin A）會轉換成Prelamin A，這種蛋白質不會跟細胞核作結合。但是在早衰症的病患中，LMNA（Lamin A）的基因發生變異，有一個胞嘧啶（C）的地方都被錯誤地轉譯成了胸腺嘧啶（T），結果製造出與正常胺基酸結構不同的蛋白質，簡稱早衰素（Progerin），這種物質會跟細胞核的表面作結合，因而產生不正常的細胞核[3,4]。

早衰症患者的外觀和生長紀錄是相當重要的診斷依據。除了有生長遲緩的問題外，常見的臨床表徵包括：（1）下顎骨發育不良，側面觀形似鳥型（bird face），且為禿頭。（2）身材矮小，體重比同齡的正常人輕。（3）四肢瘦小且關節變得明顯。（4）皮下脂肪的比例比正常人少。（5）眼球明顯突出。（6）胸骨突出，鎖骨短小。

早衰症屬於罕見疾病，文獻上有關的研究並不多，關於牙科的治療更少。本報告的目的提出一個早衰症的病例，針對其臨床的特性，探討在牙科治療所需要注意的事項。

病例

病患為42歲中年男子，因為牙齦腫痛及缺牙的問題，來本院牙科接受治療。病患身材瘦小，頭髮稀疏，側臉型呈現鳥形頭（bird face），早期出現生長遲緩的徵狀，被診斷

為早年衰老症候群（圖1）。胸部的X光片，可以發現病患短而小的鎖骨（圖2）。測顱X光片（cephalometric radiograph）顯示，下顎枝（mandibular ramus）比正常人短，下顎角通常呈現大於九十度的鈍角（obtuse mandibular angle）（圖3）。病患由於下顎發育不足，造成臉型呈現骨骼性第二類的咬合，前牙區有深咬的現象，同時因為上下顎牙弓大小差異太大，造成下顎前牙有外翻的傾向，以彌補前牙咬合的問題（圖4）。口內的檢查，發現有多顆殘根、蛀牙及邊緣不密貼的牙冠，病患之前配戴局部活動義齒，來解決缺牙所造

圖4：病患就診時的口內觀

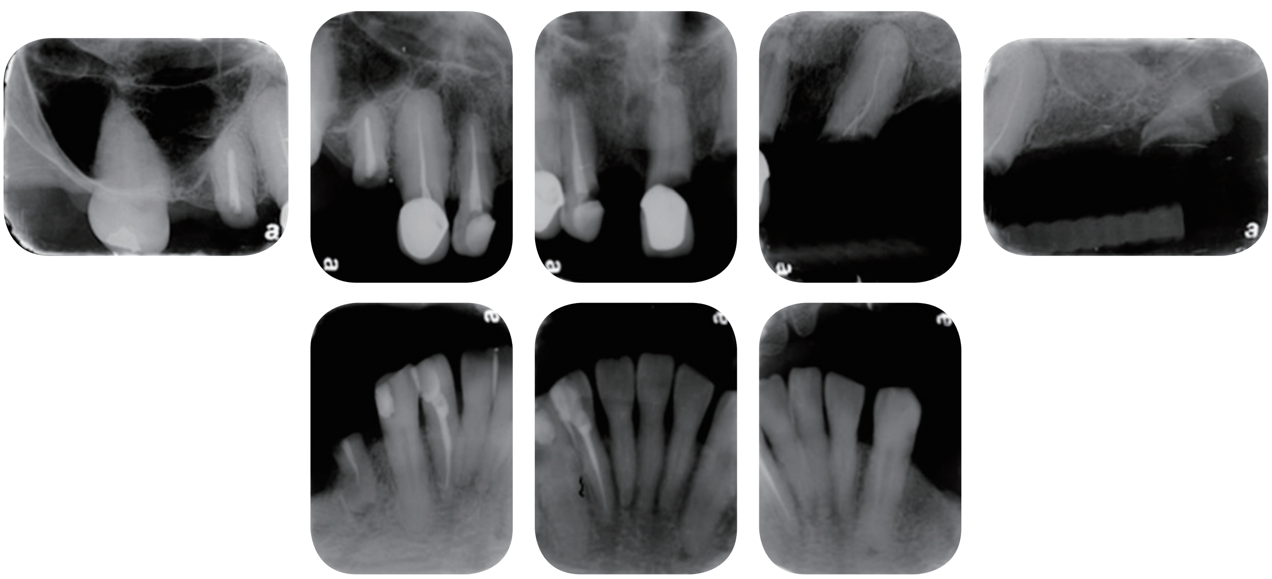

圖5：病患就診時的全口根尖X光片

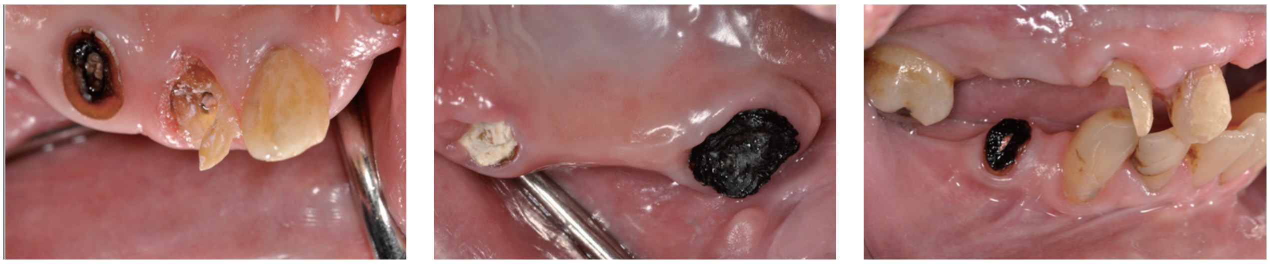

圖6：右側犬齒、左側正中門齒牙冠拆除後的正面觀、微笑及側面觀

圖7：暫用活動義齒裝戴

成的咬合問題，但由於支柱牙蛀牙的關係，造成局部活動義齒晃動，無法正常使用。至於牙周及根尖X光片的檢查，則無明顯牙周病的現象，然而蛀牙卻造成多顆牙齒的冠根比不足（圖5）。

由於經費的考量，病患不考慮進行牙齒矯正及人工植牙手術。治療的順序，首先進行第一階段的牙周治療，拆除右上顎犬齒及左上顎正中門齒的固定義齒後評估，發現剩餘的齒質不利於日後義齒的製作，因此將上述牙齒及口內其他的殘根一併拔除（圖6）。並於拔除當次，給予上顎全口及下顎遠伸性臨時活動義齒（圖7）。

等待傷口癒合期間，由於下顎左側側門齒蛀牙深及牙髓，因而進行根管治療及牙冠製作。拔牙三個月後，開始進行上顎全口義齒及下顎雙側遠伸性局部活動義齒的製作。咬合的模式，則採用平衡性的咬合（balanced occlusion）（圖8-12）。

討論

早衰症患者通常身體無法進行正常人的DNA修復工作，而失掉細胞複製及蛋白質製造的功能。當細胞老化以後，新的細胞無法

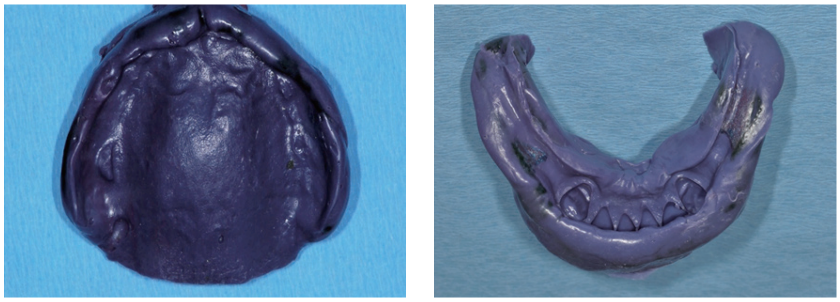

圖8：上下顎印模

圖9：長期性活動義齒蠟形試戴

正常生成取代，因此，生理機能比一般正常人退化更迅速。這種機制同樣影響在顏面、顎骨及牙齒的生長發育的表現[5]。

在顏面的表現方面，早衰症患者通常毛髮稀疏，包括頭髮及眉毛，前額明顯突出，上顏面所佔的比例大於下顏面。另外，小嘴巴以及比正常大的舌頭，則是影響牙科治療的主要問題。小嘴巴造成的開口受限，在進行印模時，一般的模托比較難置入口中，因此，利用個別模托印模是必要的工作。而比正常大的舌頭，則是印模時及影響日後活動義齒穩定性，所必須面對的課題。

由於生長遲緩，造成早衰症患者顎骨發育也受到影響。小顎症（micrognathia）常見於這類患者，齒槽骨通常有萎縮的現象（atrophy of alveolar process），而且顎骨在垂直方向的生長受限，上顎穹窿（palatal vault）呈現深且窄的形態，上下顎牙弓比正常人小，尤其是明顯發育不全的下顎骨（hypoplastic mandible）[6]。從測顱X光片（cephalometric radiograph）觀察，下顎枝（mandibular ramus）比正常人短，下顎角通常呈現大於九十度的鈍角（obtuse mandibular angle）。就牙科治療而言，萎縮的齒槽骨會影響活動義齒的穩定性；深且窄的上顎穹窿會增加印模時的困難，並且是造成印模材料變形的原因；大於

圖10：長期性活動義齒裝戴

圖11：病患配戴活動義齒後的正面觀、微笑及側面觀

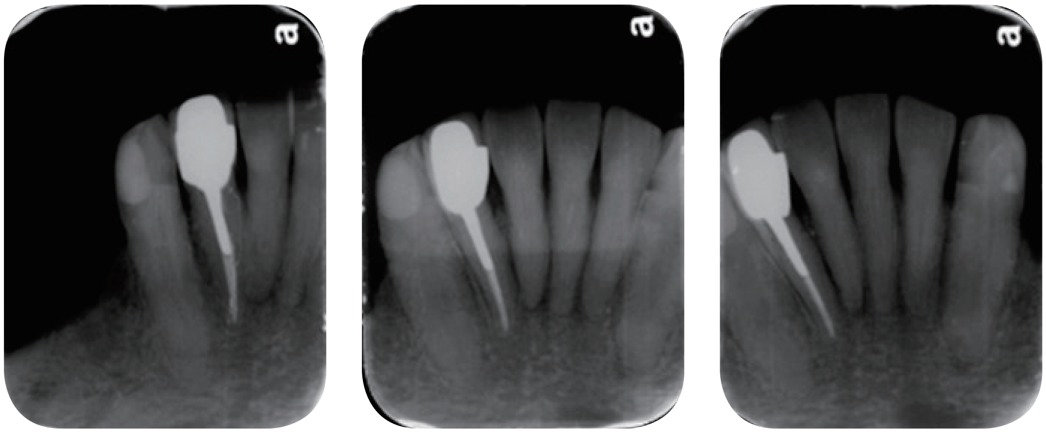

圖12：病患配戴活動義齒後的下顎根尖X光片

九十度的下顎角，對於咬合空間不足，而且需要增加垂直距離（vertical dimension）的病例而言，確實是一種挑戰。

早衰症的患者，常見有乳齒延遲脫落以及恆齒延後萌出的現象。而先天性缺牙（anodontia）及牙齒型態不正常，也可以在口腔檢查中發現。而且患者牙齒的牙髓腔，比正常牙齒狹窄，造成日後根管治療的困難度增加。由於牙齒形成的過程中，鈣化不完全常常是日後齲齒發生率偏高的主要原因[7]。因此，針對早衰症患者定期的口腔檢查，尤其是對於齲齒的預防，是最重要的。

早年衰老症候群屬於罕見疾病，長期而且有系統的醫學研究並不多見，大部分都是病例報告。隨著高齡化社會的來臨，如何延遲老化成為熱門的研究主題之一。為了從基因的缺陷，進而探索人類老化的原因，使得針對早衰症的研究，再度受到重視。而就牙科治療而言，除了認識早衰症與一般患者的差異以外，還必須了解治療方面的特殊需求及限制，尤其是減少齲齒的發生，更是牙醫師責無旁貸的任務。

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Technical Report

改良式全口假牙製作時中心關係位置紀錄取得方法
Modified Centric Record Taking Technique in Complete Denture Reconstruction

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摘要

中心關係位置（centric relation, CR）的記錄在贋復治療中扮演極為重要的角色，尤其是當面對全口無牙病患時，全口假牙的製作涉及了牙齒相關位置及咬合的重新賦與，如果在咬合器的起始定位點錯誤，那麼再完美的咬合設計恐怕也無法順利在口腔中和諧運作，如此一來將會增加臨床上咬合調整所需要的時間和影響全口假牙的穩定性。本技術報告就全口假牙贋復製作過程中中心關係位置紀錄取得方法予以改良，以減少因咬合紀錄材料的介入，影響垂直高度及改變後續的咬合器閉合路徑，以減少排牙誤差及簡化臨床咬合調整的時間。

關鍵詞： 中心關係位置, 垂直高度, 咬合器閉合路徑

Abstract

Centric relation record plays an important role in prosthodontic treatment. It provides an initial relation of the jaws and then related teeth position and occlusion in the articulator be set according to this position. If the initial position is wrong, the following teeth set up could not function smoothly as designed in the articulator and will increase the time needed for clinical occlusion adjustment. This technical report introduces a modified centric record taking technique for complete denture fabrication to minimize the change of the already determined vertical dimension and arc of closure in the articulator due to the interference of the material used in centric relation recording procedure.

Keywords: Centric relation record, vertical dimension, arc of closure in the articulator

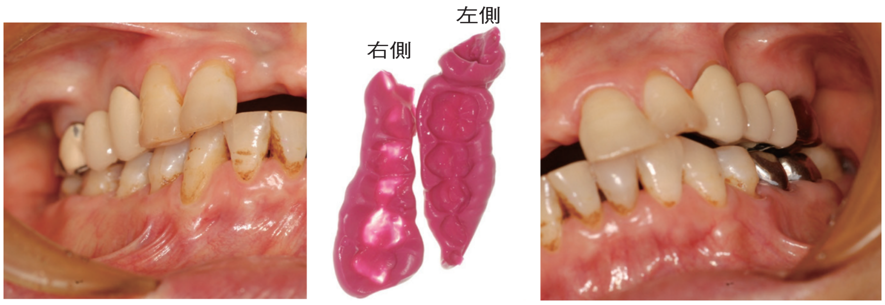

圖1：此患者在中心關係位置（CR）時，左側後牙區域接觸不穩定，為了記錄中心關係位置，材料必須充填空隙並瞬間硬化。

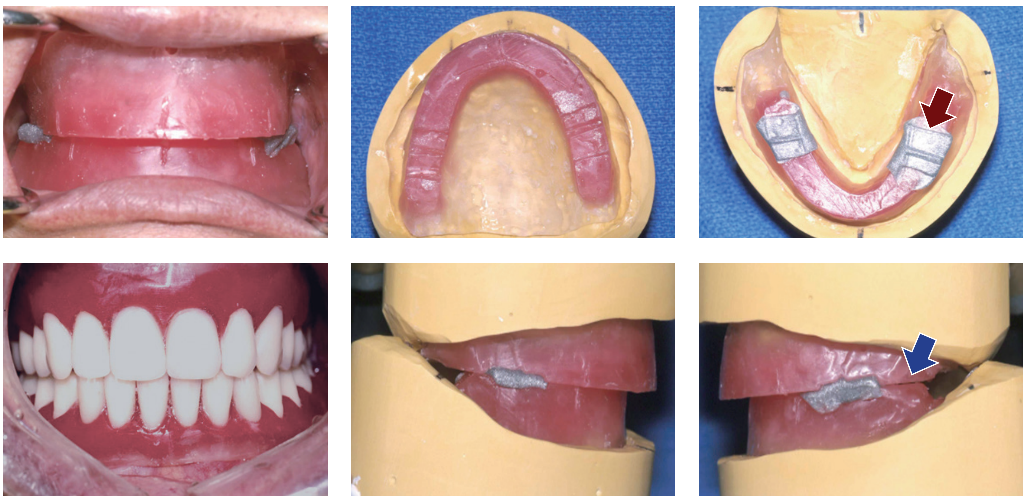

圖2：臨床蠟型假牙試戴，再次確認咬合器上的上下顎關係跟臨床上中心關係位置是否具有一致。

藍色箭頭：箭頭所指之處上下顎蠟堤之間有微小的空隙

紅色箭頭：箭頭所指之處上下顎蠟堤之間覆蓋很薄的紀錄上下顎關係的材料

中心關係位置（centric relation, CR）的記錄在贗復治療中扮演極為重要的角色，此中心位置不僅可作為判斷咬合平衡（圖1）與否、中心關係位置與中心咬合位置（centric occlusion, CO）之間是否有干擾的診斷起始位置，也是贗復成品咬合設計時的起始點[1]，尤其是當面對全口無牙病患時，全口假牙的製作涉及了牙齒相關位置及咬合的重新賦與，如果起始定位點錯誤，那麼再完美的咬合設計恐怕也無法順利在口腔中和諧運作，如此一來將會增加臨床上咬合調整所需要的時間並影響全口假牙的穩定性[2]。

傳統的全口假牙治療過程，係先以咬合蠟堤取得適當的垂直高度後，再於臼齒區域切除適當大小的上下咬合蠟堤，以留下足夠空間給用來取得咬合紀錄之材料。接著將材料放置於蠟堤適當位置後，導引病患回到非常接近已經確定之垂直高度的中心關係位置[1]。待咬合紀錄之材料硬化後，即可如鑰匙跟鎖的關係一樣，利用此中心關係位置的紀錄來，置位上顎和下顎模型，將下顎模型定位於咬合器，重現上顎和下顎在口內時的正確相關位置，以利後續排牙工作的進行。排完牙後，臨床試戴的診次即再次確認咬合器上的上下顎關係跟臨床上，中心關係位置是否一致（圖2），因此取得中心關係位置的正確紀錄是製作全口假牙的主要關鍵之一。

錯誤的中心關係位置形成的臨床徵狀包括：Inefficient mastication, General discomfort, Inflammation of mucosa, Traumatic injury to support structures, Accelerated alveolar ridge absorption, Loss of planned occlusion and Ill-fitting denture[3]。在記錄中心關係位置時常見的誤差可以來自於不穩定的關節活動、不穩定的咬合蠟堤基底座（recording base）、紀錄材料的選擇及材料使

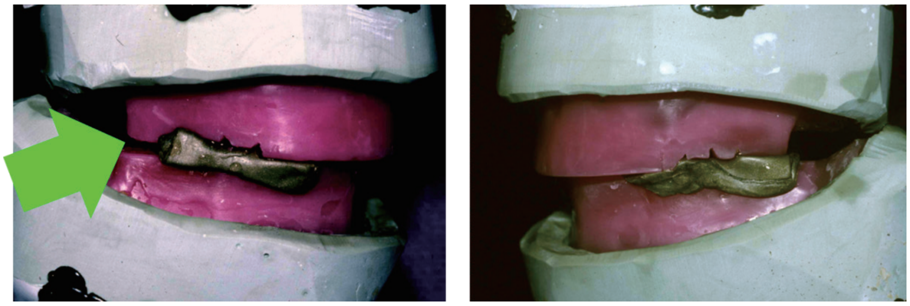

圖3：紀錄中心關係的材料太長，導致牙醫師在導引病患回到中心關係位置時，產生垂直高度的增加（箭頭所指之處的上下顎蠟堤未互相接觸）。

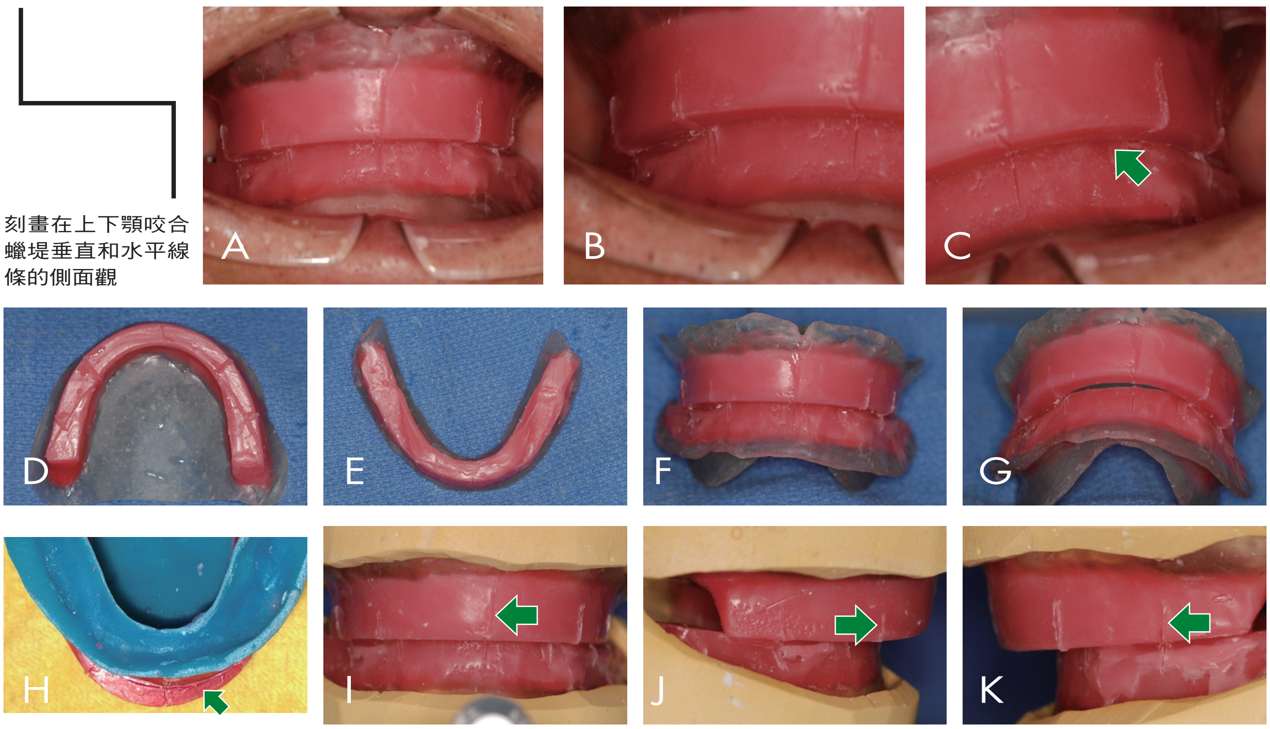

圖4：改良式全口假牙製作時，中心關係位置紀錄臨床操作步驟（A-K）。箭頭所指之處為刻畫在緊密接觸的上下顎蠟堤的垂直線條，完成中心關係位置的記錄。

用不當等生理或物理性因素。臨床上牙醫師可以控制卻也是最常被疏忽的因素，即中心關係位置記錄材料的使用不當。記錄咬合關係的材料很多，包括soft plaster of Paris、ZOE、carefully softened wax、silicon。理想的材料必須要有最小的閉合阻力（minimal closing pressure）、容易操作、工作時間長和硬化時間短的特性。目前臨床上沒有材料同時兼具上述的特性。因此傳統的全口假牙製作過程中，容易因為記錄中心關係的材料太厚、太長、閉合阻力太大和材料在咬合蠟堤上的穩定性不佳，導致牙醫師在導引病患回到中心關係位置時，產生垂直高度增加（圖3）和左右、前後之水平方向偏移的誤差。

為了減少因為使用記錄材料不當反而增加誤差，以及為了模型置位於咬合器時，也因為不須代償紀錄咬合關係的材料厚度，可以將門齒釘（incisor pin）直接設定於「0」的原點，則不會讓門齒釘再重新歸零時咬合器和病患的閉合弧形（arc of closure）變化造成另一個誤差。

改良式全口假牙製作時中心關係位置紀錄的臨床操作步驟[1]：

1. 評估發「s」或「ch」音的closest speaking space, freeway space，患者的臉型和感受，確定上下顎的垂直關係。
2. 當確定好垂直關係後，導引患者下顎到最後方，且可以重複取得的中心關係位置，讓上下顎蠟堤輕輕且緊密的接觸。
3. 直接在緊密接觸的上下顎蠟堤上刻畫5條垂直（正中線、兩側口角、兩側臼齒區域）和水平（上顎蠟堤的咬合面）的線條，記錄上下顎蠟堤前後和左右關係，完成中心關係位置的記錄（圖4–A至C）。
4. 在口外確認咬合蠟堤上刻畫的線條是否清晰和明確，可以重現上下顎的位置（圖4–D至H）。
5. 以面弓記錄上顎和顱底的關係，將上顎模型置位於咬合器之後，再藉由刻畫在咬合蠟堤上的線條，將下顎模型置位（圖6–I至K）。

結論

牙科的臨床工作很繁瑣，且使用多樣性的材料，操作步驟時的精確性和材料的物性，讓我們每增加一個步驟和材料都有可能增加誤差，造成臨床上必須要重複相同的步驟或浪費許多的臨床時間進行咬合調整[4]。故本改良式的中心關係位置紀錄取得方法，簡化了記錄中心關係位置時的過程，且可以達到咬合器和臨床上的上下顎中心關係位置一致性的目標，減少可能出現的誤差。

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2. 摘要 (abstract)：以400字為限，簡潔說明並標示研究目的、方法、結果、主要結論或新發現。若為原始著作則須說明並標示，並需附關鍵詞(key words) 5個以內。以中文投稿須有中文摘要外，另須附英文摘要。
3. 本文 (text)：
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      (3) 結果 (results)：研究結果以文字、表格或插圖表示之。
      (4) 討論 (discussion)：強調重要結果與論點，與前人論述作比較等。
      (5) 結論 (conclusion)：結論要簡要明確。
   C.技術報告(technical report)—分前言、方法描述、討論。
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the mandibular primary first molar: a longitudinal study. J Clin Pediatr Dent 1998; 22: 311-6. (2)書籍之書寫：McDonald RE, Avery DR. Dentistry for child and adolescent. 6th ed., Mosby Co, St Louis, 1994; pp339-41. (3)有編輯者之書籍章節書寫：Moore BK, Avery DR. Dental materials. In: McDonald RE, Avery DR. Dentistry for child and adolescent. 6th ed., Mosby Co., St. Louis, 1994; pp349-72. (4)電子期刊之書寫：Yavuz MS, Aras MH, üyükkurt MC, Tozoglu S. Impacted mandibular canines. J Contemp Dent Pract 2007; 8:78-85. Available at: http://www.thejedp.com/issue036/index.htm. Accessed November 20, 2007.

5. 插圖與表格 (figures and tables)：

(1) 插圖請勿放置於本文中，圖與表之數量盡量少，也不要編排，應儲存於另外的檔案夾。影像圖檔應以JPG、EPS或TIF 形式存檔。插圖以電子檔e-mail傳送投稿。
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