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Prosthodontic considerations of endodontically managed teeth

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INTRODUCTION

The restoration of the endodontically treated tooth is an important aspect of dental practice involving a range of treatment options of varying complexity. The clinician must be able to predict the probability of restoring such teeth successfully. Generally, endodontically treated teeth have experienced significant coronal destruction as well as a loss of radicular dentin, secondary to endodontic treatment. There is evidence that these teeth have a reduced level of proprioception[1] which could impair normal protective reflexes. Successful management requires an assessment of the role of the restored tooth in the overall dentition, the load it will have to bear and the status of adjacent teeth.

The intent of this article is to present a set of criteria which, when met, will indicate a predictably restorable endodontically treated tooth.

When should the definitive restoration be placed?

The success rate of endodontics

Carefully controlled clinical studies have evaluated the success rate of conventional endodontic treatment based upon radiographic evaluation. These have shown that between 83% and 94% of treatments are successful.[2] However, data from epidemiological studies paints a bleaker picture, with only a 61.77% success rate. An explanation for the difference may lie in the fact that the former root treatments were carried out under carefully controlled environments in either specialist practice or dental colleges. Today, the success rate amongst General Dental Practitioners may be better, as the majority of the studies reviewed predate 1990 and since then knowledge and techniques for root canal preparation have improved. In addition, in some studies the observation period was low, varying from as little as six months to ten years.[3]

Clearly six months is inadequate follow-up and the European Society of Endodontology suggest radiographic assessment after one year and if complete healing has not occurred, follow-up for four years. Only then is an asymptomatic root canal treated tooth with a persistent periradicular radiolucency condemned a failure[4] Four years is obviously an unacceptable time to wait before placing a definitive restoration and cross-sectional studies have shown that the technical quality of the finally obturated root canal is strongly correlated with the success of the root filling.[5,6] Short or over-extended root fillings or those with an incomplete apical seal have been found to be associated with higher failure, as have re-treatment cases[7]. Whilst these factors can be evaluated, resolution of an apical lesion will occur even in the absence of a root filling, [8] provided all the infected root canal tissue is removed and ingress of bacteria is prevented by a coronal restoration, which provides a bacterial seal. A final factor to be borne in mind when determining the prognosis of a root canal filling is whether there was a periradicular lesion present prior to root treatment. The success rate can fall from 96% where there was no pathology evident to 86% where there was a periradicular lesion. These features, such as the knowledge of an aseptic root canal preparation, obturation to achieve an apical and coronal seal, and no evidence of pre-operative periradicular pathology can be accompanied by a good prognosis and delaying the final restoration serves no purpose.

Coronal versus apical seal

Historically, endodontists have paid great importance to the creation and maintenance of an apical seal during obturation and post space preparation.[9] The effect of preparation technique, irrigant, removal of the smear layer, how the root canal is dried, which obturation technique is used and which sealer has been used[10-16] have all been investigated with regard to the integrity of the apical seal of a root canal filling. Most of these laboratory studies have used dye penetration techniques to assess the apical seal, however, a recent

study of 116 teeth root canal treated in vivo and extracted at least six months later, has cast doubts as to the clinical relevance of the apical seal.[17] In this study all of the teeth demonstrated dye leakage irrespective of whether the endodontic treatment was deemed to be successful or not. With this in mind there is mounting evidence to suggest that for a successful root canal filling the coronal seal provided by the final restoration is as, if not more, important than the apical seal of the root canal filling.[18,19] A restoration with a poor coronal seal will potentially allow saliva, bacteria and endotoxins access to the root canal and possible penetration along its entire length leading to periradicular periodontitis. [20,21] The endotoxins alone can predictably move through an obturated root canal and so bacteria around a defective coronal restoration could theoretically sustain a periradicular inflammation. In reality, Ray and Trope[22] have shown that in 1,010 endodontically treated teeth, examined radiographically, the quality of the coronal restoration is more important than the endodontic treatment for apical periodontal health.

Supra-Bony Tooth Structure

The bulk of supra-bony tooth structure is the most critical factor determining the restorative prognosis for a tooth.[23] There have been suggestions that endodontically treated teeth are somehow more "brittle" than vital teeth. Research by Helfer[24] et al has shown decreased moisture content in the dentin of pulpless teeth, the significance of which is not clear.

Huang and Schilder[25] have shown that the modulus of elasticity (Young's modulus) and the ultimate strength of dentin increase as it dehydrates (i.e. it becomes stiffer). These researchers also showed that ultimate strength in tension and compression, in both vital and non-vital dentin, is essentially identical. Interestingly, they found that Young's modulus of dentin was lower in non-vital teeth than in vital teeth. This evidence does not support the idea that the mechanical properties of non-vital dentin are significantly different from those of vital dentin.

Biologic Width

To have a healthy gingival attachment apparatus, room is required between the margin of the restoration and the crest of bone. Gargiulo et al[25] found the dimensions of the attachment apparatus to range from 1.77 mm to 2.43 mm. This means that there should be an absolute minimum of 2.5 mm between the restoration margin and the crest of bone. Fugazzotto et al[27] have recommended that at least 3 mm be allowed.

An adequate bulk of tooth coronal to the restoration margin is required to restore the tooth. The amount of coronal tooth structure, along with the position of the tooth in the arch, will dictate: the type of build-up indicated; whether a preformed post, or a cast post and core are indicated; and whether a crown is needed.

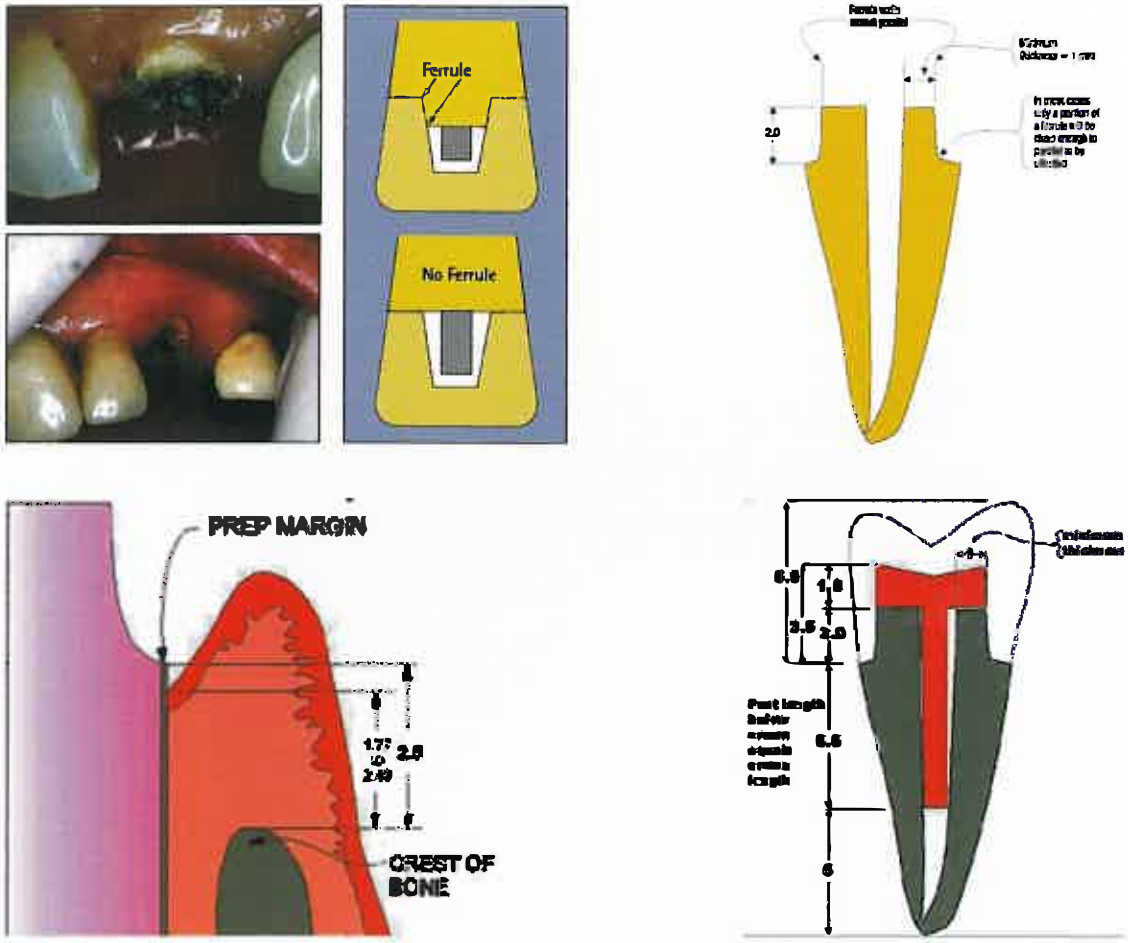
Remaining coronal tooth tissue - creating the ferrule

It is of paramount importance that as much coronal or supragingival tooth tissue is preserved as possible, as this significantly improves the prognosis of the tooth and restoration. Between 1-2 mm of tooth tissue coronal to the finish line of the crown preparation significantly improves the fracture resistance of the tooth and is more important than the type of material the core and post is made from.[28] The band of extra-coronal material (usually metal or metal ceramic) that encompasses this tooth tissue is termed the ferrule and is usually provided by the crown that is placed over the post and core system, but can be provided by a cast post and core which incorporates a diaphragm or coping.

The term ferrule is thought to be derived from the Latin word ferrum, meaning iron, and viriola, meaning bracelet.[29] Thus the ferrule effect occurs because of the crown bracing against the remaining supragingival tooth tissue. Some authors have questioned the benefit of the ferrule, however the majority of the literature would support its importance in reducing root fracture due to functional lever and torsional forces, and the wedging effect of tapered posts.[30,31]

Barkhordar et al[32] in 1989 compared restored teeth that were prepared with and without a ferrule and showed that the ferrule reduced vertical root fracture by one-third. When failure occurred in teeth with a ferrule, the failure was most commonly due to horizontal fracture compared to the vertical root fracture seen in teeth with no ferrule. Thus the teeth were more likely to be retrievable. In 1990, Sorensen and Engleman[30] suggested that the failure rate of post crowns was significantly reduced if 1 mm of coronal tooth tissue remained. However, another study by Libman and Nicholls[33] investigating the effect of cyclic loading on cast post and cores with ferrules 0.5 mm, 1 mm, 1.5 mm and 2 mm high, has shown that the 1.5 mm and 2 mm ferrules led to failure at a much higher number of cycles. A similar laboratory study also supports increased fracture resistance afforded by ferrules 1.25-2.5 mm.[34] The height of the ferrule at differing locations around the circumference of the tooth may also be important due to functional occlusal loading.

Fig 1: Ferrule vs No Ferrule



Thus a maxillary incisor would benefit from a longer ferrule on the palatal aspect and a mandibular incisor on the labial aspect.[35] Thus a 1.5 mm ferrule can be recommended labially and lingually whereas a shorter 1 mm ferrule could be accepted mesially and distally due to decreased stress in these direction

Whilst most studies on the failure of post crowns have been carried out in the laboratory, little evidence exists from clinical randomized controlled studies. One retrospective clinical study which evaluated 788 post crowns radiographically concluded that post fractures occurred in teeth with a lack of a ferrule at the crown margin.[36] However, insufficient data is given in this study as to how many teeth had a ferrule and how many did not. In addition, the extent of any coronal tooth tissue could not be estimated from the radiographs as the metal ferrule would have masked this. Despite the lack of clinical studies, the best evidence available supports the importance of the ferrule.

Intact Anterior Teeth

There is a consensus that there is no need to place crowns or posts in anterior teeth (incisors and cuspids) with essentially intact crowns, because posts donot reinforce endodontically treated teeth.[37,38] In such teeth, closure of the access preparation with a bonded composite resin restoration is all that is required, provided the tooth meets the occlusal requirements and the patient is happy with its appearance.

Posterior and Anterior Teeth Requiring Crowns

Almost without exception, endodontically treated posterior teeth (distal to the cuspid) benefit from cuspal coverage with some form of crown.[37] In addition, many anterior teeth will require crowns for esthetic, structural or occlusal reasons. For such teeth to be successfully restored, there must be a minimum of 4.5 mm of solid tooth structure above the bone crest;

given that a minimum of 2.5 mm is required for biologic width and 2 mm for an effective ferrule.

The Need For a Post

Endodontically treated teeth all require build-ups of some sort, if only to close the access preparation and fill the pulp chamber. Where a crown is to be placed on the tooth as a final restoration, this build-up is often called upon to provide resistance and retention form to the preparation. Retention of the build-up is often accomplished by placement of a post, which engages the root structure.

Nayyar et al[39] and Kane et al[40] have both described the use of amalgam cores as build-ups for posterior teeth retained by the pulp chamber or by extensions of amalgam into the coronal 2 mm to 4 mm of canal space. Kane et al showed that where 4 mm or more of pulp chamber height remained, there was no advantage to placing amalgam into the root canal space. In addition, even in teeth with only 2 mm of pulp chamber height left, the fracture loads were comparable to those of teeth with 4 mm high pulp chambers. On posterior teeth in which the core build-up can be retained by remaining pulp chamber anatomy there is no need or advantage to placement of a post.

With both anterior teeth and posterior teeth the decision to place a post is based on the answer to the question; is a post required to retain the build-up? The decision to place a post should not be based on the desire to strengthen the tooth. Sorensen and Martinoff[41] found no evidence that placement of a post and/or crown on an anterior tooth has a significant effect on the prognosis of the tooth. Where a post is necessary to retain the build-up, the length of the post and the length of the remaining apical seal can greatly influence the probability of the success of the restoration.

Principles of core buildup

The construction of a core buildup is necessary as the amount of residual tooth substance decreases, and the buildup augments the development of retention and resistance provided by the remaining tooth structure. Morgano and Brackett[42] described some of the desirable features of a core material. They include adequate compressive strength to resist intraoral forces, sufficient flexural strength, biocompatibility, resistance to leakage of oral fluids at the core- tooth interface, case of manipulation, ability to bond to remaining tooth structure, thermal coefficient of expansion and contraction similar to tooth structure, dimensional stability, minimal potential for water absorption and inhibition of dental caries.

Unfortunately, as the commonly used materials all exhibit certain strengths and weaknesses, such an ideal core material does not exist. The most commonly used core materials are cast gold, amalgam, resin-based composite and glass ionomer cement. Both cast gold and amalgam have been used successfully for many years, as they exhibit high strength and low solubility, and their coefficient of thermal expansion is similar to that of tooth substance. Placing cast gold post and core, however, is an indirect procedure requiring two visits. Both gold and amalgam are not esthetically pleasing, especially under the newer all-porcelain restorations.

Resin-based composite offers an esthetically pleasing material especially in the anterior section under an all-porcelain restoration. It has good strength characteristics and low solubility. Some of the negative features of resin-based composite are polymerization shrinkage, hydroscopic expansion as a result of water adsorption and incorporation of voids in the buildup because it cannot be condensed like amalgam. Furthermore, resin-based composite is incompatible with ZOE in many root canal sealers, which can result in resin that is not cured completely. These negative features may lead to microleakage if they are not addressed properly during placement of the material. Proper removal of the residual root canal sealer coupled with a small incremental buildup using a condensable resin-based composite material may help alleviate the potential of microleakage. In One vitro study comparing resin-based composite, amalgam and cast gold as core material under a crown in ET teeth found no significant difference in fracture and failure characteristics among these materials, provided a 2-mm ferrule existed on the margin of healthy tooth substance.[43] Glass ionomer cement, on the other hand, was shown to be weak in tensile and compressive strengths, and it had low fracture resistance as a core material in another study.[44] Glass ionomer cement also exhibits a low modulus of elasticity, poor bonding characteristics to dentin and enamel, poor condensability and high solubility. Therefore, the use of glass ionomer cement as a core material should be avoided.

Criteria For Successful Restoration

For the endodontically treated tooth requiring a post, the minimum length of remaining solid tooth would be the sum of biologic width (2.5 mm), ferrule length

(2 mm), apical seal (4 mm) and a post length (equal to crown length), (i.e. 8.5 mm + post length beyond crown margin)

For those teeth not requiring a post, the requirements are for biologic width + ferrule length (i.e. 4.5 mm of supra-bony solid tooth; this assumes adequate bone support to provide a clinically acceptable level of mobility).

In addition, consideration of the functional loads to be borne by the tooth is essential. Single abutments supporting precision attachment RPDs, distal extension RPDs or cantilever FPDs that are endodontically treated, or likely to be in future, should be avoided. Careful assessment of the occlusal demands and other loads, such as from fixed or removable partial dentures, must be made before restoration. Endodontically treated teeth that meet these criteria can be restored with a high degree of confidence.

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