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Estimation of Root Canal Obturation Leakage

Division of Oral Ecology in Health and Infection, Department of Oral Health Science, Course for Oral Life Science, Niigata University Graduate School of Medical and Dental Sciences
Nunez Phides and Hoshino Etsuro

Visualization of the internal ramifications of the root canal system has been a constant challenge for researchers for many years. Various techniques such as clearing (Robertson *et al.*, 1980) and sectioning (Kasahara *et al.*, 1990) had been proposed. Such techniques, however, involved demineralization or subsequent destruction of the tooth to reveal internal anatomy. One such study was made by Bramante *et al* (1987) who sectioned the teeth horizontally and then reassembled them in stone to compare pre- and post-instrumentation shape of the canals.

Non-invasive methods to study the root canal have also been developed. One of the earliest is by Weine *et al* (1975), in the form of simulated root canals, which involved the use of a silver point as a template. While this method showed excellent visualization, it was considered simplistic and assessment can only be made in one plane (Rhodes *et al.*, 1999). In addition, other workers have cautioned against the interpretation of results and extrapolations from this method to be applied to real root canals. (Thompson and Dummer, 1997; Smith and Edmunds, 1997). Another non-invasive method is the use of radiographic techniques but while it is reproducible and relatively easy to employ, it could only produce a two-dimensional record (Southard *et al.*, 1987). Such two-dimensional images are not sufficient to give the best representation of the internal structures of the root canal system as shown by the wealth of studies that have revealed its complexity.

Aside from anatomy of the root canal, moreover, endodontic studies also require the visualization of the canal after it has been filled because the complete obliteration of the canal space after instrumentation has remained a prime requisite for the success of endodontic treatment (Petersson *et al.*, 1986). Barthel *et al.* (1999) stated that the coronal restoration and the root filling are primary safeguards against re-infection. Gaps between the root canal filling and the dentinal wall as well as air spaces within the filling forming continuous channels to the apex may allow entry of bacteria or bacterial products that may initiate or reactivate an inflammatory process. Oral fluids like saliva and other extraneous products that could nourish the growth of persisting bacteria may also enter the canal via such spaces. Persisting bacteria which are found on the apical portions of root canals of obturated teeth are the cause of most treatment failures. (Nair PNR *et al.*, 1990). These microorganisms include *Enterococcus faecalis, Actinomyces israelii, Bacteroides gracilis*, and many others. (Sundqvist G *et al.*, 1998). The visualization methods that have thus far been mentioned focused more on the study of canals before and after instrumentation. In light of this, the need for a non-invasive, reproducible, and adequate visualization technique for filled canals, therefore, becomes paramount.

In 2003, Venturi *et al.* proposed a clearing technique that will allow the visualization of filled canals. However, demineralization of samples is inherent in clearing techniques and so it is still considered invasive. Another more widely used method is linear measurement of dye penetration along a root filling. In a review by Wu MK and Wesselink PR (1993), they concluded that more research should be devoted to developing better methodology for such leakage studies, rather than comparing the sealing ability of different materials. Because leakage studies normally require sectioning of teeth, and are thus also destructive (Clinton and Himel, 2001; Imai and Komabayashi, 2003; Gencoglu *et al.*, 2002), a dye penetration test that will not require sectioning would be a welcome development. As early as the1990's, researchers like Tachibana *et al.* (1990) and Nielsen *et al.* (1995) have used micro-computed tomography (MCT) as a tool for endodontic research. They have shown the possibility of using this technique in various fields of endodontic research like, among others, the examination of the internal and external morphologies of the tooth and assessment of volume changes after instrumentation or obturation. MCT was shown to be accurate for experimental endodontology (Rhodes *et al*. 1999), with the distinct advantage of being completely non-invasive and reproducible.

Subsequent endodontic studies with the use of MCT, however, were largely limited to the root canal shape before and after instrumentation. Few researchers have attempted the three-dimensional evaluation of root canal obturations with the use of MCT. One such study has been done by Jung M *et al*., and shall be the focus of this review.

The aim of the article *The imaging of root canal obturation using micro-CT*, by Jung M, Lommel D and Klimek J (International Endodontic Journal 38: 617-26, 2005) was to determine if MCT would be an accurate imaging technique for obturated canals. Such an investigation is necessary because recent studies regarding the study of root canals, with the use of MCT has been increasing. An assessment of this technique is needed to determine if the results obtained are reliable enough to be used as reference for future studies. Unlike most articles which dealt largely on the internal anatomy of root canals, however, Jung M *et al*. focused on the evaluation of obturated root canals.

In the study, four single rooted maxillary teeth were conventionally enlarged and filled by lateral condensation technique of gutta percha and then assessed radiographically. The samples were then examined with a MCT system SkyScan 1072 80kv. In order to assess the accuracy of the MCT images, they were compared with histological sections of the samples. Eight to twelve slices were made from each sample and prepared for histologic examination. The slices were viewed with a microscope at two-fold magnification. For qualitative assessment, photographs were taken for each slice which were then super-imposed with the corresponding slices on the MCT images. Quantitative correlation, or surface areas of the root filling and dimensions of single gutta percha points, was evaluated by an image analysis software (Analyze 5.0).

The results of the study showed that qualitatively, there was a good correlation between the histological and MCT images. Master or accessory gutta percha cones, sealer, as well as voids were similarly represented in both histologic and MCT images. Quantitatively, there was also a high correlation of the surface area of the root canal filling between the histologic and MCT images (Pearson correlation coefficient = 0.992), although the results for the surface area of the single gutta percha cones had a slightly greater difference.

The confirmation that MCT can produce images that are in very close approximation to the actual conditions in a filled canal as compared to radiographs is important for studies dealing with certain failed endodontic treatments. It becomes a valuable tool for root canal filling leakage studies, as it will aid in the analysis of obturation defects that may serve as pathways not only for oral fluids and bacteria, as mentioned earlier, but for medicaments as well. Medications in the form of a mixture of certain antibiotics have increasingly been used as endodontic treatment, especially for teeth with periradicular lesions. (Takushige T, 2004; Ozan U, 2005).

As noted previously, although many techniques had been suggested for the evaluation of the root canal system and obturation, they were mostly destructive. The study reviewed in this article demonstrated the potential of MCT as a non-destructive tool for endodontic research, in particular, root canal obturation. Radiographic image analysis in this context is not sufficient for the adequate evaluation of obturations, being only two-dimensional. The major limitation of the MCT technique is obviously its application *in vivo*. With this limitation in mind, however, it is possible to create study designs that will maximize its advantages in order to produce a more accurate representation of root canal obturations.

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