Assessment of the Apical Transportation of Root Canals Using the Method of the Curvature Radius

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The purpose of this investigation was to evaluate the occurrence of apical transportation after root canal instrumentation using only K-Flexofiles or K-Flexofiles intercalated with K-Flexofile Golden Mediums. For this purpose, the degree (Schneider's method) and the radius of the curvature was recorded before and after instrumentation. The results showed that there was no statistically significant difference between the techniques. The correlation between the degree and the radius of curvature of the root canal was not consistent, nor was there a relationship between the original radius of curvature and the apical transportation. However, determination of curvature by use of its radius has proved to be an effective method.

Key Words: instrumentation, apical transportation, cleaning and shaping.

Introduction

During instrumentation of the root canal, the development of a continuously tapered form and the maintenance of the original shape and position of the apical foramen are important objectives. However, the presence of curvatures may cause difficulty in root canal instrumentation. The final results of the instrumentation of curved root canals may be influenced by several factors: flexibility and diameter of the endodontic instruments, instrumentation techniques, location of the foraminal opening, and the hardness of dentin. Ledge formation, blockages, perforations and apical transportation are undesirable accidents observed following the preparation of curved root canals. Therefore, to deal with the complex problem of preparing curved root canals, several instrumentation techniques have been introduced.

Several studies have used Schneider's (1971) method to determine the curvature of the root canal by means of x-ray images (Cimis et al., 1988; Al-Omari et al., 1992; Cunningham and Senia, 1992; Sydney et al., 1993; Luiten et al., 1995). By this method, the angle of curvature is that formed by two straight lines, the first line parallel to the axis of the canal and the second being that which passes through the apical foramen until its intersection with the first where the curvature starts to occur. This method as well as modifications suggested by Southard et al. (1987) and Luiten et al. (1995) are open to criticism since the curvature is determined by the angle and not by the radius.

To evaluate the apical transportation of the root canal after instrumentation, several methods have been used, i.e. the visual examination of x-rays, photographs obtained from x-rays, super-imposition of x-ray images, and pre- and post-operative x-rays with millimeter grid patterns over the x-ray film (Cimis et al., 1988; Sydney et al. 1993).

Thus, the purpose of the present investigation was to determine the curvature of the root canal through radiographs and to analyze the influence of K-Flexofile Golden Mediums (Maillefer, Switzerland) files with regard to the apical transportation when used in the instrumentation of curved canals.

Material and Methods

Twenty extracted human first and second mandibular molars were selected for this study. Their distal roots were sectioned at the amelo-cemental limit using carborundum discs. Each tooth was mounted on an acrylic resin platform in two distinct positions: one in the mesio-distal plane and the other in the bucco-lingual plane. The platforms were then adapted to an x-ray machine by means of a special device which permits radiographs of the teeth in identical situations before and after the instrumentation of the root canals.
After hydration in distilled water, the samples received the following preparation. Coronary openings and access to the pulp chamber were done according to conventional endodontic techniques. The working length of each canal was determined by passing a #8 K-file (Antaeos) to the apical foramen. Working lengths and reference points were recorded for each canal. The samples were mounted on the radiographic platforms to allow a reproducible angulation of the initial and final radiographs. After radiographic processing, it was possible to determine the anatomic and foraminal exit curvature of the root canal identified by the file. The teeth were then divided into two groups of ten specimens each.
The samples in group 1 (control) were prepared conventionally over the entire extension of the root canal with K-Flexofile files up to #30. Preparation of the teeth in group 2 was done using K-Flexofile Golden Mediums, #12, #17, #22 and #27, intercalated with K-Flexofile files.
The instruments were precurved and the filing movement was done at an amplitude of 1 to 2 mm until they were loose inside the root canal. At each change of instrument, the root canal was irrigated with 2 ml 0.5% sodium hypochlorite. During instrumentation, the working lengths of the root canal were reduced due to straightness of the curvature.
Radiographs were taken after use of file #25 and #30 to determine the final curvatures and the apical transportation. The endodontic instruments were substituted after every three uses.

Determination of Curvature
Curvature of the root canals was determined by both the angle (Schneider, 1971) and the radius methods, the latter proposed in this study. In the determination of the curvature of the canals by the radius method the radiographic images were projected on a surface at a fixed distance to give an enlargement of ten times and the outline of the instrument traced on a sheet of white paper. The radius of curvature of the root canal was measured in the region of greatest curvature using the geometric method (the center of a curve is determined by the meeting of the medians of two cords in the region of greatest curvature) (Figure 1).

Figure 1 - Determination of curvature.

Determination of the apical transportation
The radiographic images were projected with an enlargement of 20 times and the outline of the tooth and the instrument were drawn on a sheet of white paper. On the radiograph image with a #10 file, a tangent was drawn at the apical foramen of the root canal, passing through the tip of the instrument. After instrumentation, the radiographs were projected on the same surface, the outline of the tooth being made to coincide with that drawn on the paper. The points of tangent at the apical foramen of the root canal corresponding to file #25 and #30 were then determined. The distance of separation between the points corresponding to the apical transportation due to instrumentation was then measured with a calipers (Mitutoyo) having a precision of 0.05 mm (Figure 2). For this experiment, apical transportations were considered mild (<0.25 mm), moderate (>0.25 and <0.50 mm) or severe (>0.50 mm) according to the classification proposed by Cimis et al. (1988).

Figure 2 - Determination of apical transportation.

Results and Discussion

The results of the measured values of the radius and angles of curvature, measured in the projected radiographs of the samples with the #10 K-file (Antaeos) and #30 K-Flexofiles are shown in Table 1. Analysis of the test results revealed that there was no relation between the variation of the angle and the radius of curvature. The angles can vary with the length of the arc without variation in the length of the radius. Determination of the curvature of the root canal using the method of Schneider (1971) presented difficulty in determining with precision the tangent that passes through the curved region of the canal as well as the straight line which passes through the tip of the instrument at the apical foramen. The canal may even present several curvatures and, by drawing a tangent to one of them, this may not be that of the smallest radius. Moreover, the angle may change with the arc length without a variation in the radius length.

In the preparation of curved canals it is important to observe the radius and not the angle of curvature since the latter does not represent the true curvature of the root canal. According to Al-Omari et al. (1992), the variation of the distance between the beginning of the curvature and the apical termination of the preparation may induce the occurrence of apical transportation with greater influence than that of the degree of curvature. Southard at al. (1987) observed that in the instrumentation of the canals other factors may be more important. Curves having a small radius can lead to greater wear than curves with a greater radius.

Our proposed method measures the radius of the root canal in its region of greatest projected curvature which is seen with ease, reducing errors committed with the Schneider's method (1971). According to the values of radius, the root canal curvature was classified as mild (>20 mm), moderate (>10 and <20 mm) or severe (<10 mm).

In all of the samples the root canal was straightened after instrumentation, which was not proportional to the value of the radius. Root canals with a smaller radius did not always result in greater straightness. It was observed that the beginning of the curvature was displaced in the apical direction of the root canal. This can be attributed to the variation in the hardness of dentin among the tooth samples, direction and intensity of force applied by the operator, flexibility of the instrument and the localization of the beginning point of the curvature. Harder dentin has greater capacity to deflect the files, directing the wear towards the external part of the curvature of the canal. The flexibility of the instrument varies along the active part, causing the bending resistance of the file to increase from D1 to D2.

It was observed that at the extremes of the curvature the wearing away of the walls of the root canals was directed toward the concave portion of the canal (cervical and apical region) and at the middle part this was greater in the convex region. This can be attributed to the mechanical resistance to deformation of the instrument which maintains its original straight form with elastic loads. Radiographically, the wearing away was towards the mesial in the apical and cervical thirds and distal in the middle third. When analyzed in the bucco-lingual direction, it was buccal in the cervical and apical thirds and lingual in the middle third.

A certain percentage of the samples had double curvature of the root canal (curvatures in the opposite direction), ten percent in the mesio-distal direction and thirty percent in the bucco-lingual. In the most apical curvatures the radius drawn for evaluation of the curve was towards the mesial in the mesio-distal analysis and towards the buccal in the bucco-lingual evaluation. In these cases the apical transportation of the root canals occurred towards the distal and lingual, respectively (Figure 3). This is due to the instrument continuing to present resistance to plastic and elastic deformation. It can also be observed in Table 1 that the average values of curvature radius are less in the mesio-distal direction than in the bucco-lingual direction.

Figure 3 - Transportation of the root canal.

The average values of apical transportations, measured in the radiographs of the samples with #20 Antaeos K files and #25 and #30 Flexofiles, are shown in Table 2. The apical transportations were mild to moderate. Clinically, however, these transportations were greater in the success of the endodontic therapy. The average apical transportations were greater in the mesio-distal direction than in the bucco-lingual direction, probably due to the smaller radius of the curvature observed in the mesio-distal direction.

Statistical analysis using the "t test" and by analysis of variation demonstrated no significant difference between the results of the two groups. Although the average of apical transportation values of the root canals are considered mild to moderate, analysis of the results showed percentage differences between the groups.

Mesio-distal transportation

Based on the classification suggested by Cimis et al. (1988), the results of the tests showed that, after instrumentation with #25-Flexofiles, apical transportation in the mesio-distal direction was mild in 50% of the samples and moderate in the remaining specimens of group 1. Transportation of the root canal was mild

in 80% of the samples of group 2 and moderate in 20%. After instrumentation with a #30 K-Flexofile the transportation was mild in 30% of the samples of group 1, moderate in 40% and severe in 30%; while, in group 2 after use of the #30 file, transportation was mild in 50% and moderate in the other 50%.

Bucco-lingual transportation
No apical transportation occurred in 40% of the samples after use of #25 K-Flexofiles in group 1, mild transportation occurred in 50%, and moderate in the remaining samples. In group 2, no apical transportation occurred in 30% of the samples and apical transportation was mild in 70%. After instrumentation with a #30 K-Flexofile in group 1, there was no apical transportation in 20% of the samples and it was mild in 80%, while in group 2, apical transportation did not occur in 20% of the samples and it was mild in 80%. After use of the #30 file in group 2, apical transportation did not occur in 20% of the samples, it was mild in 70% and moderate in the remaining 10%.

Transportation in both directions
Apical transportation of the root canals in the mesio-distal direction and bucco-lingual direction after the use of #25 K-Flexofiles occurred in 60% of group 1 samples and in 70% of those of group 2. After the use of a #30 K-Flexofile it occurred in 80% of the samples of both groups.

Conclusions

Based on the results obtained in the present study, it can be concluded that:

1) Determination of the curvature of the root canals through the use of the radius was easy and efficiently performed.

2) There was no statistically significant difference in apical transportation of the root canal between the technique using only K-Flexofiles and that using the same files intercalated with K-Flexofile Golden Mediums.

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