Location and angulation of curvatures of mesiobucal canals of mandibular molars debrided by three endodontic techniques

Posição e angulação de curvaturas radiculares em canais mesiobucais de molares inferiores preparados por três técnicas endodônticas

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Abstract: The aim of this study was to assess the correlation between the degree of angulation and the position of root curvatures and their influence on the comparative results between the performances of the Progressive, Staged and Serial Preparation Techniques. The mesiobucal canals of 70 extracted mandibular molars were filled with a radiological contrast of 100% Barium sulphate and radiographed with a direct digital radiographic system, in an apparatus that guarantees that the samples remain in the same spatial position at all times. The images were then analyzed in the Coreldraw 10 program (MicroSafe, RJ, Brasil) in accordance with two criteria: the methods of Berbert, Nishiyama[1] (1994) and Schneider[11] (1971) to determine the position and the angle of the root curvatures, respectively. Initially, the possibility of correlation between these two variables was studied. The teeth were then selected according to angulation (greater than 25 degrees) and position of root curvatures (cervical, median and apical) in order to perform the endodontic techniques. After preparation, the samples were radiographed again and the images were superimposed in order to compare the pre- and post-operative areas. The difference between them showed the percentage of widening for each technique. The results showed that there was no correlation between the angulations and the root curvature positions, and that the different positions did not interfere in the performance of the techniques. The Progressive Preparation technique produced the highest widening values for all the groups, irrespective of the root curvature position.
Descriptors: Root canal therapy; Root canal preparation; Anatomy; Abnormalities; Molar.

Resumo: O objetivo deste trabalho foi verificar a correlação entre o grau de angulação e a posição das curvaturas radiculares, e a sua influência nos resultados comparativos entre os desempenhos das técnicas do Preparo Progressivo, Escalonada e Seriada. Os canais mésio-vestibulares de 70 dentes molares inferiores extraídos foram preenchidos com um contraste radiológico de sulfato de Bário a 100% e radiografados em um sistema de radiografia digital direta, em um aparato que garantia que as amostras ficassem sempre na mesma posição espacial. As imagens foram, então, analisadas no programa Coreldraw 10 (MicroSafe, RJ, Brasil) segundo dois critérios: os métodos de Berbert, Nishiyama[1] (1994) e de Schneider[11] (1971) para determinação da posição e do ângulo das curvaturas radiculares, respectivamente. Estudou-se inicialmente a possibilidade de correlação entre essas duas variáveis. Os dentes foram, então, selecionados segundo a angulação (superior a 25 graus) e posição das curvaturas radiculares (cervical, mediana e apical) para a realização das técnicas endodônticas. Após os preparos, as amostras foram novamente radiografadas e as imagens sobrepostas para a comparação das áreas pré e pós-operatórias. A diferença entre elas mostrou a porcentagem de alargamento para cada técnica. Os resultados mostraram não existir correlação entre as angulações e as posições das curvaturas radiculares, e que as diferentes posições não interferem no desempenho das técnicas. A técnica do Preparo Progressivo mostrou maiores valores de alargamento para todos os grupos, independentemente da posição da curvatura radicular.
Descritores: Tratamento do canal radicular; Preparo de canal radicular; Anatomia; Anormalidades; Molar.

Introduction

Chemical-surgical preparation is the stage of endodontic treatment in which the root canal is cleaned and modeled. If this is well done, it should allow an enlargement of the original canal space without deforming it, enabling a three-dimensional obturation to be done, consequently promoting the repair of the periapical tissues.

However, the existence of alterations in the internal anatomy of the root canal may make it difficult to carry out treatment. Different tooth wall thicknesses, various positions and angulations of root curvatures, isthmuses, among other alterations, involve specific requirements for performing a good modeling. It is imperative for the professional who is going to work in Endodontics to have knowledge of the internal anatomy, to allow planning of the endodontic procedure, access to the pulp chamber and final obturation.

Different degrees of root curvature lead to different difficulties in canal preparation.[11] Therefore, curvatures have been classified as slight (up to five degrees), moderate (from five to twenty degrees) and severe (greater than twenty-five degrees).

The three-dimensional study of mesial root canal curvatures in mandibular molars in the buccolingual and mesiodistal directions[2] showed that 100% of the specimens presented with curvatures in both directions.

A method was developed for quantifying and locating the curvatures of root canals,[1] determining a quotient for establishing the position of the curvature along the root. Quotients lower than 0.5 represented curvatures that were concentrated in the apical third; quotients ranging from 0.5 to 2.0 represented curvatures concentrated in the middle third; and, finally, quotients above 2.0 represented curvatures in the cervical third. When applying this methodology to the radiographs of 50 extracted maxillary and mandibular molars, it was noted that the greatest concentration of curvatures was in the middle third.

Although the anatomy of each type of tooth presented common characteristics,[3,8,10] it also presented very complex variations. Irregularities, such as accessory canals and apical deltas, were practically inaccessible to mechanical preparation; curvatures resulted in the asymmetrical removal of dentin during cleaning, leading to apical transport by several degrees, and the real anatomy of the canal was much more complicated than it appeared to be radiographically, with curvatures in multiple positions and planes.

A series of endodontic techniques are recommended for the treatment of teeth with root curvatures, each of them indicating suitable resources for overcoming the difficulties related to the intrinsic demands of the treatment of these teeth.

The Serial Technique was the first technique introduced for the treatment of either straight or curved root canals.[4] The Staged Technique[13] was recommended for the treatment of curved canals, which indicated the withdrawal of the larger caliber instruments that worked at shorter lengths than the working length. The "Progressive Preparation Technique"[7] combines the advantages of the crown-apex principle with the optimization of manual instruments. It uses a different type of instrument (K-Flex or NiTi) depending on the degree of root curvature presented by the tooth. More accentuated curvatures are worked on with more flexible instruments.

The aim of this study was to assess the correlation between the degree of angulation and the position of root curvatures and their influence on the comparative results between the performances of the Progressive, Staged and Serial Preparation Techniques.

Materials and Methods

The mesiobucal canals of 70 teeth were filled with a radiological contrast of 100% Barium sulphate and direct digital radiographs were taken by an apparatus that guarantees that the radiographs are taken in the same spatial position. The images were then analyzed in the Coreldraw 10 program (MicroSafe, Rio de Janeiro, RJ, Brasil) in accordance with two criteria: The angulation and position of root curvatures.

Analysis of the position of curvatures was based on the Berbert and Nishiyama method[1] that defines two points in the cervical region (A and A') and another two in the apical region (B and B'), which determine two straight segments, straight A and straight B, that meet at point C. The two straight

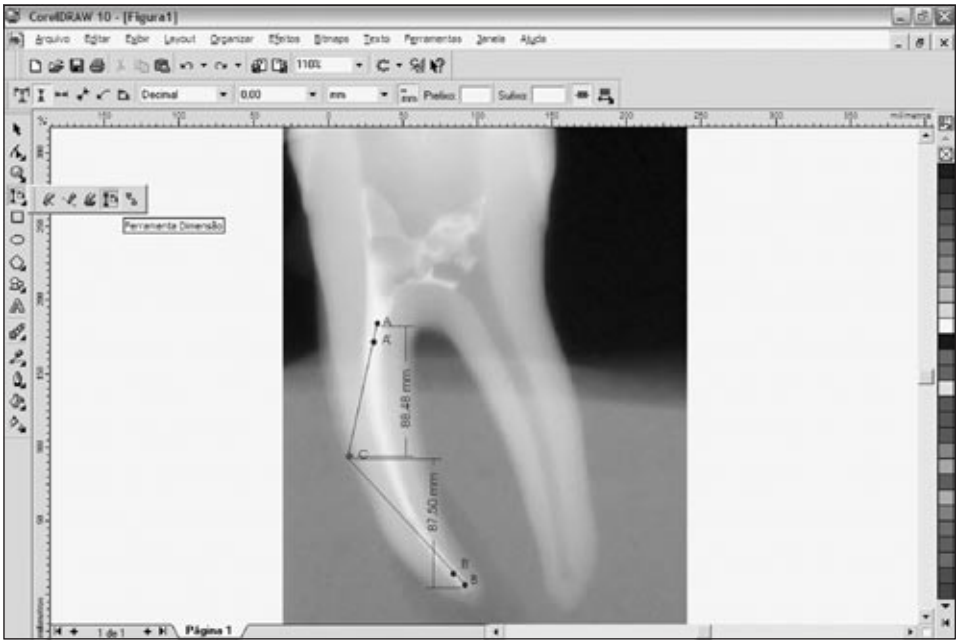


Figure 1 - Analysis according to the Berbert and Nishiyama[1] (1994) method.

segments were measured and the values divided. This division resulted in a quotient that indicated the location of the curvature: Cervical (greater than 2.0), median (from 0.5 to 2.0) and apical (smaller than 0.5) (Figure 1).

The angulations were analyzed on the basis of the Schneider method, which consists of tracing a straight line parallel to the long axis of the tooth and a second straight line starting from the apex until it meets with the first straight line at the place where the canal begins to move away from the long axis.[11] The acute angle formed is measured and is denominated the root curvature angle. The roots are then classified in accordance with the degree of the curvatures as straight (up to 5 degrees), moderate (from 5 to 20 degrees) and severe (over 25 degrees) (Figure 2).

Forty-five teeth, all of them with a curvature greater than 25 degrees, were selected and divided into three groups: One group for the Serial technique (GS), one for the Staged technique (GE), and one for the Progressive Preparation technique (GP). Each group was sub-divided into three sub-groups, one for each root curvature position: Sub-group A – cervical curvature, sub-group B – median curvature, and sub-group C – apical curvature. The apical preparations of all the techniques were performed with #30 files.

The Serial Technique was performed with the first instrument working on the working length, with filing and widening movements, until it felt loose inside the canal. It was then replaced by the immediately higher number that would be used in the same kinematics and at the same length, up to instrument #30.

The Staged Technique was performed sequentially up to instrument #25, which was denominated the "memory instrument". It was performed with a 1 mm reduction of the working length for each increase in instrument caliber, at all times reviewing the total working length with the memory instrument.

The Progressive Preparation Technique was performed by initially preparing the entry orifice of the canals with "Moura Manual Wideners". These instruments were confected by cutting 31 mm type K files (#80, #70 and #60) with a Carborundum disk to a length of 20 mm and then wearing their tips. They were then used with half-turn maneuvers in a clockwise direction. After odontometry, the canal was debrided up to at least file #25, denominated the "memory instrument". This instrument was then put into the real working length passively, without acting actively against the tooth canal walls. The crown-apex preparation then began with a K type instrument, with a diameter 4 times greater than that of

Figure 2 - Schneider[11] (1971) Method.

Table 1 - Results of teeth with cervical curvature.

Tooth	Å	Q
8	28.24	2.211
14	37.24	2.402
15	25.46	2.104
19	33.6	2.047
32	33.2	2.059
34	25.34	2.644
36	39.4	2.044
38	29.51	2.183
41	44.9	4.362
45	28.02	2.307
50	26.8	2.253
52	34.19	2.520
53	29.37	2.125
54	41.24	2.222
57	38.9	2.800
59	27.1	2.706
69	25.2	2.294

Å = measurement of the angles (°); Q = root curvature position.

the memory instrument, working in filing movements without apical pressure on the most cervical and middle regions of the canal. The next instruments were of successively smaller calibers and reached increasing apical depths of the root canal. They were interspersed with the memory instrument up to the real working length, from the greater to smaller caliber, until the memory instrument number was attained. This instrument was then replaced by a NiTi instrument of the same number, which now worked actively in the apical region, followed by another NiTi instrument of an immediately higher diameter, #30, up to the working length, to perform apical preparation. The apical preparations were performed with NiTi instruments, as all the teeth had curvatures greater than 25 degrees (severe curvatures).

The root canal preparations of all the techniques were performed with 1% NaOCl.

The teeth were radiographed again after the preparations, under the same conditions as those of the initial radiographs. The digital images were superimposed to compare the pre- and post-operative areas. The difference between them enabled the percentage of widening to be calculated for each technique, indicating how much each of them widened each group of teeth.

Results

Tables 1, 2 and 3 present the values resulting from the measurement of the angles (Å) and of the

Table 2 - Results of teeth with median curvature.

Tooth	Å	Q
2	30.9	1.766
3	26	1.551
4	29.3	1.064
5	22.37	1.705
6	22.9	1.021
7	22.65	1.284
11	43.24	1.547
16	32.3	0.909
17	30.9	0.935
18	28.6	0.881
21	37	0.721
22	29	1.291
23	29.22	0.897
24	29.5	0.991
25	37.92	0.659
26	25.4	1.145
27	26.37	0.836
29	26.5	1.048
30	25.2	1.101
33	27	1.168
35	24.7	1.027
37	36.5	0.786
39	25.6	1.462
47	26.39	1.247
49	21.49	1.644
58	20.1	1.744
62	25.86	0.740
63	28.7	1.739
65	20.1	1.844
66	21.2	1.829
70	23.6	1.000
51	20	0.789
74	33.4	0.982
75	28.4	1.068
40	21.3	0.744

Å = measurement of the angles (°); Q = root curvature position.

Table 3 - Results of teeth with apical curvature.

Tooth	Å	Q
1	25.71	0.496
9	43.24	0.227
12	33.9	0.179
20	25.2	0.209
31	26.98	0.213
42	26	0.346
43	34.54	0.192
48	26.37	0.451
60	26.83	0.496
61	49.1	0.089
67	40.7	0.181
68	26.8	0.240
71	36.25	0.162
72	21.4	0.379
73	25.48	0.497
10	38.6	0.162
64	26.2	0.381

Å = measurement of the angles (°); Q = root curvature position.

root curvature positions (Q) in accordance with the two selection criteria in the CorelDraw 10 program.

The Pearson Coefficient of Correlation was used to find out whether there was any relation between the variables Å and Q. The results indicated that r = 0, i.e., the two variables were independent; there was no correlation between them.

Graph 1 shows that the points were distributed in a dispersed manner, confirming that there was no relation between the variables.

It was observed that 50.72% of the samples presented curvatures in the median region of the root, whereas the cervical and apical regions were involved in 24.64% and 24.64% of the samples, respectively.

From the initial group of 70 teeth, 45 teeth with root curvatures greater than 25 degrees in the different positions of the above-mentioned sub-sections were then selected, in order to perform the techniques. The canal areas were measured before and after the preparations, and from the difference between the final and the initial areas, the percentage of widening for each technique was obtained (Table 4).

The Kruskal-Wallis Test (Table 5) was performed, with the intention of assessing possible differences in the values of the variables of interest (Angle and Position) among the groups considered:

Table 4 - Comparison of the widening percentages among the techniques.

Groups	GS	GE	GP
Sub-group A	51.25%	49.01%	52.73%
Sub-group B	56.27%	53.23%	59.10%
Sub-group C	43.59%	52.65%	54.89%

GS: serial; GE: staged; GP: progressive.

Table 5 - Result of the Kruskal-Wallis Test for analyzing widening.

Curvature		
Apical	Median	Cervical
0.867	0.177	0.792

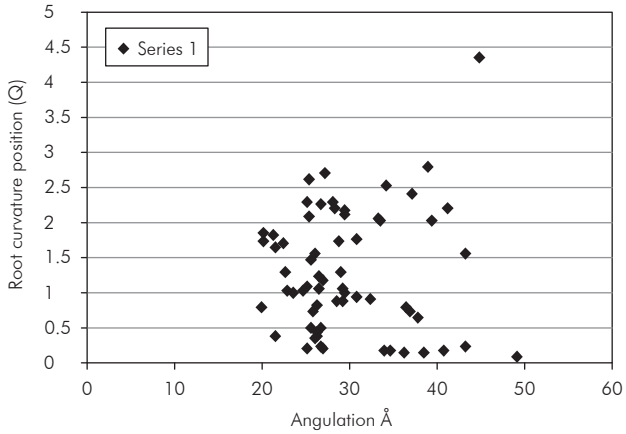
$p < 0.05$.

GS (Serial Technique), GE (Staged Technique) and GP (Progressive Preparation Technique) with the respective sub-groups A – cervical curvature, B – median curvature and C – apical curvature (Table 4). The results showed that the differences in the values among the groups considered were not statistically significant, i.e., the Technique and Curvature groups were similar.

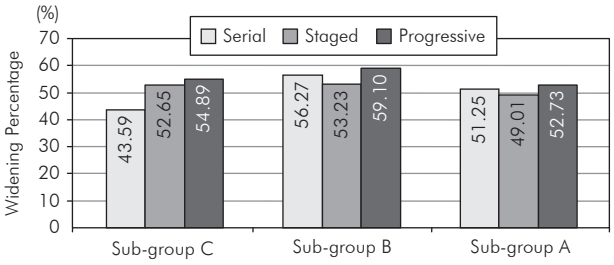
Graph 2, however, shows that in all the subgroups of teeth for each technique, the Progressive Preparation technique presented the best performance in terms of widening percentage.

Discussion

Tables 1, 2 and 3 show the tooth measurement values in relation to angulation and position of the curvature along the root. The lack of correlation between these two variables (Graph 1) reflects the anatomic diversity presented by the root canals in the studied group, indicating curvatures distributed in all regions of the root, in the most varying degrees. This result is in agreement with that of the studies of Cunningham, Senia[2] (1992) and Berbert, Nishiyama[1] (1994), who observed great variations in the degrees of root curvature presented by the teeth in their studies. The larger percentage of curvatures in the median region also coincides with the findings of Berbert, Nishiyama[1] (1994).



Graph 1 - Correlation between the Angle and the root curvature Position.



Graph 2 - Percentage of widening of the canal areas.

Fröner *et al.*[3] (1999), Pécora *et al.*[8] (2002) and Peters[10] (2004) observed that the apical anatomy of mesial roots presented a morphological complexity related to the number and shape of the root canals, and that although the anatomy of each type of tooth was shown to have common characteristics, they also presented very complex variations. They also mentioned that the curvatures resulted in an asymmetric removal of dentin during cleaning, leading to apical transport by severous degrees.

The lack of statistically significant differences among the techniques with regard to the position of curvature (Table 5) showed that the root curvature position does not interfere directly in the performance of the studied techniques.

In addition, the studies of Schneider[11] (1971), Lim, Webber[5] (1985), Pesce *et al.*[9] (1997) and Migliau *et al.*[6] (2004) observed the relation between the degree of root curvature and deformations in preparation, as they found that a larger number of undesirable alterations in the original anatomy of

the canal would occur in canals with severe curvature. Components of force were created in the presence of a curvature, which tended to displace the instrument in the opposite direction. However, Sydney[12] (1993), while studying the occurrence of apical transport in 6 groups of teeth with different angulations prepared with the Staged technique, observed that the inter-relation between the original degree of curvature and the presence of deviations was not constantly manifested.

The angulation factor was not studied in this work, as all the teeth selected for the application of the endodontic techniques presented angles greater than 25 degrees, i.e., they presented severe root curvature angulations, in accordance with the Schneider method.[11] Thus, the difficulties related to the treatment of teeth with accentuated curvatures were present for all the studied techniques.

Although the statistical analysis of the results of the three techniques did not present statistically significant differences, the comparison among the percentages of widening of the techniques did indicate that the Progressive Preparation technique presented the best results for all the groups of teeth (Table 4 and Graph 2), irrespective of the root curvature position.

Conclusions

1. There was no correlation between the position and the degree of root curvature for the 70 teeth studied in this work.
2. There was no statistically significant difference among the techniques for the groups of different positions of the root curvature.
3. When comparing the percentage of widening, the Progressive Preparation Technique presented the best performance for all the groups of teeth, irrespective of the root curvature position.

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