

# Reduction in the degree of curvature of the mesial canals of lower molars after coronal flaring with stainless steel or niti rotary instruments

Análise da redução do ângulo de curvatura de canais mesiais de molares inferiores, após o preparo cervical com instrumentos rotatórios de aço inoxidável ou niti

Débora Cintra ANDRADE<sup>1</sup>  
Bruno Alves de Souza TOLEDO<sup>1</sup>  
Fábio PICOLI<sup>1</sup>

## ABSTRACT

### Objective

This study assessed different flaring methods for eliminating coronal interferences in root canals of lower molars by analyzing the reduction in the degree of canal curvature after instrumentation.

### Methods

Forty mesial roots of lower molars were used. The mesiobuccal and mesiolingual canals were irrigated with an aqueous solution of 1% NaOCl and explored throughout. Standardized radiographs were taken with K files #10 inside the canals for assessment of the original degree of curvature before the following instrumentation: Group I - Hedströen files and Gates-Glidden burs; Group II - LA Axxess burs; Group III - rotary nickel-titanium (NiTi) K3 files; Group IV - CP-Drill burs. The roots were radiographed again with K #10 files inside after the instrumentation for assessment of the new degrees of curvature. The mean degrees of curvature of the mesiobuccal and mesiolingual canals before and after instrumentation were calculated. Reduction in the degree of canal curvature was given by the difference between the degrees before and after instrumentation.

### Results

Statistical analyses showed that all study methods were capable of reducing the degree of curvature of the root canals by removing coronal interferences.

### Conclusion

The LA Axxess burs were the most efficient study instruments for removing the anatomic coronal interferences, reducing the degree of curvature of the mesial canals by a mean of 11.52°.

**Indexing terms:** Dental instruments. Endodontics. Root canal preparation.

## RESUMO

### Objetivo

Avaliar diferentes métodos de preparo para eliminação de interferências cervicais em canais radiculares de molares inferiores, por meio da análise da redução do ângulo de curvatura.

### Métodos

Foram utilizadas 40 raízes mesiais de molares inferiores. Seus canais (mesiovestibulares e mesiolinguais) foram irrigados com NaOCl 1% e explorados em toda sua extensão. Realizou-se tomadas radiográficas padronizadas com limas K #10 no interior dos canais, para a avaliação dos ângulos de curvatura originais, antes da realização dos seguintes preparos: Grupo I - Limas Hedströen e Broca de Gates Glidden; Grupo II - Broca LA Axxess; Grupo III - Limas rotatórias K3 de NiTi; Grupo IV - Brocas CP-Drill. Após os preparos foram realizadas novas tomadas radiográficas com limas tipo K #10 nos canais, para reavaliação dos ângulos de curvatura, obtendo a média dos valores de curvatura dos canais mesiovestibulares e mesiolinguais, antes e após o preparo. A diferença entre os valores originais e os valores obtidos após o preparo, permitiu estabelecer o grau de redução do ângulo de curvatura dos canais.

### Resultados

Após análise estatística verificou-se que todos os métodos de preparo estudados foram capazes de reduzir o ângulo de curvatura dos canais, por meio da remoção das interferências cervicais.

### Conclusão

O preparo realizado com as brocas LA Axxess foi o que melhor removeu as interferências anatômicas cervicais, reduzindo o ângulo de curvatura dos canais preparados em média em 11,52°.

**Termos de indexação:** Instrumentos odontológicos. Endodontia. Preparo de canal radicular.

<sup>1</sup> Universidade de Franca, Faculdade de Odontologia. Av. Dr. Armando Salles Oliveira, 201, caixa postal 82, Parque Universitário, Franca, SP, Brasil. Correspondência para / Correspondence to: BRS TOLEDO. E-mail: <brunotoledo87@yahoo.com.br>.

## INTRODUCTION

The biomechanical phase of root canal preparation is considered one of the most important in endodontic therapy, since the canal is not only cleaned and disinfected mechanically by the instruments and chemically and physically by the irrigants, but also shaped in a way that facilitates its sealing.

The greatest challenges for endodontists in the biomechanical phase are directly related to the anatomic characteristics of the canals, such as constriction and curvature<sup>1</sup>.

In 1961, Phillipas<sup>2</sup> showed that continuous deposition of physiological or pathological dentin in the pulpal chamber may create obstructions that reduce the diameter of the root canals, especially in the coronal third, impairing their localization, flaring, and filling<sup>3</sup>.

It is essential to maintain the original path of the canals, even of those with marked curvatures, but flaring may cause ledging, zipping, or even perforations<sup>1,4-5</sup>.

Therefore, flaring the coronal third of the canal is recommended to remove interferences in the entrance of the canals before flaring the middle and apical thirds. This maneuver enables straighter access to the apical region of curved canals<sup>6-7</sup>, better determination of the working length and diameter of the first apical instrument<sup>8-11</sup>, and better irrigant action in the apical third, resulting in better cleaning and disinfection<sup>7</sup>.

Given the importance of this maneuver, many preparation techniques have been proposed. Goering et al.<sup>12</sup> developed a technique for the instrumentation of molar root canals that begins with anti-curvature shaping of the coronal and middle thirds to eliminate interferences using the Hedström hand files and Gates-Glidden burs. Berbert et al.<sup>13</sup> introduced changes to the Oregon technique (crown-down), which originally instrumented the canals with the Gates-Glidden burs to promote greater canal flaring and remove interferences in the coronal and middle thirds.

The advance of metallurgy and introduction of the nickel-titanium alloy in endodontics<sup>14</sup> promoted a revolution in instrument design, resulting in the emergence of rotary instruments of different materials, with different cross-sectional sections, tapers, lengths, and cutting angles.

Some of these instruments were developed to replace the Gates-Glidden burs for the coronal flaring of curved canals<sup>15</sup>, but studies in the literature that assess the efficacy of such instruments are scarce.

The present study assessed the different preparation methods used for reducing coronal interferences by analyzing the resulting reduction in the degree of curvature of the mesial canals of mandibular molars.

## METHODS

Forty human mandibular first molars that had been extracted because of caries and/or periodontal disease were used in this study. The study complies with Resolution 196/96 of the National Health Council and was approved by the local Research Ethics Committee under protocol number n. CAAE - 0090.0.393.000-09.

Once the crowns were open, the teeth were sectioned longitudinally along the buccolingual midline by a low speed diamond saw to separate the mesial roots from the distal roots.

The mesial roots (mesiobuccal and mesiolingual) were irrigated with an aqueous solution of 1% sodium hypochlorite and explored in their full length to remove pulpal debris and detect possible obstructions.

Once no obstructions were found, chemically-polymerized acrylic resin blocks were made for each specimen. The teeth were embedded in a standardized fashion to facilitate radiographic analyses before and after root canal instrumentation.

K files #10 were introduced in the mesiobuccal canals until their tips appeared in the apical end. The teeth were then radiographed in their resin blocks. The same procedure was done for the mesiolingual canals.

The radiographs were scanned and the software ImageTool 3.0 (UTHSCSA, San Antonio, USA) was used for determining the degree of curvature of the roots.

Depending on the degree of curvature, the roots were divided into four experimental groups with ten specimens each in a way that the groups did not differ significantly ( $p > 0.05$ ).

Coronal interference was reduced by different methods, limited to the coronal and middle thirds of the canals, not exceeding a depth of 16 millimeters.

The canals in Group I were prepared by anti-curvature filing using the Hedström files numbers 15, 20, and 25 sequentially, followed by the Gates-Glidden burs #2 and #3 (Dentsply-Maillefer, Switzerland) in a single motion, until resistance was found.

The canals in Group II were prepared using the La Axxess burs (Sybron-Endo, USA) #20/.06 and #35/.06 in a low rotation contra-angle handpiece.

The canals in Group III were instrumented with K3 files (Sybron-Endo, USA), # 25/.10, # 25/.08, and #35/.06 from the VTVT kit (Variable Tip, Variable Taper) in the rotary endodontic motor Endo-mate II (NSK, Japan), used at a constant speed of 250 rpm.

The canals in Group IV were prepared in the same way as those of Group II, but with the burs CP-Drill (Injecta, Brazil), #25/.14 and #30/.18.

At every instrument switch and at the end of the instrumentation, the canals were irrigated with 3mL of an aqueous solution of 1% sodium hypochlorite.

Once the preparations were ready, the roots were placed in the corresponding blocks and K files #10 were inserted in the root canals for the periapical radiographs.

The radiographs were scanned and the software ImageTool 3.0 (UTHSCSA, San Antonio, USA) was used for determining the degree of curvature of the canals after instrumentation.

The arithmetic means of the degree of curvature of the mesiobuccal and mesiolingual canals before and after instrumentation were calculated.

Reduction in the degree of curvature of the canals after instrumentation was given by the difference between the original degree and that after instrumentation. These data were then treated statistically.

## RESULTS

The results show the differences in the degree of curvature before and after instrumentation.

**Table 1.** Difference between the degree of curvature (°) of the mesiobuccal and mesiolingual canals before and after instrumentation and the arithmetic means by group. Franca (SP), 2010.

Specimens	Group I	Group II	Group III	Group IV
	Gates difference	LA Axxess difference	K3 difference	CP Drill difference
01	2.83	5.06	9.38	11.18
02	2.40	4.79	14.53	6.51
03	9.25	15.22	10.66	5.85
04	7.65	12.04	1.28	2.82
05	7.25	15.58	2.18	8.0
06	12.50	4.96	4.43	10.17
07	1.82	13.99	2.62	6.43
08	1.36	17.13	5.27	6.95
09	6.56	12.43	4.29	13.23
10	5.65	14.06	4.08	7.74
Mean	5.72	11.52	5.87	7.88

Once the differences between the degrees of curvature of the mesiobuccal and mesiolingual canals

before and after instrumentation had been calculated, the Bartlett test was done to verify if the variances were homoscedastic, that is, if they were statistically similar. The results of the Bartlett test are shown in Table 2.

**Table 2.** Result of the Bartlett test. Franca (SP), 2010.

Variation factors	
Bartlett statistical value	2.095
P-value	0.5530
P-value (summary)	NS
Are the variances significantly different (p< 0.05)?	No

The Bartlett test shows that the tested variances were not significantly different (p>0.05), which allows the use of parametric statistical tests. The parametric test most fit for the experimental model is one-way analysis of variance (one-way ANOVA). One-way ANOVA results are shown in Tables 3 and 4.

**Table 3.** One-way analysis of variance results. Franca (SP), 2010.

Variation factor	
Number of groups	4
F-value	4.633
R <sup>2</sup> -value	0.2785
P-value	0.0077
Are the means significantly different (p<0.05)?	Yes

**Table 4.** One-way analysis of variance results. Franca (SP), 2010.

Analysis of variance	Sum of the squares	Degrees of freedom	Mean squares
Treatment	219.0	3	72.99
Residual	567.2	36	15.75
Total	786.1	39	

Once analysis of variance showed that there were statistically significant differences (p<0.05), the Tukey test was used for determining which preparation method removed coronal interference most effectively (Table 5).

**Table 5.** Tukey test. Franca (SP), 2010.

Tukey test	Mean difference	q	P-value	Summary
Gates-Glidden vs LA Axxess	-5.799	4.620	P < 0.05	*
Gates-Glidden vs K3	-0.1450	0.1155	P > 0.05	ns
Gates-Glidden vs CP Drill	-2.161	1.722	P > 0.05	ns
LA Axxess vs K3	5.654	4.505	P < 0.05	*
LA Axxess vs CP Drill	3.638	2.898	P > 0.05	ns
K3 vs CP Drill	-2.016	1.606	P > 0.05	ns

Note: ns: not significant. \*: significant at the 5% level.

The Tukey test showed that the reductions in the degree of curvature achieved by different instrumentation methods differed significantly. The LA Axxess burs was the most efficient for removing anatomic coronal interference, reducing the degree of curvature of the canals by 11.52° on average. This result were significantly better than those obtained by the K3 files and Gates-Glidden burs ( $p < 0.05$ ), which reduced the degree of curvature of the canals by only 5.87° and 5.72°, respectively. The results of the latter two instrumentation methods were statistically similar ( $p > 0.05$ ).

Instrumentation with the CP-Drill burs reduced the degree of curvature of the canals by 7.88°. This result was intermediate, worse than that obtained by the LA Axxess bur but better than those obtained by the K3 files and Gates-Glidden burs, but the differences were not significant ( $p > 0.05$ ). These results are illustrated in Figure 1.

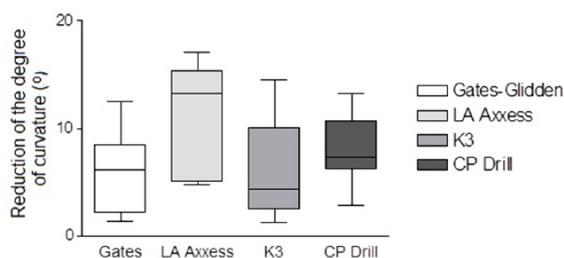


Figure 1. Reduction in the degree of curvature (°) of the canals achieved by different instruments as they removed coronal interference. Franca (SP), 2010.

## DISCUSSION

The literature has shown that the incidence of zipping and perforations during endodontic treatment is greater in molars than in other teeth<sup>16-17</sup>.

The mesial roots of lower molars have anatomic interferences at the entrance of the canals because of the continuous deposition of physiological or pathological dentin, resulting in a gradual increase in the degree of curvature of the canal.

A greater degree of curvature invariably leads to a greater incidence of iatrogenic errors. Eleftheriadis & Lambrianidis<sup>5</sup> assessed 388 teeth with treated roots and found a greater incidence of iatrogenic errors (zipping and perforations) in molars. Among treated molars, zipping was found in 15.3% of the straight canals, 43.9% of the moderately curved canals, and 61% of the severely curved canals. For this reason, the mesial roots of lower molars were chosen for this study.

To prevent these iatrogenic errors during the instrumentation of molar root canals, in 1980 Abou-Rass<sup>4</sup> suggested flaring toward a safety zone, which is located in the mesial wall of the root canals of lower molars because the dentin on this wall is morphologically thicker. This maneuver is called anti-curvature filing and promotes a marked reduction in the degree of curvature of the canals.

According to Biral et al.<sup>18</sup>, this occurred when rotary instruments became a must among the instruments used by endodontists for the treatment of root canals.

The stainless steel Gates-Glidden burs are well established instruments in endodontics, having been used since the 18th century<sup>19</sup>. During many years, these burs were considered first-choice instruments for the removal of interferences, but with the advance of metallurgy and metal alloys, new instruments were developed for this purpose.

Some of the instruments used nowadays for the removal of coronal interferences and reduction of canal curvature in addition to the Gates-Glidden burs are the LA Axxess bur, the CP-Drill, and the rotary nickel-titanium instruments with greater tapers, such as the K3 files.

The results of the present study show that the LA Axxess burs promote a greater reduction in canal curvature by removing interferences than the other study instruments. This might be explained by the characteristics of the LA Axxess burs and their kinematics. Duarte et al.<sup>20</sup> reported that the LA Axxess 35.06 and Gates-Glidden 3 burs resulted in thinner root walls and that they should be used with caution in the mesial canals of molars.

These instruments are made from stainless steel and coated with a layer of titanium nitride to increase their hardness. They have a taper of 0.06, a positive cut angle and non-cutting tip<sup>1</sup>. Since the shank is inflexible, the endodontist can flare the thicker dentin walls to preserve the fragile areas, as proposed by Abou-Rass<sup>4</sup>.

In the present study, the ability of the CD-Drill burs to reduce the degree of canal curvature was intermediate. These instruments are made from stainless steel, and have a neutral cutting angle (90°) and tapers of 0.14 and 0.18 in burs #25 and #30, respectively<sup>1</sup>. Although they have an inflexible shank that enables a range of motion similar to that of the LA Axxess burs, that is, directed flaring, their smaller cutting efficiency and greater taper prevents them from reaching the deeper ends of the coronal and middle thirds, limiting them to opening the canals.

The results obtained by the Gates-Glidden burs and K3 rotary files were similar. However, both were inferior to the other study instruments.

The Gates-Glidden burs are made from stainless steel, have a non-cutting tip, short cutting blades, and an intermediate or long thin and flexible shank. These instruments require a low-speed contra-angle handpiece<sup>1</sup>. Given their flexible and fragile shank, they need to be used with caution, since they may cause zipping<sup>21</sup>. Since they do not allow the endodontist to direct the flare, its ability to reduce the degree of curvature and eliminate interferences is limited.

The K3 files are made from a nickel-titanium alloy, require very-low-speed endodontic motors (150 to 350 rpm), and have a positive cutting angle.

According to Leonardo & Leonardo<sup>22</sup>, the action of the nickel-titanium instruments against the canal walls can be controlled by applying greater lateral pressure in the desired direction. However, in this study, this anti-curvature motion did not achieve a marked reduction in the degree of canal curvature by removing the interferences.

These data corroborate those obtained by López et al.<sup>21</sup> who observed that the K3 files with tapers 0.10 and 0.08 and Gates-Glidden burs numbers 1 and 2 flared the coronal third similarly. Sanfelice et al.<sup>23</sup> used computed tomography to compare the coronal flaring achieved by four instruments, namely ProTaper files, Gates-Glidden burs, K3 files, and LA Axxess burs, and concluded that none of these instruments damaged the dentin structure of the distal wall of lower molar mesial canals.

Therefore, because of the different materials, morphological characteristics, and kinematics of each endodontic instrument, endodontists need to be familiar with the limitations of each instrument so that they may choose safely the method they wish to use.

## **CONCLUSION**

The methods and results of the present study indicate that all coronal flaring methods were capable of reducing the degree of canal curvature by removing the coronal interferences in the mesial root canals of lower molars.

Of the study instruments, the LA Axxess burs removed the anatomic coronal interferences most effectively.

## **Collaborators**

DC ANDRADE recorded the results, performed the experimental procedures, and wrote the article. BAS TOLEDO searched the literature and wrote the article. F PICOLI supervised the study, helped to conceive the methods, followed the procedures, statistically analyzed the results and conclusion, and wrote the article.

## **REFERENCES**

1. Sydney GB, Batista A, Deonizio MD. Acesso radicular. *Robrac*. 2008;17(43):1-12.
2. Philippas GG. Influence of occlusal wear and age on formation of dentin and size of pulp chamber. *J Dent Res*. 1961;40(6):1186-98. doi: 10.1177/00220345610400061301.
3. Lazzaretti DN, Camargo BA, Della Bona A, Fornari VJ, Vanni JR, Baratto Filho F. Influence of different methods of cervical flaring on establishment of working length. *J Appl Oral Sci*. 2006;14(5):351-4. doi: 10.1590/S1678-77572006000500010.
4. Abou-Rass M. The anticurvature filling method to prepare the curved root canal. *J Am Dent Assoc*. 1980;101(11):792-94.
5. Eleftheriadis GI, Lambrianidis TP. Technical quality of root canal treatment and detection of iatrogenic errors in an undergraduate dental clinic. *Int Endod J*. 2005;38(10):725-34. doi: 10.1111/j.1365-2591.2005.01008.x.
6. Travassos RMC, Rodrigues VMS, Pontes MMA, Alves DF. Estudo de duas técnicas de preparo cervical associadas ao sistema rotatório Pow-R: estudo in vitro. *Rev Cons Reg Odontol Pernambuco*. 2001;4(1):43-8.
7. Estrela C, Santos M, Bombana AC, Pesce HF. Análise da composição química de aços inoxidáveis de brocas Gates-Glidden de diferentes procedências. *Rev Odontol USP*. 1993;7(4):251-5.
8. Tan BT, Messer H. The effect of instrument type and preflaring on apical file size determination. *Int Endod J*. 2002;35(9):752-8. doi: 10.1046/j.1365-2591.2002.00562.x.
9. Pécora JD, Capelli A, Seixas FH, Marchesan MA, Guerisoli DMZ. Biomecânica rotatória: realidade ou futuro? *Rev Assoc Paul Cir Dent*. 2002;56(supl):4-6.
10. Macedo MCS, Cardoso RJA, Bombana AC. Avaliação do desgaste do terço cervical dos canais méso-vestibulares de molares superiores submetidos a diferentes procedimentos de preparo de suas entradas. *J Bras End*. 2003;4(15):317-23.

11. Barroso JM, Guerisoli DMZ, Capelli A, Saquy PC, Pécora JD. Influence of cervical preflaring on determination of apical file size in maxillary premolars: SEM analysis. *Braz Dent J.* 2005;16(1):30-4. doi: 10.1590/S0103-64402005000100005.
12. Goering LA, Michelich RJ, Shultz HH. Instrumentation of root canals in molars using the step-down technique. *J Endod.* 1982;8(12):550-4. doi: 10.1016/S0099-2399(82)80015-0.
13. Berbert A, Bramante CM, Bernardineli N, Moraes IG, Garcia RB. Técnica de óregon modificada. *RGO - Rev Gaúcha Odontol.* 1996;44(3):141-2.
14. Walia H, Brantlye WA, Gerstein H. Initial investigation of the bending and torsional properties of nitinol root canal files. *J Endod.* 1988;14(7):346-51. doi: 10.1016/S0099-2399(88)80196-1.
15. Miranzi BAS, Miranzi MAS, Miranzi AJS, Oliveira WJ, Borges GA, Araujo LCR. Avaliação in vitro das distorções promovidas em canais radiculares artificiais curvos comparando o preparo cervical com limas de níquel-titânio acionadas a motor e brocas de Gates-glidden. *Rev Odonto Cienc.* 2005;20(49):245-50.
16. Greene KJ, Krell KV. Clinical factors associated with ledged canals in maxillary and mandibular molars. *Oral Surg.* 1990;70(4):490-7.
17. Kapalas A, Lambrianidis T. Factors associated with root canal ledging during instrumentation. *Endod Dent Traumatol.* 2000;16(5):229-31.
18. Biral RR. Técnicas de instrumentação que incluem instrumentos rotatórios no preparo biomecânico dos canais radiculares. In: Leonardo MR, Leal JM. *Endodontia: tratamento de canais radiculares.* 3ª ed. São Paulo: Panamericana; 1998. p. 419-28.
19. Lopes HP, Elias CN, Estrela C, Costa Filho AS. Influence of diameter variation of gates-glidden drills on torsion resistance. *Braz Dent J.* 1994;5(2):141-4.
20. Duarte MAH, Bernardes RA, Ordinola-Zapata R, Vasconcelos BC, Bramante CM, Moraes IG. Effects of gates-glidden, la axxes and orifice shaper burs in the cervical dentin thickness and root canal area of mandibular molars. *Braz Dent J.* 2011;22(1):28-31. doi: 10.1590/S0103-64402011000100004.
21. Lopez FU, Ferronato G, Limongi O, Barletta F, Irala LE. Análise comparativa in vitro do desgaste promovido nos terços cervical e medio dos canais radiculares méso-vestibulares de molares superiores pelo sistema K3 e limas manuais associadas a brocas Gates Glidden. *Rev Facul Odontol Porto Alegre.* 2006;47(2):9-13.
22. Leonardo MR, Leonardo RT. *Sistemas rotatórios em endodontia: instrumentos de níquel titânio.* São Paulo: Artes médicas; 2001.
23. Sanfelice CM, Costa FB, Reis Só MV, Vier-Pelisser F, Souza Bier CA, Grecca FS. Effects of four instruments on coronal pre-enlargement by using cone beam computed tomography. *J Endod.* 2010;36(5):858-61. doi: 10.1016/j.joen.2009.12.003.

Received on: 22/4/2011

Final version resubmitted on: 26/6/2011

Approved on: 25/7/2011