Influencia del Calibre del Glide Path en la Fractura de Instrumentos Rotatorios

Influence of the Glide Path Caliber on the Fracture of Rotary Instruments

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ABSTRACT

During endodontic procedures, the potential for instrument fracture is present; Any attempt must be made to avoid this complication, because its solution is complex, requiring skill, equipment and time.

Aim: To evaluate the influence of manual glide path caliber on the fracture frequency of mechanical rotary instruments.

Methodology: Recently extracted mandibular molars were selected, permeabilizing the canals with K08 and 10 files, independent canals were included. Radiographs with K10 inside, applying the Pruett method, recording the maximum value for the angle and the minimum value for the radius between the two views (clinical and proximal). The teeth were classified according to the angle and radius of curvature and the initial apical caliber, using the mesiobuccal canal with one group and the mesiolingual canal with another. The sample was 60 canals. Groups were randomly assigned. The glide path was performed, with a K file, balanced force technique, irrigating between files. An inexperienced operator mechanically instrumented according to the manufacturer's sequence, the number of uses of each instrument was controlled, each instrument used was observed with a microscope, and the fractures were confirmed radiographically. The data obtained were analyzed using Proportions Test and One Way ANOVA Test. A p-value ≤ 0.05 was established.

Results: 6 instruments were separated when the glyde path was performed up to K10, 5 up to K15 and 1 up to K20.

Conclusions: The caliber of the manual glide path influences the fracture frequency of mechanical rotary instruments, when it is performed by inexperienced operators.

KEYWORDS: manual pre-flaring; mechanical instrumentation; fracture of instruments; ProTaper; rotary instruments.

RESUMEN

Durante la conformación endodóntica, la posibilidad de fractura de instrumentos está presente; cualquier intento debe hacerse para evitar dicha complicación, porque su solución es compleja, requiere habilidad, equipamiento y tiempo.

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Objetivo: Evaluar la influencia del calibre del glide path manual en la frecuencia de fractura de los instrumentos rotatorios mecánicos.

Metodología: Se seleccionaron molares mandibulares recientemente extraídos, permeabilizando los conductos con limas K08 y 10, se incluyeron los conductos independientes. Radiografías con K10 en su interior, aplicando el método de Pruett, registrándose el valor máximo para el ángulo y el valor mínimo para el radio entre las dos vistas (clínica y proximal). Se clasificaron los dientes de acuerdo al ángulo y radio de curvatura y al calibre apical inicial, utilizando el conducto mesiovestibular con un grupo y el mesiolingual con otro. La muestra fue 60 conductos. Se asignaron los grupos aleatoriamente. Se realizó el glide path, con lima K, técnica de fuerzas balanceadas, irrigando entre limas. Un operador inexperto instrumentó mecánicamente con secuencia del fabricante, se controló el número de usos de cada instrumento, se observó cada instrumento utilizado con microscopio, confirmándose las fracturas radiográficamente. Los datos obtenidos fueron analizados mediante Test de Proporciones y Test One Way ANOVA. Se estableció un p-valor ≤ 0.05.

Resultados: Se separaron 6 instrumentos cuando el glyde path se realizó hasta K10, 5 hasta K15 y 1 hasta K20.

Conclusión: El calibre del glide path manual influye en la frecuencia de fractura de los instrumentos rotatorios mecánicos, cuando ésta es realizada por operadores inexpertos.

PALABRAS CLAVE: Vía lisa y reproducible; instrumentación mecánica; fractura de instrumentos; ProTaper; instrumentos rotatorios.

INTRODUCTION

There are great differences of opinion regarding the best methods of preparing root canals. Cases of endodontic failures provide irrefutable evidence that unresolved controversies perpetuate clinical failures and decrease success rates.

Clinicians must continually try to discover the most effective techniques , supported by independent studies. This work focuses on the fundamental concepts, strategies and techniques in practice that can provide superior results in cleaning and shaping root canals.

As it is, the establishment of a free and reproducible path (glide path), prior to mechanical instrumentation, in order to avoid fracture of the instruments, which could compromise the success of the endodontic treatment .

The main objective of Endodontics is to preserve the dental organ[1], and it achieves this through the formation, disinfection and three-dimensional filling of the root canal system.

Meeting objectives:

- Biological
- Radiographic
- Clinical[2]

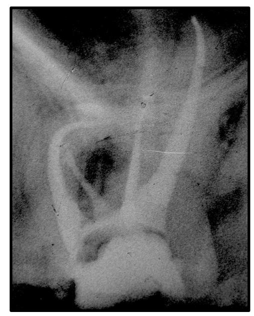

Fig. 1 Root canal treatment

All of this must be achieved without creating iatrogenic mishaps[3], such as blockages, steps, transportation, perforations, or fracture of instruments.

The conformation of the canals is a critical aspect[4, 5] because it influences the result of the complementary phases, such as irrigation, obturation, and therefore, the success of the treatment itself.

This shaping is carried out mainly using manual and motor-driven or mechanical instruments. The instruments Mechanical elements can be made of stainless steel, carbon steel or nickel - titanium.

Its properties include:

- Shape memory[5], that is, the ability to return, in the event of deformation, to its initial shape.

- Low elasticity or Young's modulus[5], which is defined as the result of the ratio between the tension applied to a body and the deformation it produces (it is a typical constant value for each material).

- High elastic limit or resilience[5], which is the property of storing energy when the material deforms.

- Corrosion resistance[5].

All this made this alloy attractive to Andreasen and collaborators, who in 1971 incorporated it into the world of Dentistry, specifically in the field of orthodontics.

These phenomena are possible thanks to certain structural transformations:

- Austenitic-Martensitic[6], which consist of the change of its crystalline structure from a primary phase called austenitic in which the structure is cubic, centered and stable, to a secondary or martensitic phase, in which it becomes dense hexagonal.

- Super Elasticity Transition Phase[6]: Between both phases there is a change stage, which gives rise to a third super elasticity transition phase, where the best characteristics of the alloy are obtained.

Currently there are many mechanical instrumentation systems, one of the most recognized and used worldwide is the ProTaper® system (Dentsply-Maillefer, Ballaigues, Switzerland), which was presented during the American Association of Endodontics (AAE) congress in the year 2001[7, 8, 9].

The main characteristics of the ProTaper® System according to its manufacturer are:

- Multiple and progressive taper (2%-19%)[10], which makes possible the formation of specific sections of the root canal, S1 is designed to prepare mainly the coronal third, S2 the middle third and F1, F2 and F3 the apical third.

- Convex triangular cross section[8]: The convex triangular cross section (fig. 4) results in a reduced contact area between the dentin and the cutting turns of the instrument, accentuating its cutting efficiency, thus reducing stress torsional and facilitating the widening of the root canal.

- Variable pitch (no. of turns per mm.)[11]: or variable helical angle, which is the angle formed between the cutting groove and the longitudinal axis of the instrument, the balanced coils in the instrument improve its cutting action, allowing better removal of debris out of the canal and preventing the instrument from becoming wedged in the walls of the canal (screwing effect).

- Partially inactive tip[12, 13]

- Positive cutting angle[10]

- Short handle[12]

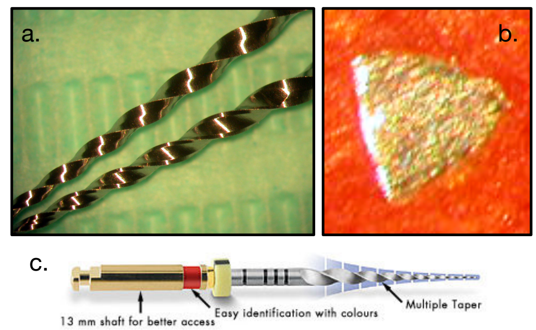

Fig. 2 a)Radial land F3; b)cross section; c)multiple taper

Shaping files (or S files) have multiple and progressive taper:

SX: D0 = 0.19mm; 3,5% - 19% D1 a D9 y 2% D10 a D14

S1: D0 = 0.17mm; 2% - 11% D1 a D14 ≈ 4%

S2: D0 = 0.20mm; 4% - 11.5% D1 a D14 ≈ 4.5%

The Finishing files (or F files), have multiple and decreasing taper, the decreasing taper ensures continuous flexibility of the file and avoids a large diameter along the axis of the instrument:

F1: D0 = 0.20mm; 7% D1 - D3, disminuir hasta D14 ≈ 5.5%

F2: D0 = 0.25mm; 8% D1 - D3, disminuir hasta D14 ≈ 5.5%

F3: D0 = 0.30mm; 9% D1 - D3, disminuir hasta D14 ≈ 5.5%

With the introduction of NiTi rotary instruments, there was an increase in the frequency of fractured instruments[14, 15, 16], not because the alloy fractures more, in fact it is more resistant, but mainly due to misuse of the nickel-titanium instruments.

NiTi instruments can fracture for two main reasons:

- Torsion
- Cyclic fatigue[6, 17, 18, 19, 20]

When there is separation of the instrument, the disinfection, conformation and obturation of the canal system is compromised, and the prognosis conditioned, because remnants of pulp tissue and bacteria may remain, thus compromising the success of the treatment.

Torsion fracture occurs when the tip or any other part of the instrument becomes wedged in the walls of the canal and becomes blocked, while the handpiece and the rest of the instrument continue to rotate; When this occurs, the elastic limit of the alloy is exceeded, and leads to separation of the instrument; This type of fracture is due to the application of excessive force apically during instrumentation.

Cyclic fatigue fracture occurs when a freely rotating instrument, which has been previously weakened by alloy fatigue, is placed under stress and various other factors, these cause the alloy to go from the austenitic phase to the martensitic phase. , and that is when the fracture of the instrument occurs at the point of maximum flexion (maximum stress).

Among the different factors that influence the separation of NiTi rotary instruments we have:

- Anatomy (mainly the angle and radius of curvature)[21]
- Access[22, 23]
- Operator experience[24]
- Electric motors with torque and speed control[6]
- Instrument design[10]
- Inadequate work protocol[10]
- Dentin chips and gaps[25]

Among the main design variations, which took place when moving from manual to mechanical instruments, was the change from having an active tip (cutting) to an inactive one (non-cutting).

This gives the instrument the ability to remain and work more centered in the canal, thereby achieving less deformation and transportation; In addition, avoiding the creation of steps and perforations in the walls of the canals.

This innovation becomes the main cause of fracture, which the endodontist can control,[26, 27, 28] because when this non-cutting tip encounters a portion of the canal that is narrower than its size, it cannot penetrate and twists in such a way. portion, while the rest of the instrument continues to rotate; When the elastic limit of the alloy is exceeded, torsion fracture occurs.

This is why the manufacturers of the various NiTi mechanical instrumentation systems, and especially the ProTaper® System, recommend the establishment of a continuous, smooth and reproducible path (Glide Path) prior to the use of mechanical instrumentation.[10]

According to the manufacturer, the glide path should be done with K-type hand files up to 15 gauge (ISO)[10, 12, 17, 18, 26]

In the current literature there is a consensus that it is important to perform manual instrumentation (glide path), prior to mechanical instrumentation,[10, 12, 17, 18, 26] but there is no consensus as to what caliber such manual instrumentation should be performed.

It seems that there are very few studies to date that evaluate the influence of glide path caliber on the percentage of fracture or permanent deformation of Ni-Ti instruments.

That is why the objective of this study is to determine the influence of the glide caliber path, in the instrument separation of the ProTaper® system.

MATERIAL AND METHODS

Recently extracted mandibular molars were selected, with complete root development of the mesial root, the teeth were stored in physiological saline. With the help of a handpiece and a carbide disc, the distal root was sectioned.

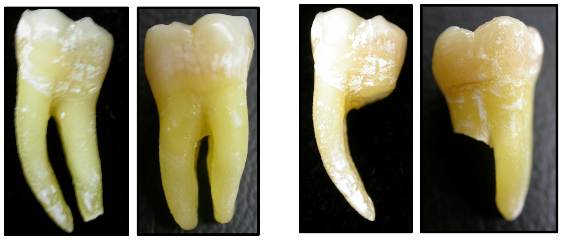

Fig. 3 Initial photos and section of the distal root

An initial x-ray was taken (Kodak, Stuttgart, Germany) both in the vestibulo-lingual (clinical view) and mesio-distal (proximal view) direction.

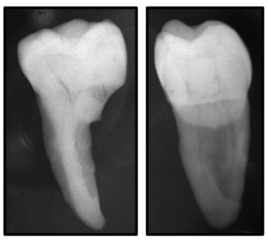

Fig. 4 Initial radiographs

The access cavity was created, with a DG16 endodontic explorer (Hu-Friedy Inc., Chicago, Illinois) the main canals (mesiobuccal, mesiolingual and distal) were located. Occlusal wear was carried out (cuspid reduction) to have a stable reference point when determining the working length and throughout the procedure. Once the canals were located, they were catheterized and permeabilized with 08 and 10 gauge type K manual files (Dentsply-Maillefer, Ballaigues, Switzerland), impregnated with glyde® (Dentsply-Maillefer, Ballaigues, Switzerland), discarding any teeth that were not permeable.

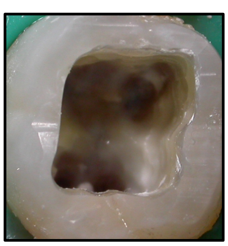

Fig. 5 Access cavity

Once permeable, teeth in which their canals had the same apical foramen were discarded. Only samples that had independent canals (Vertucci type IV) under magnification (Zeiss Opni Pico dental microscope, Germany) at 25x were taken into account. At the same time, the working length (LT) was determined by subtracting 0.5mm from the length at which the file emerges from the apical foramen.

Fig. 6 Vertucci type IV canals and determination of LT

For this confirmation, and to analyze the angle and radius of curvature of each canal, a radiography, with K10 files inside, in vestibulo-lingual and mesio-distal projection, applying the Pruett method, recording the highest value for the angle and the minimum value for the radius between the two views (view clinical and proximal).

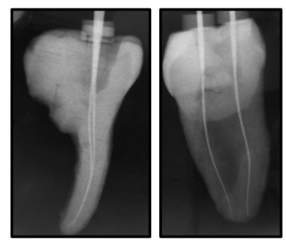

Fig. 7 Rx. To analyze the angle and radius of curvature with the Pruett method

Samples that had canals with an initial caliber greater than a K20 file were discarded.

To try to control the anatomical variable, the sample was distributed in such a way that the mesiobuccal canal was part of one group, while the mesiolingual canal of the same tooth was part of another.

Fig. 8 Distribution of the different sample groups

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The teeth were classified according to the angle and radius of curvature and the initial apical caliber. In total, the final sample was 30 teeth (60 canals) divided into three groups (glide path with K10, K15 or K20), being classified as follows:

Diente	Conducto	LT	Ángulo V-L	Radio V-L	Ángulo M-D	Radio M-D	Máx. Curvatura	Mín. Radio	LAI	Grupo
3B	ML	19.5	29	14	38	13	38	14	K10	A
1A	MV	20	22	16	34	16	34	16	K10	A
20A	MV	19	24	18	45	12	45	18	K10	A
20B	ML	18.5	24	18	11	22	24	22	K10	A
5A	MV	17.5	25	20	13	24	25	24	K10	A
29B	ML	16.5	18	24	32	19	32	24	K10	A
8B	ML	19	14	12	12	27	14	27	K10	A
18A	MV	19.5	36	18	31	29	36	29	K10	A
7A	MV	20.5	30	29	34	7	34	29	K10	A
30B	ML	18.5	26	30	0	0	26	30	K10	A
9B	ML	19	38	22	20	36	38	36	K10	A
19A	MV	19.5	32	36	31	33	32	36	K10	A
6B	ML	15.5	27	14	9	37	27	37	K10	A
2A	MV	21	16	40	14	38	16	40	K10	A
2B	ML	21	16	40	18	37	18	40	K10	A
12A	MV	21	28	28	11	50	28	50	K10	A
23A	MV	18.5	18	24	13	50	18	50	K10	A
23B	ML	18	18	24	12	75	18	75	K10	A
6A	MV	17	27	14	D	D	D	D	K10	A
9A	MV	18.5	38	22	D	D	D	D	K10	A

Tabla 1 Ángulo y radio de curvatura del grupo A

Diente	Conducto	LT	Ángulo V-L	Radio V-L	Ángulo M-D	Radio M-D	Máx. Curvatura	Mín. Radio	LAI	Grupo
16B	ML	18	30	11	40	12	40	12	K15	B
8A	MV	19.5	14	12	27	9	27	12	K15	B
14A	MV	16	17	15	46	9	46	15	K15	B
15A	MV	18.5	21	17	12	19	21	19	K15	B
13A	MV	19.5	32	22	22	18	32	22	K15	B
26B	ML	17.5	23	22	25	16	25	22	K15	B
1B	ML	18.5	22	16	25	23	25	23	K15	B
14B	ML	15	17	15	15	23	17	23	K15	B
24A	MV	18.5	47	23	31	18	47	23	K15	B
28B	ML	16.5	20	28	31	19	31	28	K15	B
22A	MV	18	60	22	21	29	60	29	K15	B
10B	ML	20	32	9	27	29	32	29	K10	B
5B	ML	17.5	25	20	22	31	25	31	K15	B
4A	MV	17.5	36	15	19	35	36	35	K15	B
15B	ML	17.5	21	17	13	40	21	40	K15	B
17B	ML	18.5	25	40	13	29	25	40	K10	B
12B	ML	21	28	28	7	90	28	90	K15	B
19B	ML	19	32	36	0	0	32	36	K15	B
7B	ML	20.5	30	29	D	D	D	D	K10	B
21A	MV	18.5	34	23	D	D	D	D	K15	B

Tabla 2 Ángulo y radio de curvatura del grupo B

Diente	Conducto	LT	Ángulo V-L	Radio V-L	Ángulo M-D	Radio M-D	Máx. Curvatura	Mín. Radio	LAI	Grupo
10A	MV	20	32	9	20	14	32	14	K15	C
4B	ML	16.5	36	15	14	11	36	15	K15	C
11B	ML	19.5	47	15	22	18	47	18	K15	C
16A	MV	19	30	11	20	19	30	19	K15	C
22B	ML	17	60	22	45	18	60	22	K15	C
26A	MV	16.5	23	22	0	0	23	22	K20	C
13B	ML	18.5	32	22	27	23	32	23	K15	C
21B	ML	18.5	34	23	22	22	34	23	K15	C
24B	ML	18.5	47	23	29	22	47	23	K15	C
11A	MV	19	47	15	29	27	47	27	K20	C
28A	MV	16.5	20	28	17	29	20	29	K15	C
30A	MV	19	26	30	30	15	30	30	K10	C
18B	ML	19.5	36	18	16	31	36	31	K15	C
27A	MV	11.5	21	40	0	0	21	40	K20	C
27B	ML	11.5	21	40	0	0	21	40	K20	C
17A	MV	18.5	25	40	18	38	25	40	K15	C
25A	MV	19	16	47	19	34	19	47	K20	C
25B	ML	18	16	47	0	0	16	47	K20	C
3A	MV	19.5	29	14	D	D	D	D	K10	C
29A	MV	16.5	18	24	D	D	D	D	K15	C

Tabla 3 Ángulo y radio de curvatura del grupo C

The groups were assigned randomly: A = glide path K10; B = glide path K15 and C = glide path K20.

It was carried out the glide path, with the type K file impregnated with Glyde® (Dentsply-Maillefer, Ballaigues, Switzerland), with balanced force technique, performing irrigation with 3 ml of 4.2% sodium hypochlorite (Conejo, Henkel, Barcelona, Spain) between files, using a 27 gauge syringe and needle.

An inexperienced operator was then calibrated to perform the mechanical instrumentation in the sequence proposed by the manufacturer for short canals, that is, S1, SX, S1, S2; applied with an electric motor with torque and speed control ATR® (Dentsply-Maillefer, Ballaigues, Switzerland).

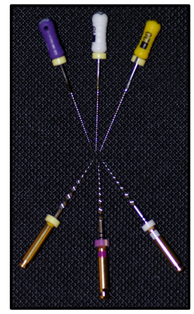


Fig. 9 Files used in the study

During instrumentation, the time until reaching the working length was recorded, as well as the instrumentation time, without counting the irrigation time or the change of files.

It is controlled the number of uses of each instrument, discarding them every 5 teeth (10 canals). Each instrument used was observed under a dental microscope (Zeiss Opni Pico, Germany) at 25x magnification to determine deformations or fractures, confirming radiographically.

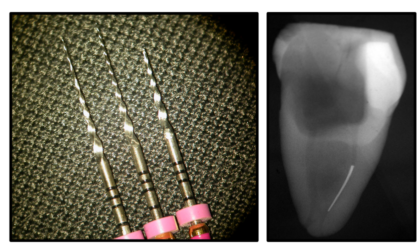


Fig. 10 Deformed, normal and fractured instrument

The data obtained were analyzed using a Proportions Test for the qualitative variables and the One Way ANOVA non-parametric statistical test for the continuous quantitative variables. A significance level of 95% was established, p-value ≤ 0.05.

RESULTS

Group	Separate or despirated instruments
A Glide Path K10	6
B Glide Path K15	5
C Glide Path K20	1

Tabla 4 Number of separated or despirated instruments

Finding that there are no statistically significant differences between Group A (glide path K10) and Group B (glide path K15) with a p-value = 0.723255.

Among Group B (glide path K15) and Group C (glide path K20), there are differences but not statistically significant with a p-value = 0.0765221.

While among group A (glide path K10) and group C (glide path K20) there are statistically significant differences p-value = 0.0374679.

Group	Short sequence	Normal sequence	Long sequence	Total
A Glide Path K10	9	8	2	19
B Glide Path K15	9	8	0	17
C Glide Path K20	15	5	0	20

Tabla 5 Short sequence = S1, S2
Normal sequence = S1, SX, S1, S2
Long sequence = S1, SX, S1, SX, S1, S2

Finding that there are no statistically significant differences between the different groups p-value = 0.1087.

Group	Time LT
A Glide Path K10	27.32
B Glide Path K15	25.12
C Glide Path K20	14.9

Tabla 6 Time in seconds to reach LT (net instrument. time)

Finding that there are statistically significant differences between the different groups, the glide path group being faster K20 p-value = 0.0086.

Group	Total Time Mechanical
A Glide Path K10	31.89
B Glide Path K15	28.06
C Glide Path K20	19.55

Tabla 7 Time in seconds of mechanical instrumentation (net instrumentation time)

Finding that there are no statistically significant differences between the different groups p-value = 0.0506.

Group	Total Time
A Glide Path K10	31.89
B Glide Path K15	33.06
C Glide Path K20	29.55

Tabla 8 Time in seconds of total manual + mechanical instrumentation (net instrumentation time)

There are no statistically significant differences between the different groups p-value = 0.7852.

DISCUSSION

Human teeth[29, 30, 31, 32] were selected to maximally reproduce the different physical and chemical properties inherent to dentin, as well as the anatomy of each tooth, since it has been demonstrated by Kartal and Hale[32], that humans teeth can present various curvatures in the different views (clinical and proximal) while acrylic blocks present standard curvatures and only in one view.

Lower molars were selected[32] due to the radius and degree of curvature that they present, and because the configuration of the mesial canals of lower molars creates greater technical difficulties for dentists during chemical-mechanical preparation. The population or race variable, not recorded in the study, may be important since different populations may present characteristic anatomical features.

Cunningham and Senia[33], as well as Kartal and Hale[32] found varying degrees of curvature in both views (B-L and M-D). For this reason, radiographs were taken in clinical and proximal views in order to determine the degree and radius of curvature[21, 34] of both views and, thus, be able to determine the maximum curvature and the smallest radius of each canal, as described by Pruett[21], and in this way distribute the sample more homogeneously between the different groups.

Radiographs were taken with the parallelism technique[35], using a long cone, both in the buccolingual and mesiodistal directions, in order to minimize radiographic distortion.

Endodontic access[36] in standard form[37], allowing as direct access as possible to the apical third. For the initial calibration of the canal, some authors such as Tan et al.[38] have recommended performing apical calibration with lightspeed files, because these have a small active part, an inactive tip and the stem is without taper, which allows them to slide better along the canal, thus avoiding any possible coronal interference. In our study we do it with K files since it reproduces what we generally use in daily practice, what interests us most in this study is the glide path or manual preflaring that is performed along the entire canal with manual files.

To try to control the anatomical variable, the sample was distributed so that the canals of the same tooth were included in different groups, that is, the mesiobuccal canal was instrumented with a certain caliber of glide path, and the mesiolingual canal with another glide path, alternating the groups in the different teeth, thus, as far as possible, having two similar canals, as done by Ankrum et. al.[39] in his studio.

The glide path of each group was carried out with type K files, as in the article published by Elio Berutti[17] and also because they are sold worldwide, impregnated in Glyde®, using the balanced force technique (Roane technique), performing copious irrigation with 3 ml of 4.2% sodium hypochlorite between each file using a 27-gauge syringe and needle.

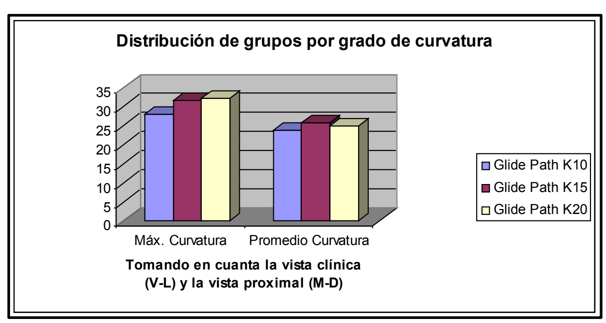
An inexperienced operator was calibrated[33] for instrumentation with mechanical files, because if an emerging technique or technology improves the result of the work of an inexperienced operator, this will be of equal benefit, in hands with more experience; but not the other way around.

For mechanical instrumentation, the electric motor with torque and speed control ATR® was used[12], the instrumentation sequence was recommended by the manufacturer for short canals and with brushing movements as recommended by Blum et . al.[10] for ProTaper® Shaping Series[9, 12].

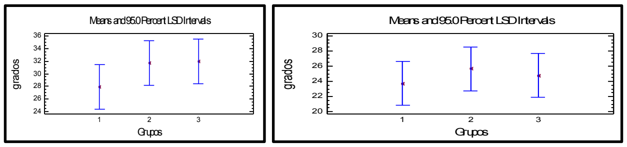
Only the “shaping” series was used[8, 9, 12, 38, 41] why the glide path influences only these instruments and not those of the “finishing” series, since the S1 is designed to work mainly the coronal and middle portion and the S2 the middle portion of the canal; conclude that, different studies such as that of Tan[38] and that of Roland[41], the apical portion, by nature, is normally larger in size than a 20 file; It is also documented by Tan et al.[38] that with prior preflaring, the apical gauge increases by 2 or 3 sizes to the initial apical gauge.

The number of uses of each instrument was controlled, discarding these every 5 uses (5 instrumented teeth or 10 canals), because as determined by Berutti et. al.[17] in their study, an average of 9.9 canals could be instrumented without the ProTaper® system instruments suffering permanent deformation or fracture, and they also commented that the ProTaper® S series instruments (shaping files) could be used more times than the F series instruments (finishing files), since, according to this study, the life expectancy of the F1 is 60% less than that of S1, and that of F2 80% less than S1.

After use, the instrument was inspected under a microscope at 25x magnification[42].

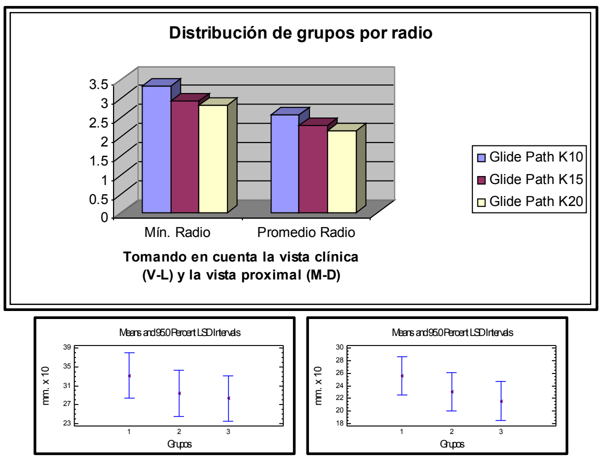


Graph 1 Analysis of the distribution of the groups with respect to the angle of curvature



p-value = 0.4514 p-value = 0.7997

Finding that there are no statistically significant differences between the different sample groups (maximum curvature and average curvature).

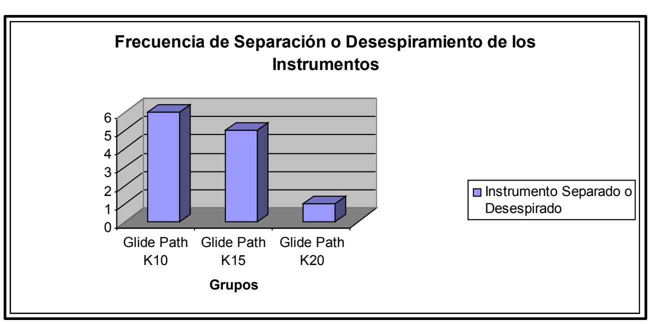


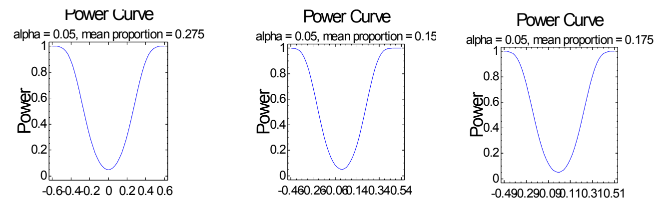
p-valor = 0.5780 p-valor = 0.4178

Graph 2 Analysis of the distribution of the groups with respect to the radius of curvature

There are also no statistically significant differences between the different sample groups in terms of radius.

The previous graphs show us that the distribution of the groups was homogeneous in terms of the angle and radius of curvature, so it had no impact on the deformation or fracture of the rotary mechanical instruments.





p-valor = 0.72325 p-valor = 0.07652 p-valor = 0.03746

Graph 3 Instrument separation frequency

Finding that there are no statistically significant differences between Group A (glide path K10) and Group B (glide path K15) with a p-value = 0.723255.

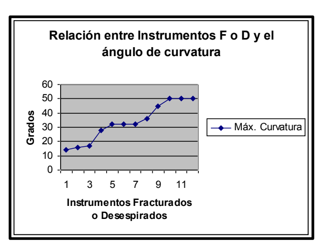
Among Group B (glide path K15) and Group C (glide path K20), there are differences but not statistically significant with a p-value = 0.0765221.

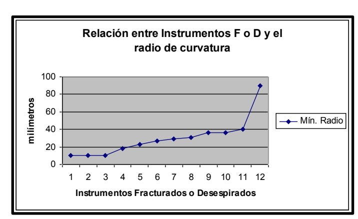
While among group A (glide path K10) and group C (glide path K20) there are statistically significant differences p-value = 0.0374679.

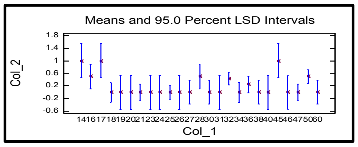
In this statistical analysis we can observe how a trend is marked, and it shows us that by increasing the caliber of manual instrumentation prior to rotary mechanical instrumentation (glide path), statistically significant differences are obtained as the caliber of the preparation increases, resulting in a reduction in the possibility of fracture of the mechanical instruments.

Relationship between fractured or despirated instruments and the angle and radius of curvature:

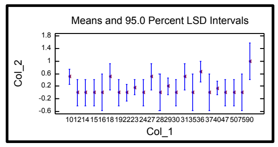
Diente No.	Conducto	Máx. Curvatura	Mín. Radio	Cuantificación Instrumento Sepa. o Desesp.**
20A	MV	45	18	1 (S2 D1)
8B	ML	14	27	1 (S1 D8)
19A	MV	32	36	1 (S2 D3)
2A	MV	16	40	1 (S2 D5)
6A	MV	D	D	1 (S1 R6)
9A	MV	D	D	1 (S1 D4)
14B	ML	17	23	1 (S1 R3)
10B	ML	32	29	1 (S2 D1)
12B	ML	28	90	1 (S1 R2)
19B	ML	32	36	1 (S1 R1)
21A	MV	D	D	1 (S2 D3)
18B	ML	36	31	1 (S2 D9)







p-valor = 0.1986



p-valor = 0.5506

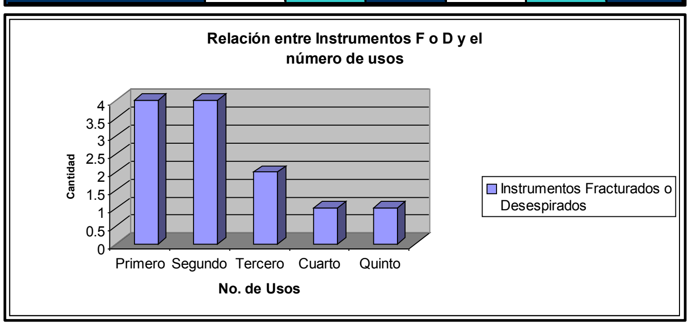
Graphs 4 and 5 Distribution of the angles and radii of curvature of the teeth where instruments were separated

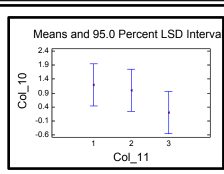
When analyzing them, it was found that there are no statistically significant differences between the different groups.

From what we can determine that the despirated or fractured instruments were not due to a radius or degree of curvature, the sample was homogeneous.

Relationship between fractured or despirated instruments and the number of uses:

Grupo	1 uso	2 uso	3 uso	4 uso	5 uso	Total
Glide Path K10	1	2	2	1	0	6
Glide Path K15	3	2	0	0	0	5
Glide Path K20	0	0	0	0	1	1
Total	4	4	2	1	1	12





p-valor = 0.6025

Graph 6 Relationship between fractured instruments and the number of uses thereof.

There are no statistically significant differences between the different groups.

It is important to note that 8 of the 12 instruments that were separated did so during the first and second use of the file, which shows that the separation of instruments was not linked to the number of uses, thus validating what was found by Berutti et. al.[17] in terms of the number of uses of ProTaper® instruments.

It is important to mention that when a glide path is made to a K20 file, rotary files reach working length more quickly, we found statistically significant differences in this data, although this analysis was not the main objective of the study, it was an interesting finding, which demonstrates how this glide path caliber makes the work of the first rotary files easier.

Finally, it is important to remember that the data obtained in this study were achieved through mechanical instrumentation by an inexperienced operator; these data could vary for endodontists with experience and better tactile sensation regarding the use of rotary instruments.

CONCLUSIONS

- Manual glide path caliber influences the frequency of fracture or permanent deformation of the mechanical rotary instruments of the ProTaper® system, when this is performed by inexperienced operators.

- The glide path performed with a K10 file does not influence the frequency of fracture or permanent deformation of the ProTaper® system instruments, when it is performed by inexperienced operators.

- The glide path performed with a K15 file does not influence the frequency of fracture or permanent deformation of the ProTaper® system instruments, when it is performed by inexperienced operators.

- The glide path performed with a K20 file influences reducing the frequency of fracture or permanent deformation of the mechanical rotary instruments of the ProTaper® system, when this is performed by inexperienced operators.

- Manual glide path caliber to a K20 file, influences decreasing the time in which the first mechanical rotary instrument of the ProTaper® system reaches the working length.

FUTURE PERSPECTIVES

Study the influence of glide path caliber in the frequency of fracture or permanent deformation of mechanical rotary instrumentation in general.

Furthermore, the influence of coronal widening (preflaring) on mechanical rotary instrumentation must be determined.

The influence of the glide path on the vertical and torque forces exerted during mechanical rotary instrumentation (for example through endograms) must be assessed, as well as on the cyclic fatigue of mechanical rotary instruments.

Finally, it must be determined whether the glide path caliber influences the frequency of fracture or permanent deformation of mechanical rotary instrumentation, when said instrumentation is performed by expert operators (endodontists).

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CONFLICT OF INTEREST DECLARATION

The authors declare that there is no conflict of interest related to this study.

DATA AVAILABILITY DECLARATION

Data available on request.

AUTHOR CONTRIBUTIONS

CAB performed experiments, analyzed data and wrote the manuscript, FDT, MRC analyzed data and revised the manuscript. CAC reviewed, validated the manuscript and contributed to the concept.

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