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ORIGINAL ARTICLE/ARTICOLO ORIGINALE

# Effect of apical preparation on different needle depth penetration



*Influenza della preparazione apicale sulla profondità di penetrazione di differenti aghi da irrigazione*

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## KEYWORDS

Apical shape;  
Irrigation;  
Needle;  
Nickel–titanium;  
Instruments.

## Abstract

**Aim:** Shaping should be complemented by antiseptic solution. These are often delivered using a needle and syringe. But apical penetration of the irrigation solution is of only 1 mm beyond its tip. The aim of our study was to evaluate the influence of the apical preparation on the penetration depth of some needles.

**Methodology:** 24 teeth were divided randomly into two groups and prepared in continuous rotation (350 rpm) with Revo-S<sup>®</sup> or ProTaper<sup>®</sup> to sizes AS 30, 35 and 40 and F1, F2 and F3 respectively. Four types of endodontic needles were used. Three sizes of stainless steel needles:

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**PAROLE CHIAVE**

Preparazione apicale;  
Irrigazione;  
Aghi;  
Nichel-titanio;  
Strumenti.

25, 27 and 30 gauge and one of nickel–titanium needle: 30 Gauge. Each needle was inserted and its length of penetration measured before the root canal preparation and after the finishing files. *Results:* Multivariate analysis of variance showed significant differences for the finishers ( $p < 0.0001$ ) and the kind of needle ( $p < 0.0001$ ). The PLSD Fisher's test can highlight the differences between the six types of apical shaping used (independently of the needle type). The same differences were observed between the four types of needle (independently of the apical finish) ( $p = 0.0232$ ).

Variance analysis between the four different needles is statistically significant for each apical shaping ( $p < 0.0001 \times 6$ ). Variance analysis among the six types of finish is statistically significant for each type of needle ( $p < 0.0001 \times 4$ ).

*Conclusions:* This study shows that the apical preparation influences the penetration depth of needles. The 27 gauge needles reach the last millimetre only with the Revo-S<sup>®</sup> system shaped with AS 40. Finally, the 30 gauge needles reach it for all finishers except the ProTaper<sup>®</sup> F1.

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**Riassunto**

*Scopo:* La preparazione canalare dovrebbe essere integrata dall'utilizzo di soluzioni antisettiche. Queste vengono rilasciate all'interno del canale utilizzando specifiche siringhe ed aghi endodontici, ma la penetrazione apicale della soluzione irrigante è di appena 1 mm oltre la punta dell'ago. Lo scopo del nostro studio è stato quello di valutare l'influenza della preparazione apicale sulla profondità di penetrazione di alcuni aghi endodontici.

*Materiali e metodi:* 24 denti sono stati divisi casualmente in due gruppi e preparati in rotazione continua (350 rpm) con Revo-S<sup>®</sup> o ProTaper<sup>®</sup> a 6 differenti dimensioni di preparazione, AS30, AS35 e AS40 e F1, F2 e F3 rispettivamente. Sono stati utilizzati quattro tipi di aghi endodonzia, tre in acciaio inossidabile di differenti dimensioni: 25, 27 e 30 gauge e uno in nichel-titanio da 30 Gauge. Ogni ago è stato inserito nel canale e la sua lunghezza di penetrazione misurata prima e dopo la preparazione canalare.

*Risultati:* L'analisi multivariata della varianza ha mostrato differenze significative per i l'ultimo strumento utilizzato ( $p < 0,0001$ ) e il tipo di ago ( $p < 0,0001$ ). Il test di Fisher ha evidenziato delle differenze tra i sei differenti tipi di sagomatura apicale utilizzati (indipendentemente dal tipo di ago) e tra i quattro tipi di aghi utilizzati (indipendentemente della finitura apicale) ( $p = 0,0232$ ). L'analisi della varianza è statisticamente significativa tra i quattro aghi diversi per ogni differente tipo di sagomatura apicale ( $p < 0,0001 \times 6$ ) e tra i sei differenti tipi di rifinitura per ogni tipo di ago ( $p < 0,0001 \times 4$ ).

*Conclusioni:* In conclusione, questo studio dimostra che la preparazione apicale influenza la profondità di penetrazione degli aghi da irigazione. Gli aghi calibro 27 raggiungono il millimetro apicale solo con il sistema di Revo-S<sup>®</sup> di taglia 40. Gli aghi calibro 30 raggiungono il millimetro apicale per tutti gli strumenti da preparazione apicale utilizzati tranne che per il ProTaper<sup>®</sup> F1.

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**Introduction**

Endodontic cleaning needs to remove all pulp tissue, micro-organisms and dentin debris from the canal during root canal shaping.<sup>1</sup> However, it was shown that the canal preparation is influenced by the great variability of root canal anatomy. Indeed the instruments (both manual and rotary) do not reach certain areas such as cracks, crevices, isthmus, accessory canals and apical deltas.<sup>2,3</sup>

The action of the instruments should be complemented by antiseptic solution.<sup>3</sup> These are often delivered using a needle and syringe. But studies indicate that the apical penetration of the irrigation solution is of only 1 mm beyond the tip of the needle.<sup>2,4</sup> The aim of our study was to evaluate the influence of the apical preparation on the penetration depth of some needles.

**Materials and methods**

24 teeth from the tooth bank of the Endodontic Department of the Dental Faculty of Toulouse were selected. Only single-rooted teeth having a mature apex and a root curvature less than 15° were included in this study. Those with cracked roots, root caries, resorbed or immature apex or endodontic treatment were excluded.

The teeth were divided randomly into two groups of 12. The access cavity was performed using a turbine, diamond bur (diameter 12) and endo-Z<sup>®</sup> (ref 801-012FG and E0152FG Stoner France, Toulouse, France). Then the initial penetration was performed using K files diameter 10 (Micro-Mega, Besancon, France). Working length (WL) was determined under a stereo-microscope (Wild M3B, Leica, Heerbrugg, Switzerland) at  $\times 16$  magnification. When this file reached

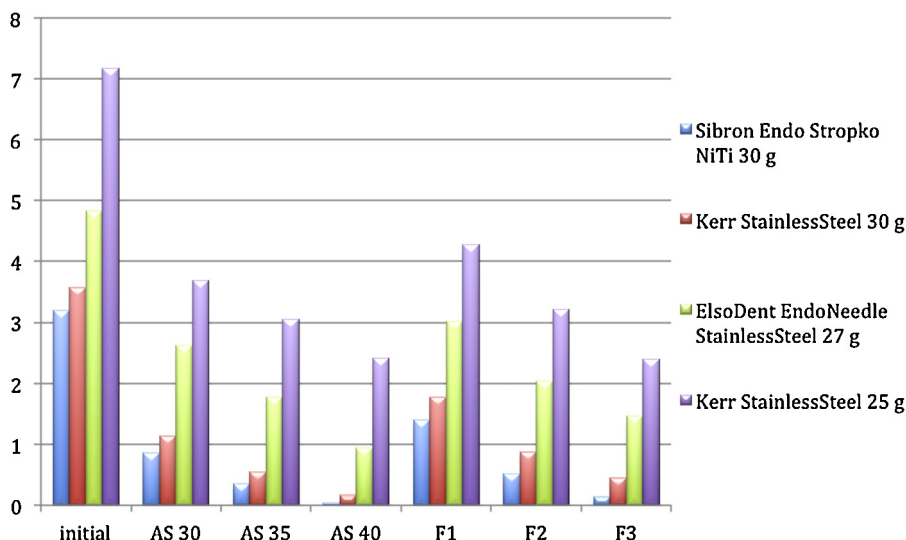


Figure 1 Mean difference depth to working length depending on needle and apical finish.

the apical foramen, half a millimetre was removed to determine the working length.

Secondly, root canals were prepared using nickel–titanium files in continuous rotation at a speed of 350 rpm (X-Smart®, Dentsply, Konstanz, Germany). Each group was shaped with a nickel–titanium system dedicated to initial treatment: the first with Revo-S® (Micro-Mega, Besancon, France), the second with ProTaper® (Maillefer, Ballaigues, Switzerland). Revo S®-sequence was used with a flaring file (EndoFlare®, Micro-Méga, Besançon, France) in the coronal part (3–4 mm maximum), then SC1 shaped the 2/3 of WL and the other files reached the WL (SC2, SU, AS 30, AS 35 and AS 40).

ProTaper® sequence was used with the Sx® in the coronal part and all the other files reached the WL (S1, S2, F1, F2 and F3). 2 mL of 2.6% NaOCl was used between each instrument.

Four types of endodontic needles were used. Three sizes of stainless steel needles: 25, 30 gauge (Irrigation Probe®,

Kerr Hawe, Bioggio, Switzerland) and 27 gauge (Endoneedle®, Elsodent, G-Pharma, Cergy Pontoise, France) and one size of nickel–titanium needle: 30 Gauge (Stropko®, SybronEndo, Orange, CA). Each needle was inserted and its length of penetration measured before the root canal preparation and after the finishing files: AS 30, AS 35 and AS 40 for Revo-S®, and F1, F2 and F3 for ProTaper®. The depth of penetration was indicated by a double rubber stop on the needle and measured on a Polydentia gauge (Mezzovico, Switzerland) with the accuracy of a quarter of a millimeter.

Analysis of the variance and PLSD Fisher’s tests were done with Statview 5.0 software (Sas Institute, Orange, CA) and alpha risk fixed at 5%.

Results

Penetration depth of each needle is measured and the distance between the needle tip and the working length is calculated (Fig. 1). The PLSD Fisher’s test can highlight the differences between the six types of apical shaping used (independently of the needle type) (Table 1). The same differences were observed between the four types of needle (independently of the apical finish) (p = 0.0232).

Multivariate analysis of variance showed significant differences for the finishers (p < 0.0001) and the kind of needle (p < 0.0001) (Table 2).

Table 1 PLSD Fisher’s test for the finishing parameter.

	Mean diff.	P-value	Significance
AS 30 vs AS 35	0.677	<0.0001	S
AS 30 vs AS40	1.199	<0.0001	S
AS 30 vs F1	-0.525	0.0003	S
AS 30 vs F2	0.429	0.0030	S
AS 30 vs F3	0.975	<0.0001	S
AS 35 vs AS 40	0.522	0.0004	S
AS 35 vs F1	-1.202	<0.0001	S
AS 35 vs F2	-0.248	0.0904	NS
AS 35 vs F3	0.298	0.0422	S
AS 40 vs F1	-1.724	<0.0001	S
AS 40 vs F2	-0.771	<0.0001	S
AS 40 vs F3	-0.224	0.1226	NS
F1 vs F2	0.953	<0.0001	S
F1 vs F3	1.500	<0.0001	S
F2 vs F3	0.547	0.0002	S

Table 2 Needles able to reach biological goals depending on apical shaping. (N1: Sibron Endo Stropko NiTi 30G; N2: Kerr Stainless steel 30G; N3: Kerr Stainless steel 25G; N4: Elsodent Endoneedle Stainless steel 27G).

	F1	F2	F3	AS 30	AS 35	AS 40
Recommended needle	No	N1 N2	N1 N2	N1	N1 N2	N1 N2 N4

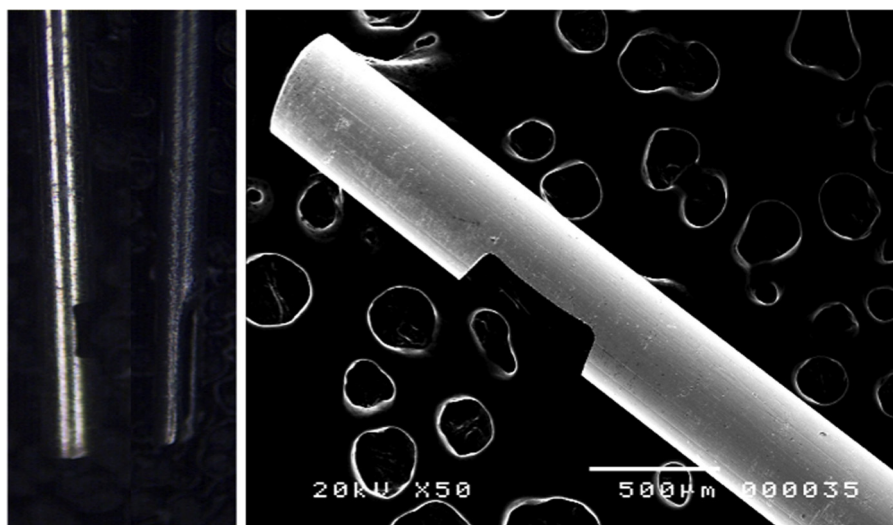


Figure 2 Photography and SEM picture of endodontic needle's tip design.

Variance analysis between the four different needles is statistically significant for each apical shaping ( $p < 0.0001 \times 6$ )

Finally, according to the apical finishing, all the needles did not reach the working length minus one millimetre corresponding to biological criteria defined previously.

Variance analysis among the six types of finish is statistically significant for each type of needle ( $p < 0.0001 \times 4$ ).

## Discussion

This study shows that the apical preparation influences the penetration depth of needles.

Natural teeth were chosen to take into account the variability of root canal anatomy<sup>5</sup> and the influence of shaping. The teeth chosen had low curvature. The results were not influenced by the angle and radius of curvature. Greater curvatures could block the needle above leading to increasing differences between the needles.

A total of 12 teeth per group were chosen as in other similar studies.<sup>6,7</sup> This is a small number but leads to a sufficient statistical power to take into account the variability of measurement.

Determining the working length was performed using stereo-microscope that allows accurate visualization of the file when it reaches the apex.<sup>6</sup> This technique is reliable, reproducible and avoids any bias or electronic measuring secondary to radiographic interpretation.

Measurement of working length as the needle penetration depth is done using a gauge. A digital calliper could be used.<sup>6</sup> Its accuracy reaches one-tenth of a millimetre in contrast to the gauge whose accuracy is only a quarter of a millimetre. However it was decided to use the gauge because it is a frequently used clinical tool.<sup>8</sup>

Needles of three diameters were used to evaluate the different penetration depths depending on the size. We also compared two needles of the same diameter but different material (stainless steel and nickel titanium). For the same gauge, representing the external diameter of the needle, the

penetration capacity is different depending on the alloy of the needle ( $p = 0.0179$ ). The use of a super-elastic alloy therefore optimizes the penetration of the irrigation needle. However the design of these apical needles is different (Fig. 2) with a true lateral deflection for the Kerr's 30 gauge stainless steel and a side discharge for the Sibron's 30 gauge NiTi Endo.

Although the protocol of the Revo-S has no flaring tool,<sup>9</sup> one (EndoFlare<sup>®</sup>, Micro-Mega, Besançon, France) was added into the sequence to mimic the ProTaper<sup>®</sup>'s one. This flaring tool eliminates interference and initial constraints of the canal. It therefore facilitates the action of endodontic instruments and the needle insertion. Its lack of use would little or not change needle penetration measures performed during the final apical preparation of the canal. The average length of tooth preparation is 21.60 mm. The canal length is about 13 mm long, which corresponds to a diameter of preparation for the canal entrance of 0.97 mm well above the preparation with an EndoFlare<sup>®</sup> even with a penetration of 4 mm (0.63 mm).

## Conclusion

Our study shows that the apical preparation influences the penetration depth of needles that reach the biological criteria. The minimum apical preparation should vary depending on the type of needle used. It appears that the Revo-S system reaches these criteria regardless of the apical finish used for 30 gauge needles or with the AS 40 finisher for 27 gauge needles whereas the ProTaper system requires at least a F2 preparation and the use of 30 gauge needle.

Similarly, different needle types should be used depending on the apical preparation. 25 gauge needles are inconsistent with such biological criteria. Those over 27 reach it only with the Revo-S system shaped with AS 40. Finally, the 30 gauge needles reach it for all finishers (AS 30, AS 35, AS 40, F2 and F3) except the F1. But passive ultrasonic irrigation may be an adjunctive treatment for improving the root canal system cleaning.<sup>4</sup>

## Conflict of interest

The authors have no conflicts of interest to declare.

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