

## Study of endodontic working length of Korean posterior teeth

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### ABSTRACT

**Objectives:** The aim of this study was to investigate average working lengths of Korean posterior teeth and evaluate validity of endodontic file length.

**Materials and Methods:** The endodontic working length of the posterior teeth of 670 Korean patients were measured than each mean value and standard deviation were investigated than the frequency deviation and standard deviation per each length were calculated.

**Results:** Among the canals of premolar, 66.5% of canal length was marked under 20 mm by endodontic working length and 95.4% could be measured under 22 mm and Among the canals of molars, 95.5% of canal length was marked under 20 mm endodontic working length .

**Conclusions:** With the result of measurement of endodontic working length of premolars of Korean, it suggested that 23 mm endodontic file is more proper than the 21 mm and 25 mm file on the market. [J Kor Acad Cons Dent 2010;35(6):429-435.]

**Key words:** Molar; Ni-Ti file; Premolar; Working length

-Received 29 May 2010; revised 27 August 2010; accepted 30 August 2010-

### Introduction

As a result of concerns that arose nearly 40 years ago, efforts were made to standardize endodontic files and root canal filling materials. This resulted in an international standard for endodontic files, known in the United States as ANSI standard No. 58 and No. 28. The taper of the instruments is prescribed to be 0.02 taper of length, starting at the tip. Three standard lengths are available as 21 mm, 25 mm, and 31 mm. The working part of the instrument must be at

least 16 mm.

After introduction of nickel-titanium (Ni-Ti) to endodontics since 1988, Ni-Ti hand files and rotary instruments have become popularized because of their properties of superelasticity and shape memory.<sup>1</sup> Ni-Ti files also have standard length (21 mm, 25 mm) except several orifice shapers.<sup>2-5</sup>

For the size of the rubber stop is 1 mm, it is possible to perform canal shaping up to 20 mm, based on endodontic working length, when using 21 mm file. However using a long length file is uncomfortable

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\*This study was supported by the Wonkwang Health Science University in 2008.

since these Ni-Ti files should be mounted on a hand-piece and can't apply precurvature. In clinical procedure of endodontic treatment, the time for patients to keep their mouth open is longer than in any other treatment. If the time of mouth opening increases, patient will feel discomfort and side-effects like temporo-mandibular joint disease might occur.<sup>6,7</sup> Using long instruments will also give difficulties during the treatment procedures for the operator too.

The lengths of the endodontic instruments are designed to be based on the length of the tooth. There are several methods for measuring these lengths of the teeth.<sup>8</sup> There are methods like, measuring directly from extracted tooth, surveying from the radiographic films or by measuring the working length of the tooth.<sup>9</sup> This method of measuring working length of the tooth can be done by measuring the length of the extracted tooth, using radiographic references or by using electronic working length measuring instruments. In vivo study, the radiographs are not always reliable because they can show considerable deviations depending upon the angles of the X-ray cone.<sup>10</sup> The apical constriction of the the root also does not coincide with the anatomic apex.<sup>8,11,12</sup> It is deviated linguo-buccally or mesio-distally from the root. If the exit deviates bucco-lingually, it is very difficult to locate accurately the position of the apical foramen using only roentgenograms, even with multi-directed angles.<sup>13</sup>

The electric apex locator (EAL) machine has attracted a great deal of attention because it operates on the basis of the electrical impedance rather than by a visual inspection.<sup>13</sup> EALs help to reduce the treatment time and the radiation dose, which may be higher with conventional radiographic measurements. In addition, EALs were reported to be an accurate<sup>14-18</sup> and reproducible method as the newest third generation type and can acknowledge a root perforation.

International standard follow the average tooth lengths of caucasian people.<sup>9,19,20</sup> Although there were reports on the average tooth length of caucasian people, few information on the differences of canal lengths between the races is available.

Therefore, the aim of this study was to investigate average working lengths of Korean posterior teeth and evaluate validity of endodontic file length.

## Materials and Methods

Six hundred and seventy Korean patients who received a root canal treatment of posterior teeth at ○○ University between 2006 and 2008 were randomly selected and classified with data warehouse (Sybase IQ 12.6, Sybase, Oakwood, US). Teeth with severe dental caries, fixed prosthesis, or those that were impossible to negotiate the apical region due to calcification or other reasons were excluded. 2nd mesio-buccal canal of maxillary molar and mandibular molar with C-shaped canal were excluded.

The clinical procedures for the root canal treatment were executed by single operator. Access cavities were made using the standard clinical procedures and 0.5 mm occlusal reduction from marginal ridge was performed. The endodontic working lengths were first measured using an electronic measuring device (Root-ZX; J. Morita Co., Kyoto, Japan), and the lengths were then verified by taking periapical radiographs. Any electronic length within 1.0 mm of the radiographic tooth length was regarded as a reliable initial working length.<sup>11</sup> Only the initial working length was used in this study because the working length might change as the canal became enlarged.<sup>21</sup>

These measured endodontic working lengths were record on computer based charts then abstracted and conversed by ETCL program (Data Stage 7.1, IBM, New York, US) which then stored at data warehouse. Data from measured endodontic working lengths were analyzed by OLAP program (Hyperion Intelligence 8.5, Oracle, Redwood, US).

Endodontic working lengths of 487 premolar canals and 870 molar canals were measured in this study. Mean and standard deviation of endodontic working length of the each tooth were computed than frequency distribution classified by length was measured. Normal distribution classified by length using mean and standard deviation was measured.

## Results

The endodontic working lengths of posterior teeth in Korean are given in Table 1 and 2. It is showing the number of surveyed canals per canal location, mean value and standard deviation for each tooth.

Maxillary premolar was classified into subclasses according to the number of canal, premolars with 1 canal and premolars with 2 canals. Identically mandibular 1st molar were classified according to the number of the distal canal, into molars with 1 distal canal or molars with 2 distal canals.

Table 3 shows the number of canal per each length of molars. Total of 487 canals of molar were measured and maxillary first premolar with less than 20 mm of

endodontic working length were counted up to 112 whereas calculated up to 324 canals when all 4 premolar were considered. Canals of premolar which was less than 22 mm by length was summed up to 465.

Table 4 shows the number of tooth per each length of premolars. Total of 870 canals of premolar were measured and maxillary first molar with less than 18 mm of endodontic working length were counted up to 149 whereas calculated up to 549 canals when all 4

**Table 1.** Mean value of working length (mm) in maxillary teeth

Tooth	Canal	Number of canals	Mean ± (SD)
1 <sup>st</sup> premolar	One canal	22	19.7 ± (1.48)
	Buccal	68	19.5 ± (1.61)
	Palatal	68	19.3 ± (1.55)
2 <sup>nd</sup> premolar	One canal	68	19.0 ± (1.67)
	Buccal	29	19.2 ± (1.64)
	Palatal	29	19.4 ± (1.54)
1 <sup>st</sup> molar	Mesiobuccal	85	18.1 ± (1.14)
	Distobuccal	85	18.1 ± (0.99)
	Palatal	85	19.0 ± (1.30)
2 <sup>nd</sup> molar	Mesiobuccal	65	17.4 ± (0.95)
	Distobuccal	65	17.3 ± (1.01)
	Palatal	65	18.2 ± (0.87)

**Table 2.** Mean value of working length (mm) in mandibular teeth

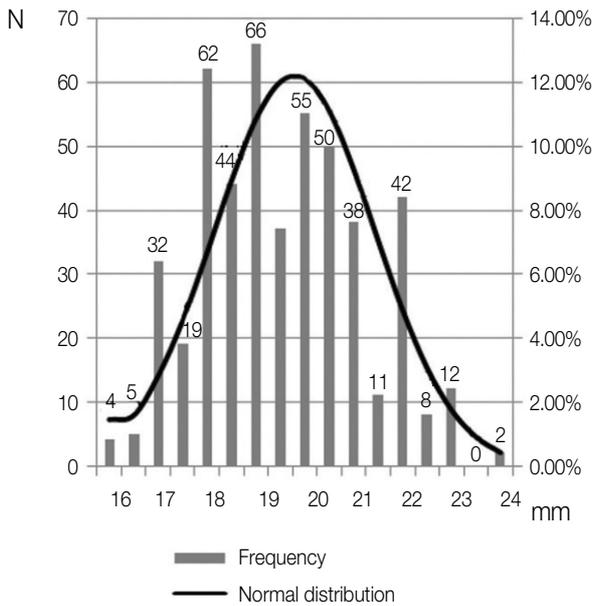
Tooth	Canal	Number of canals	Mean ± (SD)
1 <sup>st</sup> premolar	One canal	99	20.3 ± (1.56)
2 <sup>nd</sup> premolar	One canal	104	19.4 ± (1.52)
1 <sup>st</sup> molar	Mesiobuccal	66	18.3 ± (1.01)
	Mesiolingual	66	18.3 ± (0.98)
	Distal one canal	36	18.5 ± (0.95)
2 <sup>nd</sup> molar	Distobuccal	30	18.5 ± (0.81)
	Distolingual	30	18.4 ± (1.25)
	Mesiobuccal	64	18.4 ± (0.95)
	Mesiolingual	64	18.4 ± (0.88)
	Distal	64	18.5 ± (1.06)

**Table 3.** The number of canals classified by length in premolar

Tooth	Canal length (mm)				
	Under 20	20.5-21	21.5-22	22.5-23	23.5-24
Maxillary 1 <sup>st</sup> premolar	112	22	20	4	0
Maxillary 2 <sup>nd</sup> Premolar	94	15	13	4	0
Mandibular 1 <sup>st</sup> premolar	45	30	15	7	2
Mandibular 2 <sup>nd</sup> premolar	73	21	5	5	0
Total	324	88	53	20	2

**Table 4.** The number of canals classified by length in molar

Tooth	Canal length (mm)				
	Under 18	18.5-19	19.5-20	20.5-21	21.5-22
Maxillary 1 <sup>st</sup> molar	149	61	23	17	5
Maxillary 2 <sup>nd</sup> molar	154	30	9	2	0
Mandibular 1 <sup>st</sup> molar	128	71	21	5	3
Mandibular 2 <sup>nd</sup> molar	118	45	22	5	2
Total	549	207	75	29	10



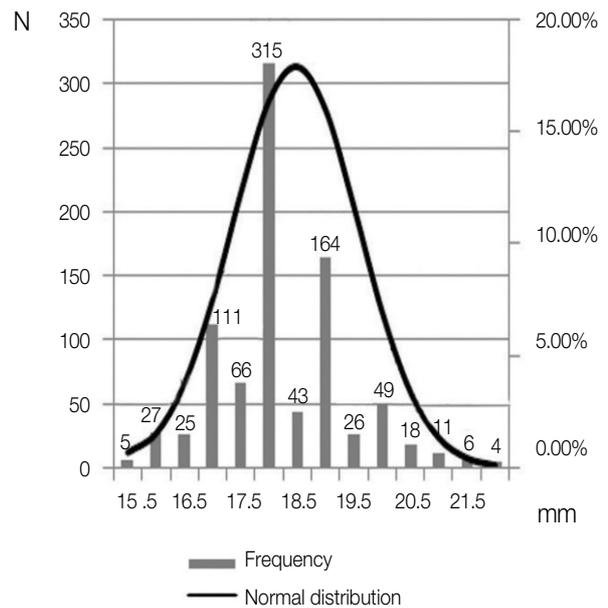
**Figure 1.** The number of canals classified by length in premolar. Frequency distribution and normal distribution.

molar were considered. Canals of molar which was less than 20 mm by length was summed up to 831.

Figure 1 shows the normal distribution and frequency distribution sorted by the length of the premolar, the mean value (19.54 mm) and standard deviation (1.62) of the premolars. The right side of the vertical axis shows the number of frequency which 19 mm was most frequent, numbering 66, followed by 18 mm, 20 mm and 20.5 mm in sequence according to the frequency deviation. The scale at left side of the vertical axis shows the probability of normal distribution. Figure 2 shows the normal distribution and frequency distribution sorted by the length of the molar, the mean value (18.21 mm) and standard deviation (1.10) of the molars. Scale at right side of vertical axis shows the number of frequency as same as Figure 1. Taking look at the frequency deviation, 18 mm was most frequent, followed by 19 mm, 17 mm in sequence according to the frequency deviation.

### Discussion

This study was performed to find out the properness of length of the standard endodontic files for the



**Figure 2.** The number of canals classified by length in molar. Frequency distribution and normal distribution.

endodontic working length of Korean, by examining the endodontic working length of premolars and molars of Korean. As mentioned at the introduction, for the size of the rubber stop is 1mm, it is possible to perform canal shaping up to 20 mm, based on endodontic working length, when using 21 mm file. In the case of the premolar, 66.5% of the working length was under 20 mm, and 95.4% were under 22 mm. According to the fact that the standard endodontic files on the market is usually 21 and 25 mm, 21 mm file is not sufficient to use for premolar and for that reason the length of the files must be at least 23 mm for adequate use. For the case of the molar, 86.9% of the working length was under 19 mm and 95.5% were under 20 mm. Considering the endodontic working length, files shorter than 20 mm is not suitable for the molar and it must be longer than 21 mm for adequate use.

Various studies are conducted to improve the intra-oral accessibility of the instruments of endodontic treatment. For the case of Ni-Ti file, development of micro hand piece instead of existing contra-angle low speed hand piece made it much easier to apply into the patient's oral cavity. For some files, K3 rotary Ni-Ti file (SybronEndo, Orange, California, US) for

example, handle design were shortened without affecting the working part of the instrument to develop the intra-oral accessibility.<sup>5</sup> Consequently, choosing the proper length of the instrument for the patient's working length will affect the intra-oral accessibility.

At most of the files the rubber stop has the thickness of approximately 1.0 mm. This is thought to be because the rubber stop must have some rigidity during the filing process. However if the rubber stop can be made thinner with certain rigidity, the length of the instruments can be shorter to that extent.

Occlusal reduction was performed for every endodontic treatment of the posterior teeth in this study. Occlusal reduction was carried out to set a fixed reference point during the measurement of endodontic working length. Occlusal reduction was set 0.5 mm lower from the marginal ridge to minimize the error of reduction amount of each tooth. It could have been set based on the cusp, but variations according to the amount of abrasion might be severe, so marginal ridge were set to be the basis.

Crown restoration has to be carried out to reinforce the weakened tooth during the endodontic treatment. For tooth preparation for the crown restoration, 1.5 mm at the occlusal surface must be reduced. Considering this fact, occlusal reduction during the endodontic treatment of posterior tooth can be carried out up to 1.5 mm for the max. 21 mm file was the most proper length of the file for posterior tooth as the result of this study, however if the thickness of the rubber stop can be reduced and the amount of occlusal reduction is controlled, shorter files might be able to be used for the canal shaping.

The length of the teeth is already being measured by various methods in several studies.<sup>22-26</sup> The data acquired from extracted tooth or method using radiographic pictures can be useful for studies on anatomical form, size and length, but it is not useful to decide the length of the instruments of endodontic treatment in actual clinical use.

In this study, the endodontic working lengths were measured instead of the length of the tooth. This is because the endodontic instruments (ex: file, GGD bur) is used on clinical practice based on the endodontic working length. There are reports that

previous study also measured the endodontic working length, but was limited into a portion of teeth, which is different with this study.<sup>27</sup>

There is body of opinion that there are difference in root canal lengths between Asians and western population with the latter having longer teeth. Kim et al. researched the difference of the tooth length of Korean and Occidentals and reported that there is difference between those two. In this study, the endodontic working length of the Korean was measured to inquire most adequate file length.

Various programs were used in this study in order to abstract and analyze the data (computer based charts, ETCL program, data warehouse, OLAP program). This method will ease the effort to find the data recorded separately, and will be utility to use in framing all kinds of dental statistics later on.

## Conclusions

The aim of this study was to investigate average working lengths of Korean posterior teeth and evaluate validity of endodontic file length. In this study, the endodontic working length of the posterior teeth of 670 Korean patients were measured than each mean value and standard deviation were investigated than the frequency deviation and standard deviation per each length were calculated. As the result, following conclusion was acquired.

1. Among the canals of premolar, 66.5% of canal length was marked under 20 mm by endodontic working length and 95.4% could be measured under 22 mm.
2. With the result of measurement of endodontic working length of premolars of Korean, it suggested that 23 mm endodontic file is more proper than the 21 mm and 25 mm file on the market.
3. Among the canals of molars, 95.5% of canal length was marked under 20 mm endodontic working length
4. With the result of measurement of endodontic working length of premolars of Korean, it suggested that 21 mm endodontic file on the market can be used for most canals.

The most proper length of the instruments for majority of the canal shaping was found in this study

by measuring the endodontic working length of Korean. Adequate length of the instrument will be useful both for the patients and the operators.

### References

1. Kim S. Modern endodontic practice: instruments and techniques. *Dent Clin North Am.* 2004;48(1):1-9.
2. Barbakow F. The LightSpeed system. *Dent Clin North Am.* 2004;48(1):113-135.
3. Clauder T, Baumann MA. ProTaper NT system. *Dent Clin North Am.* 2004;48(1):87-111.
4. Hsu YY, Kim S. The ProFile system. *Dent Clin North Am.* 2004;48(1):69-85.
5. Mounce RE. The K3 rotary nickel-titanium file system. *Dent Clin North Am.* 2004;48(1):137-157.
6. Takatsuka S, Yoshida K, Ueki K, Marukawa K, Nakagawa K, Yamamoto E. Disc and condyle translation in patients with temporomandibular disorder. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2005;99(5):614-621.
7. Nunez SC, Garcez AS, Suzuki SS, Ribeiro MS. Management of mouth opening in patients with temporomandibular disorders through low-level laser therapy and transcutaneous electrical neural stimulation. *Photomed Laser Surg.* 2006;24(1):45-49.
8. Kuttler Y. Microscopic investigation of root apices. *J Am Dent Assoc.* 1955;50(5):544-552.
9. Eliasson S, Lavstedt S, Ljungheimer C. Radiographic study of alveolar bone height related to tooth and root length. *Community Dent Oral Epidemiol.* 1986;14(3):169-171.
10. Forsberg J. Radiographic reproduction of endodontic "working length" comparing the paralleling and the bisecting-angle techniques. *Oral Surg Oral Med Oral Pathol.* 1987;64(3):353-360.
11. Burch JG, Hulen S. The relationship of the apical foramen to the anatomic apex of the tooth root. *Oral Surg Oral Med Oral Pathol.* 1972;34(2):262-268.
12. Dummer PM, McGinn JH, Rees DG. The position and topography of the apical canal constriction and apical foramen. *Int Endod J.* 1984;17(4):192-198.
13. Kim E, Lee SJ. Electronic apex locator. *Dent Clin North Am.* 2004;48(1):35-54.
14. Vajrabhaya L, Tepmongkol P. Accuracy of apex locator. *Endod Dent Traumatol.* 1997;13(4):180-182.
15. Czerw RJ, Fulkerson MS, Donnelly JC, Walmann JO. In vitro evaluation of the accuracy of several electronic apex locators. *J Endod.* 1995;21(11):572-575.
16. Ibarrola JL, Chapman BL, Howard JH, Knowles KI, Ludlow MO. Effect of preflaring on Root ZX apex locators. *J Endod.* 1999;25(9):625-626.
17. Shabahang S, Goon WW, Gluskin AH. An in vivo evaluation of Root ZX electronic apex locator. *J Endod.* 1996;22(11):616-618.
18. Cho.Y.L, Son.W.H, Hwnag.H.G. An accuracy of the several electronic apex locators on the mesial root canal of the mandibular molar *J Kor Acad Cons Dent.* 2005;30(6): 477-485.
19. Kim E, Fallahrastegar A, Hur YY, Jung IY, Kim S, Lee SJ. Difference in root canal length between Asians and Caucasians. *Int Endod J.* 2005;38(3):149-151.
20. Perzigian AJ. Allometric analysis of dental variation in a human population. *Am J Phys Anthropol.* 1981;54(3):341-345.
21. Cho.J.I, Jin.M.W, Kim.Y.K, Kim.S.K. Change of working length in curved canals by various instrumentation techniques. *J Kor Acad Cons Dent.* 2006;31(1):30-35.
22. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. *Int Endod J.* 2001;34(5):359-370.
23. Ng YL, Aung TH, Alavi A, Gulabivala K. Root and canal morphology of Burmese maxillary molars. *Int Endod J.* 2001;34(8):620-630.
24. Ahmed HA, Abu-bakr NH, Yahia NA, Ibrahim YE. Root and canal morphology of permanent mandibular molars in a Sudanese population. *Int Endod J.* 2007;40(10):766-771.
25. Pattanshetti N, Gaidhane M, Al Kandari AM. Root and canal morphology of the mesiobuccal and distal roots of permanent first molars in a Kuwait population—a clinical study. *Int Endod J.* 2008;41(9):755-762.
26. Peiris HR, Pitakotuwage TN, Takahashi M, Sasaki K, Kanazawa E. Root canal morphology of mandibular permanent molars at different ages. *Int Endod J.* 2008;41(10):828-835.
27. Park.S.H, Noh.B.H, Hwang.H.G. A Comparison of the length between mesio-buccal and mesio-lingual canals of the mandibular molar. *J Kor Acad Cons Dent.* 2004;29(6):541-547.

## 국문초록

## 한국인의 구치부 근관작업장에 관한 연구

김정엽<sup>1</sup> · 이상훈<sup>2</sup> · 이광희<sup>3</sup> · 박상혁<sup>1,4\*</sup><sup>1</sup>경희대학교 대학원 치의학과 치과보존학교실, <sup>2</sup>경희 management company 의료정보팀<sup>3</sup>원광보건대학 치위생과, <sup>4</sup>경희대학교 동서신의학병원 치과병원 보존과

**연구목적:** 본 연구의 목적은 한국인의 근관 작업장에 대한 ISO규격의 근관 치료용 기구의 길이가 적절성을 평가하기 위한 것이다.

**연구 재료 및 방법:** 2006-2008년까지 경희의료원 동서신의학병원 보존과에서 구치부의 근관 치료를 받은 환자를 670명 선발하였다. 모든 근관 치료는 한 명의 술자에 의해 시행되었으며 통법의 와동을 형성하였고 변연 융선부터 0.5 mm의 교합면 삭제를 시행하였다. 근관장은 전자 근관장 측정기(Root ZX)를 이용하여 측정하였고 방사선 사진으로 보정하였다. 근관장의 길이는 근관 성형 정도에 따라 달라지기 때문에 이 실험에서는 초기 근관장만을 이용하였다. 심한 우식이 있거나 보철물이 있는 경우, 근관이 석회화 되어서 정상적인 근관 치료를 할 수 없는 경우, 상악 대구치의 근심 설측 근관과 하악의 C-shape 근관을 가진 치아는 실험군에서 제외하였다. 총 487개 소구치 근관과 870개 대구치 근관의 근관장을 측정하였고 각각의 평균 및 표준편차를 측정하였다. 또한 각 길이별 빈도 분포 및 정규 분포를 관찰하였다.

**결과:**

1. 소구치 근관에서 20 mm 이하의 근관장을 갖는 경우는 전체의 66.5%였으며 22 mm 이하의 근관장을 갖는 경우는 전체의 95.4%였다.
2. 한국인의 소구치 근관장을 측정한 결과, 현재 시판중인 21 mm, 25 mm의 기구보다는 23 mm의 기구가 더 적절하였다.

**결론:** 한국인의 소구치 근관 치료시 21 mm, 25 mm의 기구보다는 23 mm의 기구가 더 적절하였으며 대구치의 경우 21 mm의 기구의 사용이 적절하다고 사료된다.

**주요단어:** 대구치; 소구치; 작업장; Ni-Ti 파일