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Source / Izvornik: **Collegium antropologicum, 2013, 37, 437 - 442**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

Coll. Antropol. **37** (2013) 2: 437–442
Original scientific paper

An *in vitro* Morphological Investigation of the Endodontic Spaces of Third Molars

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A B S T R A C T

Aim of this paper was to investigate the particular anatomic features of the endodontic space of third molars in the general population of Croatia. A total of 106 fully developed third molars (56 maxillar and 50 mandibular) has been analyzed. The respective number of roots and of root canals, the structure of the roots, and the curvature and absolute length of the root-canals were analyzed. In most cases, upper third molars had three roots (83.9%), while most of the lower molars were single rooted (56.0%). Upper third molars had mostly three root canals (75.1%), lower third molars two (90.0%). In both jaws, most third molars had curved canals (60.7% in the upper and 84.0% in the lower jaw). 12.5% of upper third molars had lateral and accessory canals, whereas only 4.0% of the lower third molars were found to have them. The Student t-test showed statistically significant differences ($p<0.05$) in the length of the root-canals, mesiobuccal and distobuccal canals being significantly shorter than palatinal canals. The same test showed that in the lower third molars the mesial root canals were significantly longer that the distal ones, although slightly. The results obtained are in compliance with similar results by other authors; however, they tend to show some specific population-related features.

***Key words**: endodontics, endodontic space, morphology, third molar*

Introduction

The meaning and significance of the third molars for oral health has been a controversial topic and the focal point of numerous disputes and differences in opinion among dental practitioners and the scientists alike. It is a matter of common knowledge that third molars, also referred to as wisdom teeth, are the most irregular of all molars, susceptible to reduction and agenesis. According to these facts, and enhanced by the Buttler-Dalberg theory on instability of the teeth with respect to their position in the dental arch, many contemporary researchers are dealing with the frequency of incidence of third molars and their importance for the modern human. Some authors believe that third molars do not have a significant role within the framework of the oro-dental system, since those teeth are frequently the cause of pathological conditions and pain. Those authors recommend preventive extractions of all third molars, in order to prevent inflammatory and painful conditions caused by them or they even go so far as to prevent the growth of the germs of those teeth by applying certain surgical techniques[1–4].

The evolution has remarkably affected the importance of third molars. Archeological findings suggest that dental diseases have been comparatively rare, with the predominance of caries and periodontitis. Main dental disturbances in the prehistoric man seems to have been the result of extreme occlusal wear and its accompanying effects. Therefore, third molars had a predominant role in the reduction of the occlusal wear, since they were enlarging the total masticatory surface.

By the end of the 17th century the mankind saw a dramatic increase of dental diseases, mainly as a consequence of great changes in lifestyle and nourishment[2,5–7]. Since that time the change had occurred not only with regard to third molars, but rather to all teeth. The actual incidence of diseases in the past times is difficult to as-

Received for publication September 27, 2010

sess due to lack of accurate data. A number of authors point to the fact that extracting third molars at an advanced age in life is associated with higher a risk for periodontal defects on the distal wall of the second molar, various problems during the surgical intervention, damage inflicted to the nerves, and similar[8–12]. Pain and pathology associated with third molar extractions are well known. These extractions have over the years often been taken as a model in the clinical testing of analgesics, steroids, antibiotics, general anesthetics, and sedatives[13]. When extracting a third molar, problems may arise both during and after the surgical intervention[14]. The extraction of a partially or fully formed third molar is an invasive surgical operation which traumatizes the dento-alveolar tissue and also the physiological condition of the patient. Pain, hemorrhage, swelling, trismus, infections, alveolar ostitis, nerve damage, and destruction of the tooth supporting tissues are the usual complications associated with third molar extractions. Opening of the sinuses, displacement of fractured roots and fracture of tuber/mandible may also happen, however, less frequently[1,11,15–17].

Hicks et al.[18], oppose the extraction of the asymptomatic, painless impacted third molars, in part because of the well-known lack of information on the pathology of third molars.

Although some authors[8] believe that third molars do not have a significant role within the entire orofacial system, and even recommend germectomy or that erupted, those teeth should be preemptively extracted, there are ongoing changes in the research of their general importance. Since for prosthetic, orthodontic, or some other reasons it is sometimes necessary to preserve the third molars, an endodontic treatment is often required on exactly those teeth[8,19]. Endodontic treatment of third molars is often difficult because those teeth are less accessible and their endodontic anatomy is unpredictable and prone to variations, regardless of the outer appearance of the crown, which may be absolutely normal. It is therefore the aim of the present research to investigate the endodontic space of third molars and variations in shape in terms of the appearance of the root canals, all done *in vitro*. Not only will this further improve our knowledge on the morphology of the endodontic spaces of third molars in the population in the Republic of Croatia, but it will thereby contribute to the success and reliability of the clinical treatment of same.

Materials and Methods

The research was performed on 106 extracted intact human third molars (56 maxillary and 50 mandibular). All teeth used in the research have been previously extracted for orthodontic or periodontal reasons (degree 4 mobility). All teeth had pertained to people living in the Republic of Croatia. Following the extraction, the teeth were rinsed under hot water and cleansed from blood remnants by immersion into 3% hydrogene solution and consequently stored in 2.5% Na-hypochlorite solution.

Immediately prior to the treatment the teeth were disinfected with 70% alcohol and dried. Trepanation of the pulp chamber was performed in a way similar to that applied in standard clinical treatments. The roof of the pulp chamber was opened with a steel bur. After the bottom of the pulp chamber became visible, together with the entrances to the root-canals, the root-canals were injected with methylene blue solution and treated with the No 15 Kerr file (Kerr Dental Manufacturing Co. Orange, CA, USA), or a thinner one where needed. The Kerr file was then fixed by glass-ionomer cement (Fuji Plus, GC, Japan) at the entrance of the root canal. Subsequently, each canal was cut by a rotating diamond polishing disc. The root was separated at the upper end of the Kerr file. Where needed, the remaining dentin was removed with a fissure steel bur. Finally, the canals were died using a very fine brush in order to emphasize the root canals, and the color surplus was removed by sand paper.

On each tooth the number of roots, appearance of the root (fused or independent), number and type of root-canals, curvature of the root-canals (curved, straight, or a combination curved and straight), as well as the presence of lateral or accessory canals was recorded. The length of the root canals was measured in millimeters. The physical length was measured with electronic apex locator and a Kerr file, measuring the distance from the entrance to the root canal to the apical foramen.

Results

Number of roots

The number of roots in the upper third molars ranged between 1 and 4, where the lower third molars had either one or two roots. Most of the upper third molars examined had three roots (47/56; 83.9%), followed by single-rooted ones (5/56; 8.9%) and those with two roots (3/56; 5.4%); only one upper third molar in the entire sample was found to have four roots (1/56; 1.8%).

The lower third molars were, in most cases, single-rooted (28/50; 56.0%), whereas in 22 cases double roots were found (22/50; 44.0%).

Appearance of roots

The upper third molars examined had in 66.1% of cases (37/56) independent roots, whereas in the remaining 33.9% of cases (19/56) the roots were fused.

In the lower jaw, all third molars (50/50; 100.0%) had independent roots. The Fischer exact test showed a statistically significant difference with respect to the appearance of the roots between the upper and the lower third molars ($p<0.001$).

Number of root canals

The number of canals in the upper third molars ranged between 1 and 4. In the upper third molars, three root-canals (mesiobuccal, distobuccal and palatinal canals) were found in 75.1% of cases (42/56). Two canals (buccal and palatinal) were found in 7.1% of cases (4/56).

TABLE 1
DISTRIBUTION OF THE UPPER THIRD MOLARS WITH RESPECT TO THE STRUCTURE OF THE ROOT-CANALS

Root-canals	Number of teeth	%
MB+DB+P	42	75.0
2MB+DB+P	5	8.9
B+P	4	7.1
single-root	4	7.1
MB+DB+2P	1	1.9
Total	56	100.0

MB – mesiobuccal root-canal; DB – distobuccal root-canal; P – palatinal root-canal; B – buccal root-canal

TABLE 2
DISTRIBUTION OF THE LOWER THIRD MOLARS WITH RESPECT TO THE STRUCTURE OF THE ROOT-CANALS

Root-canals	Number of teeth	%
M+D	45	90.0
MB+ML+D	3	6.0
Single-root	2	4.0
Total	50	100.0

M – mesial root-canal; D – distal root-canal; MB – mesiobuccal root-canal; ML – mesiolingual root-canal

Same percentage (7.1%) referred to the single-canal teeth (4/56). Finally, in 10.7% of cases (6/56) four root-canals were found in the combinations as follows: two mesiobuccal canals, one distobuccal and one palatinal canal; two palatinal canals, one mesiobuccal and one distobuccal canal. Table 1 shows the distribution of the upper third molars with respect to the structure of the root-canals.

The number of root-canals in the lower third molars varied between one and three. Most frequently, lower third molars had two root canals (45/50; 90.0%), one mesial and one distal. In 6.0% of cases (3/50) three canals were found (mesiobuccal, mesiolingual, and distal canal), whereas in 4.0% of cases (2/50) only one root-canal was found. Table 2 shows the distribution of the lower third molars with respect to the structure of the root-canals.

Curvature of the root-canals

In the upper jaw, the most frequent were the third molars having all their canals curved (34/56; 60.7%), followed by molars with only straight canals (13/56; 23.2%), and finally and least frequently, the teeth having a combination of the two shapes, i.e. having some of their canals curved, and some straight (9/56; 16.1%).

Likewise, the lower-jaw third molars had, most frequently, all their root-canal curved (42/50; 84.0%). However, the number of the molars with only straight canals is lower than that in the upper jaw, being as low as 16.0% (8/50). Not a single lower third molar was found to have a curved-and-straight combination of the canal shape. Generally, (the upper and the lower third molars combined), the most frequently found are the curved canals, followed by the straight canals, and the least frequently those having a curved and a straight canal on the same tooth.

Presence of the lateral and accessory canals

In the upper third molars, the lateral and accessory canals were found in 12.5% of cases (7/56), whereas in the lower third molars it was so in as few as 4.0% of cases (2/50). The Fischer exact test showed no statistically significant difference with respect to the incidence of the lateral and accessory canals between the upper and the loser third molars ($p<0.167$).

Length of the root-canals in third molars

Table 3 shows a descriptive statistics for the lengths of the root-canals in the upper-jaw third molars. In those upper third molars having three root-canals (a mesiobuccal, a distobuccal, and a palatinal), the longest in average has been the palatinal one (18.7±0.2 mm), and the shortest the distobuccal one (17.3±0.2 mm). If a tooth had two buccal canals, the additional canal would be the shortest (12.8±0.8 mm). In the case of a tooth with only one canal, the measurement showed it was the longest of all (19.5±0.6 mm).

TABLE 3
LENGTHS OF THE ROOT-CANALS IN THE UPPER-JAW THIRD MOLARS

	Root-canals					
	MB	MB (the second one)	DB	P	B	Single-root
Total number of root-canals measured	48	5	48	52	4	4
Mean values (mm)	18.0	12.8	17.3	18.7	19.3	19.5
Margin of error	0.3	0.8	0.2	0.2	0.9	0.6
Minimum (mm)	12.0	11.0	12.0	14.0	17.0	18.0
Maximum (mm)	21.0	15.0	20.0	21.5	21.0	21.0

MB – mesiobuccal root-canal; DB – distobuccal root-canal; P – palatinal root-canal; B – buccal root-canal

TABLE 4
DESCRIPTIVE STATISTICS FOR THE LENGTHS (IN MILLIMETERS) OF THE ROOT-CANALS IN THE LOWER-JAW THIRD MOLARS

	Root-canals				
	M	MB	ML	D	Single-root
Total number of root-canals measured	45	3	3	48	2
Mean values (mm)	18.9	18.0	17.8	18.6	20.0
Margin of error	0.2	0.6	0.4	0.2	1.0
Minimum (mm)	13.0	17.0	17.0	13.0	19.0
Maximum (mm)	22.0	19.0	19.0	22.0	21.0

M – mesial root-canal; MB – mesiobuccal root-canal; ML – mesiolingual root-canal; D – distal root-canal

By using the Student t-test, the differences in length between the mesiobuccal, distobuccal and palatinal root-canals of the upper third molars were compared (other root canals were not taken into consideration because of their small total number in the sample). The test showed statistically significant differences ($p<0.05$) in the length of the root canals, namely the mesiobuccal (18.0±0.3 mm) and the distobuccal (17.3±0.2 mm) being statistically remarkably shorter than the palatinal (18.7±0.2 mm) ones.

Table 4 shows a descriptive statistics for the lengths of the root-canals in the lower third molars. The Student t-test showed that in the lower third molars the mesial root-canals, although just very slightly, were statistically longer than the distal ones (18.9±0.2 mm vs. 18.6±0.2 mm; $p<0.05$).

Discussion

It is evident from the results obtained here that maxillary third molars have 1–4 roots. Sidow et al. found, on a sample of 150 upper third molars originating from the general North American population, one root in 15.0%, two roots in 32.0%, three roots in 45.0%, and four roots in the remaining 7.0% of cases[20]. Guerisoli et al. on a 155-piece general South American population upper third molar sample, found one to five roots, with an apparent prevalence of the 3-rooted specimens[21]. Alavi et al., working on a sample of 151 upper third molars gathered from the general Thai population, found three roots in 51% of cases, the remaining 49% being either coalescent, or having only one root[22, 23]. Although the incidence of 3-rooted third molars varies greatly (45% to 83.9%), we are still inclined to conclude that maxillary third molars show a certain amount of similarity to the first and the second maxillary molars[24] that are known to have, in the greatest percentage of cases, three roots[25, 26].

In the present research, 56.0% of mandibular third molars had one root, and the remaining 44.0% had two roots. Sidow et al. on the sample consisting of 150 pieces of North-American-population mandibular third molars found one root in 17%, two roots in 77%, but also three roots in 5%, and even four roots in 1% of the cases[20]. Guerisoli et al. found that the most frequent are the lower third molars with two roots (69.34%), but they also reported occurrence of three roots[21]. Gulabivala et al., based on a sample of 58 lower third molars from Burma (now Myanmar), reported about two roots in 68%, coalescent roots in 20%, and one root in the remaining 11% of cases[27]. If we compare the number of roots in the mandibular third molars with the number of roots in first and the second mandibular molars[25,26,28,29], we can confirm that in the most cases all these teeth have two roots, but also that third molars showed the greatest variation and irregularity.

In the present research, most maxillary molars had three root canals, followed by the group with four canals and the group with one or two root canals with a combined percentage of 7.1%. If we compare our findings with published data, it becomes evident that Guerisoli et al.[21] most frequently found three root canals (67.8%), then four (14.2%), and even five canals in 1.9% of the maxillary third molars investigated. In 75% of cases a mesiobuccal, a distobuccal and a palatinal root-canals were found in the maxillary third molars. Two mesiobuccal ones, and a distobuccal and a palatinal root-canals were found in 9% of cases. Only one buccal and one palatinal were found in 7%, whereas, in the equal percentage of 7%, only one root was found in the maxillary third molars. Sidow et al. report that the number of root canals in maxillary third molars vary from one to six. The teeth with one root have shown the most peculiar morphology of the endodontic space[20]. Pecora et al. found the maxillary third molars in the South American population to have three root canals in 68% and four root canals in the remaining 32% of cases[30]. Alavi et al. have established a great variability in terms of the number of root canals in the maxillary third molars[23]. The greatest percentage obtained, otherwise comparable to other research, was that referring to the three-root-canal maxillary third molars, was 54% of cases, whereas the four-root-canal maxillary third molars did vary in the literature from 56% to over 85%[25,26,29]. In the mandibular third molars, however, in the present research, in 90% of cases, two root canals (one mesially and one distally) were found; three root-canals (a mesiobuccal, a mesiolingual, and a distal) were found in 6%, and one root-canal only in 4% of cases. Guerisoli et al. reported that most of the teeth had two root canals (69.3% of cases), warning about very frequent anatomic variations[21]. Same authors also found that lower third molar more often had three roots than one root. Two canals were found in 40% of the cases of single-rooted teeth, while teeth with two roots had very variable morphology, the number of canals ranging from 1 to 6. The authors reported the so-called C-shape canal in 2.2% of the cases. Gulabivala et al. found in 61% of cases of mandibular third molars two root canals; 11% of them had the C-shape[27]. Similarly, Šutalo et al. found the C-shape in 11% cases of mandibular second molars[31]. Curved canals were found in 76.8% of examined teeth, the remaining canals were straight. Blašković-Šubat et al. reported following percentages of the curvature of root canals in upper third molars: 68% of palatinal roots, 50% of bucomesial roots, and 37% of buccodistal roots[32]. Compared with first and second maxillary molars, the following curvature presence is found: for the maxillary first molars (palatinal canals – 57%, mesiobuccal – 79%, and distobuccal – 45%) and the maxillary second molars (palatinal – 37%, mesiobuccal – 54%, and distobuccal – 17%)[29].

Curved root canals were found in 84% of the lower third molars. Blašković-Šubat et al. found the curvature in 65% of the mesial roots and 80% of the distal roots[32]. Comparably, the curvature was present in 84% of the mesial canals of the first mandibular molars and 26% of the distal canals. Martić et al. found the deviation frequency in 60.25% of lower permanent incisors[33].

In our research, lateral and accessory canals were found in 12.5% of maxillary third molars. Alavi et al. reported 16% for all groups of maxillary molars (first, second and third)[23]. Additionally, Ingle also found lateral and accessory canals in first and second maxillary molars[29].

Lateral and accessory canals were found in only 2% of lower molars, although Walton and Vertucci claim that the frequency of accessory canals is higher in posterior teeth[26]. Gulabivala et al. did not find any lateral or accessory canals in mandibular third molars[27]. Ingle repoed lesser percentage of lateral or accessory canals[29], and Martić et al. found accessory canals in 33.33% of the lower permanent incisor[33].

The average measured length of root canals of maxillary third molars was 18.0 mm (range 12.0 – 21.0 mm). Having analyzed the individual roots, we have found the palatinal canal to be the longest when three canals were present (buccomesial (18.0 mm), buccodistal (17.3 mm), and palatinal (18.6 mm)). In cases with only two canals, the buccal canal was longer (19.25 mm). Guerisoli et al. found the average lengths for the maxillary third molars to be 19.1 mm for the buccomesial canal, 17.8 mm for the buccodistal, and 19.5 mm for the palatinal one[21]. Finally, in teeth with only one root, measured length was in average 18.6 mm. The lengths of the root canals in the first maxillary molars were: buccomesial 19.9 mm, buccodistal 19.9 mm, and palatinal 20.6 mm. In the second maxillary molars, those values were: buccomesial 20.2 mm, buccodistal 19.4 mm, and palatinal 20.6 mm[29]. Hence, the average length of the canals in the third maxillary molars is comparable with the length of first and second maxillary molars' canals. The average length of the root canals in the mandibular third molars was 18.9 mm, (range 13.0 – 22.0 mm). The average length of the mesial root-canal was 18.9 mm and that of the distal was in average 18.6 mm. Guerisoli et al. reported the average length of the mesial root canal to be 19 mm, and distal one 18.6 mm[21]. One-rooted teeth had the average length of 18.7 mm. The average length of both mesial and distal canals in the first mandibular molars was 20.9 mm, while in second mandibular molars it was 20.9 mm for the mesial canals and 20.8 mm for the distal ones.

Conclusion

The information on the endodontic space of third molars surely contributes to its better use in the reconstructive dentistry, prosthodontics and orthodontics. Due to certain differences specific to populations, of which most are dimensions as well as morphological characteristics in general, as well as their endodontic spaces, further research should be encouraged in order to identify the population and/or national specific features in the morphology of this group of teeth. This would be a welcome contribution to an enhanced level of success of the specifically endodontic and general dental treatments and *ipso facto* a good road to the reduction of expenses in obtaining the oral health destroyed due to inadequate or unsuccessful treatments.

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IN VITRO MORFOLOŠKO ISTRAŽIVANJE ENDODONTSKOG PROSTORA TREĆIH KUTNJAKA

S A Ž E T A K

Svrha ovog rada je utvrđivanje anatomskih osobitosti endodontskog prostora gornjih i donjih trećih kutnjaka u hrvatskoj populaciji. Obrađeno je ukupno 106 potpuno razvijenih trećih kutnjaka od čega 56 gornjih i 50 donjih. Analiziran je broj korijenova i korijenskih kanala, njihova struktura, zakrivljenost i ukupna dužina. U najvećem broju slučajeva gornji treći kutnjaci su imali tri korijena (83,9%) dok su donji treći kutnjaci uglavnom bili jednokorijenski (50,6%). Gornji treći kutnjaci su uglavnom imali tri korijenska kanala (75,1%), a donji dva (90,0%). U obje čeljusti, najčešći su bili treći kutnjaci sa zakrivljenim kanalima (60,7% u gornjoj i 84,0% u donjoj čeljusti). Kod gornjih trećih kutnjaka su bočni i akcesorni kanali pronađeni u 12,5% slučajeva, a kod donjih u 4,0% slučajeva. Studentov t-test je pokazao statistički značajnu razliku ($p<0,05$) u dužini korijenskih kanala, pri čemu su meziobukalni i distobukalni kanali bili statistički značajno kraći nepčanih kanala. Osim toga, test je pokazao da su kod donjih trećih kutnjaka, mezijalni korijenski kanali, neznatno, ali statistički značajno duži od distalnih. Dobiveni rezultati su u skladu sa rezultatima istraživanja drugih autora, međutim postoji tendencija određenih populacijski specifičnih značajaki.