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ASSESSMENT OF POSTOPERATIVE MORBIDITY AND ROOT MIGRATION IN APPLICATION OF THE METHOD OF CORONECTOMY

ПРОЦЕНКА НА ПОСТОПЕРАТИВЕН МОРБИДИТЕТ И КОРЕНСКА МИГРАЦИЈА ПРИ ПРИМЕНА НА МЕТОДОТ НА КОРОНЕКТОМИЈА

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Abstract

Background: Extraction of the impacted mandibular third molar represents a complicated surgical intervention due to the position of the inferior alveolar nerve and is often accompanied by postoperative neurosensory deficit. The risk of changing sensitivity is significantly lower when performing coronectomy, as a technique for conventional surgical extraction and prevention of potential neuropathy. **Aim:** The presented paper focuses on the importance of using coronectomy as an alternative surgical technique, due to its demonstrated efficacy in cases with high risk of nerve injury, in order to achieve good clinical results and minimize possible sudden complications. **Materials and methods:** The research sample includes a total of 30 patients who were diagnosed with presence of an impacted mandibular third molar in close relation to the mandibular canal, according to the clinical examination and radiological evaluation using cone beam computed tomography (CBCT) and conventional radiography. The sample is divided into two groups: control group (15 patients) in which a conventional operative extraction of an impacted lower third molar will be performed, and the other experimental group (15 patients) where the method of coronectomy was performed. **Results:** The mean follow-up time was 12 months for the experimental group of patients (where coronectomy was performed), and a mean root migration of 2.52±0.46 was observed. Regarding the postoperative complications, one patient with IAN injury and paresthesia was observed in the control group, which disappeared within one month, while in the group of coronectomy none of the patients have been diagnosed with this injury. For $p>0.05$, no significant differences were determined between two groups, regarding swelling. While for $p<0.05$, pain intensity in patients in control group was significantly higher compared to the patients in experimental group. **Conclusion:** Coronectomy can be considered a safe treatment alternative for patients who demonstrate elevated risk for injury to the inferior alveolar nerve with removal of the third molars. Coronectomy does not increase the incidence of damage to the inferior alveolar nerve and would be safer than complete extraction in situations in which the root of the mandibular third molar overlaps or is in close proximity to the mandibular canal. **Key words:** coronectomy, impaction, mandibular third molar, inferior alveolar nerve, CBCT.

Апстракт

Вовед: Екстракцијата на импактиран мандибуларен трет молар претставува комплицирана хируршка интервенција поради положбата на долниот алвеоларен нерв и често е придружена со постоперативен неуросензитивен дефицит. Ризикот од промена на чувствителноста на нервот е значително помал при изведување на коронектомија, како техника за конвенционална хируршка екстракција и спречување на потенцијална неуропатија.**Цел:** Презентираниот труд се фокусира на предноста на спроведување на коронектомија како алтернативна хируршка техника, поради нејзината покажана ефикасност во случаи со висок ризик од повреда на нервот, со цел да се постигнат добри клинички резултати и да се минимизираат можните ненадејни компликации.**Материјал и метод:** Истражувачкиот примерок вклучува вкупно 30 пациенти на кои им е дијагностицирано присуство на импактиран мандибуларен трет молар во блиска кореација со мандибуларниот канал, според клиничкиот преглед и радиолошката евалуација со помош на компјутерска томографија со конусен зрак (CBCT) и конвенционална радиографија. Примерокот е поделен во две групи: контролна група (15 пациенти) во која се реализира конвенционална оперативна екстракција на импактиран мандибуларен трет молар и другата експериментална група (15 пациенти) каде е спроведена методата на коронектомија. **Резултати:** Просечното време на следење беше 12 месеци за експерименталната група на пациенти (каде беше реализирана коронектомија), а беше регистрирана просечна вредност на миграција на коренот од 2,52±0,46. Во однос на постоперативните компликации, во контролната група е регистриран еден пациент со повреда на долен алвеоларен нерв и парестезија, која исчезнала во рок од еден месец, додека во групата на коронектомија на ниту еден од пациентите не им била дијагностицирана оваа повреда. За $p>0,05$ не беа утврдени значајни разлики помеѓу две групи за отокот. Додека за $p<0,05$, интензитетот на болката кај пациентите во контролната група беше значително повисок во споредба со пациентите во експерименталната група. **Заклучок:** Коронектомија може да се смета за безбедна алтернатива за третман за пациенти кои покажуваат зголемен ризик за повреда на долниот алвеоларен нерв при екстракција на третиот мандибуларен молар. Коронектомијата не ја зголеми инциденцата на оштетување на долниот алвеоларен нерв и би била побезбедна метода од целосната екстракција на забот, во ситуации во кои коренитe на третиот мандибуларен молар се во непосредна близина со мандибуларниот канал. **Клучни зборови:** коронектомија, импакција, мандибуларен трет молар, долен алвеоларен нерв, CBCT.

Introduction

Impacted teeth are fully formed in the jawbone but have not yet erupted in their place, or anywhere else on the dental arch, due to disruption of the eruptive process. The impaction of third mandibular molars is followed by the appearance of pathological conditions, with different degrees of severity. Therefore, this imposes the need for a radical therapeutic approach, i.e. their surgical extraction.

The most common and severe complications of third molar extraction surgery include dry socket, postoperative infection, alveolar bone fracture, damage of inferior alveolar nerve or lingual nerve and, in rare cases, mandibular fracture. Therefore, intentional coronectomy is a well-established technique where the root/roots of the wisdom tooth are left in situ and only the crown is sectioned and removed (odontectomy). This technique was proposed by Knuttson K.[1] in 1989, as an alternative method for preserving the inferior alveolar nerve (IAN). The method aims to remove only the crown of the tooth, leaving the root intact in the alveolus in situ, Leung Y. et al.[2] This procedure has been proven to be effective at reducing the risk of mandibular third molar surgery, but it has its own complications[3]. According to Rezai F. et al.[4] the disadvantages of this technique include: creation of deep periodontal pockets on the distal surface of the second molar, migration of the root with the eventual need for a second surgical procedure (reoperation), occurrence of alveolitis, local postoperative wound infection, postoperative pain, accidental removal of the root, which may increase the risk of injury to the contents of the mandibular canal.

By applying certain radiological modalities, the ratio of the root complex of the impacted tooth and the mandibular bone canal are precisely detected. CBCT is used in implantology, oral and maxillofacial surgery, orthodontics, endodontics. CBCT is an appropriate method in the case when the ratio of the roots of the impacted mandibular third molar with the contents of the mandibular canal, as well as other adjacent anatomical structures, needs to be visualized in a three-dimensional view[5,6].

Material and methods

The research sample in our study includes a total of 30 patients who were diagnosed with an impacted mandibular third molar in close proximity to the mandibular canal, according to the clinical examination and the radiological evaluation using cone beam computed tomography (CBCT) and conventional orthopantomography. Based on the American Society of Anesthesiologists criteria, our patients belong to the following group: ASA I (normal, healthy patients) and ASA II (patients with moderate systemic disease, such as: smokers, pregnant women, obesity (30<BMI (body mass index)<40), moderate lung disease)[7]. The sample was divided into two groups: one group (15 patients) where the method of coronectomy was applied, and the other control group (15 patients) in which a conventional operative extraction of an impacted lower third molar was performed. All the procedures were performed by the same surgeon using the same approach. For CBCT and conventional orthopantomogram imaging, CS 8100 3D was used, imaging was performed in the radiographic cabinet “Mintas", Tetovo. (Figure 1 and Figure 2).

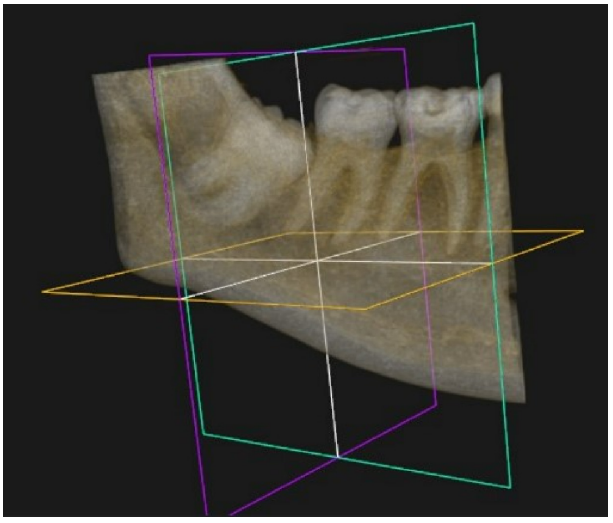


Figure 1. *CBCT of impacted molar 48*

Figure 2. *CBCT of impacted molar 48*

The planned therapeutic procedure is implemented following the basic surgical principles in relation to the conventional surgical extraction and the coronectomy method, i.e. surgical principles for work in soft and bony tissue. Regarding the surgical technique of coronectomy we follow the steps below: to achieve a painless area, a local block anesthesia is applied for n.alveolaris inferior, n.lingualis and n.buccalis, with 2% mepivacaine hydrochloride with 1:20000 levonordefrin; then a full thickness mucoperiosteal incision is elevated with a buccal release; a conservative buccal trough is created using a round carbide bur on a surgical handpiece to allow access to the cementoenamel junction of the tooth; we take care to maintain as much crestal bone height as possible by minimising the width of the buccal trough; after exposing the teeth, a round carbide bur is used to make a 45^{o} cut through the tooth at the level of the cementoenamel junction; the crown is delicately fractured and separated from the residual roots of the tooth; the remaining enamel is typically reduced approximately 2 mm below the buccal crest of the alveolar bone; the surgical wound is closed primarily (Figure 3, Figure 4, Figure 5 and Figure 6). Patients were subject to clinical and radiological evaluation in an observation period of 6 and 12 months following the surgical intervention.

Figure 3. *Elevation of mucoperiostal lambo*

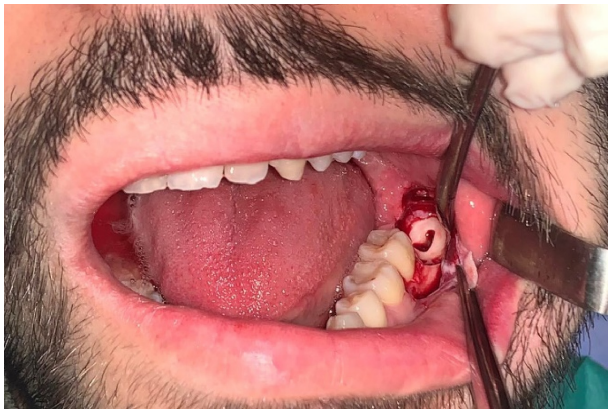


Figure 4. *Sectioning of the crown*

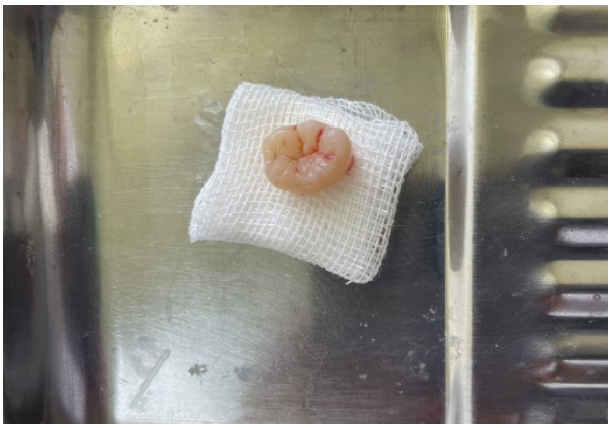


Figure 5. *Full crown removal*

Figure 6. *Surgical wound closed primarly*

Exclusion criteria from the study:

- Horizontally placed impacted mandibular third molar (along the direction of extension of the mandibular canal) where there is a high risk of injury to the inferior alveolar nerve during tooth separation.
- Acute infection present in the oral cavity or in the close area of the tooth - subject to coronectomy.

Early postoperative observation of the patients includes a control examination on the first, third and seventh day after the surgical intervention. The subject of analysis is the clinical expression of postoperative morbidity, with special emphasis on the IAN injury, intensity of postoperative pain (VAS scale), and assessment of postoperative swelling (facial reference points).

Pain assessment – will be realized through a horizontal VAS scale to determine the intensity of pain from 1 to 10 by the patient on the first, third and seventh day postoperatively Kaczmarzyk T. et al.[8] (figure 7).

Assessment of swelling – measuring the distance of certain points in the face, tragus (point A), labial commissure (point C), pogonion (point D), lateral angle of

the eye (point B) and angle of the mandible (point E), with flexible splint on the first, third and seventh day postoperatively, Essam Ahmed Al-Moraissi et al.[9] (figure 8)

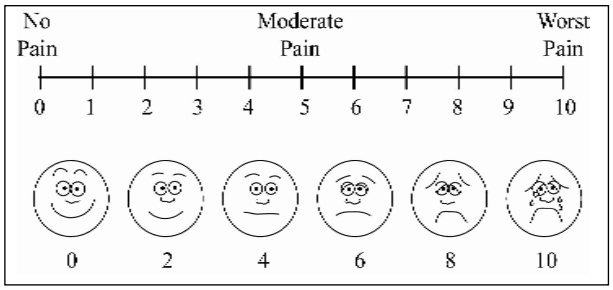


Figure 7. *VAS scale – intensity of pain*

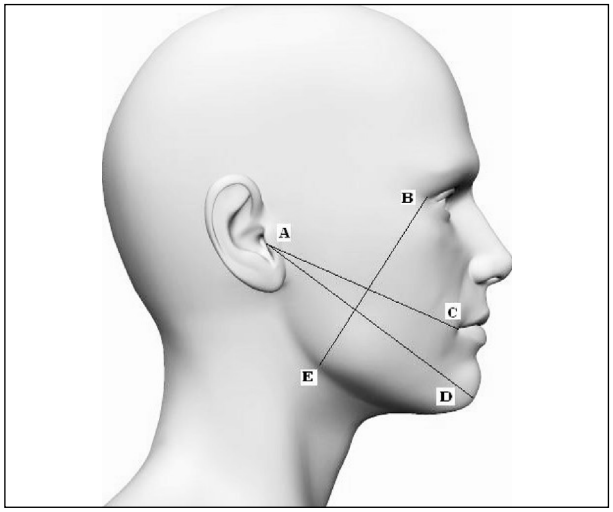


Figure 8. *Facial reference points for swelling measurement*

The radiographic analysis of root migration in patients who have undergone coronectomy was performed on the 6-th and 12-th month-period after the intervention (Figure 9 and Figure 10).

Figure 9. *Immediately after coronectomy*

Figure 10. *Root migration after 12 months*

Statistical analysis

The data obtained during the research were statistically processed using the SPSS software package, version 22.0 for Windows (SPSS, Chicago, IL, USA). The analysis of the attributive (qualitative) series was done by determining the coefficient of relationships, proportions and ratios, and they were shown as absolute and relative numbers. Numerical (quantitative) series were analyzed using measures of central tendency (average, median, minimum values, maximum values), as well as measures of dispersion (standard deviation). Shapiro-Wilk W test was used to determine the normality of the frequency distribution of the studied variables. The Wilcoxon Signed Ranks Test was used to test the significance of the difference between two dependent parameters with irregular frequency distribution. The Mann-Whitney U Test was used to determine a statistically significant difference between two independent quantitative parameters with irregular frequency distribution. A two-tailed analysis with a significance level of $p<0.05$ was used to determine statistical significance.

Results

Data of post-operative complications of the group with conventional extraction of the third mandibular molar, and from a 12 month follow-up period of patients with impacted mandibular third molar treated with coronectomy technique were collected. The assessment and evaluation of all cases were done by the same surgeon who performed the operation. Each patient was reviewed, and information on postoperative complications, such as pain, swelling, IAN injury and migration of the root was collected.

The distribution of the Experimental Group (EG), from 15 (100%) patients, according to gender, indicated the presence of 5 (33.33%) males and 10 (66.67%) females with a

Table 1. Analysis of groups according to gender

Groups	Gender			1p
	EG	CG	Total	
Male	5 (33,33%)	8 (53,33%)	15 (50%)	X^2=1,221; df=1; p=0,2691
MaleFemale	10 (66,67%)	7 (46,67%)	15 (50%)	

EG=Experimental Group; CG=Control Group; [1]Pearson Chi-square test; *significant for p<0,05

Table 2. Analysis of groups by age (years)

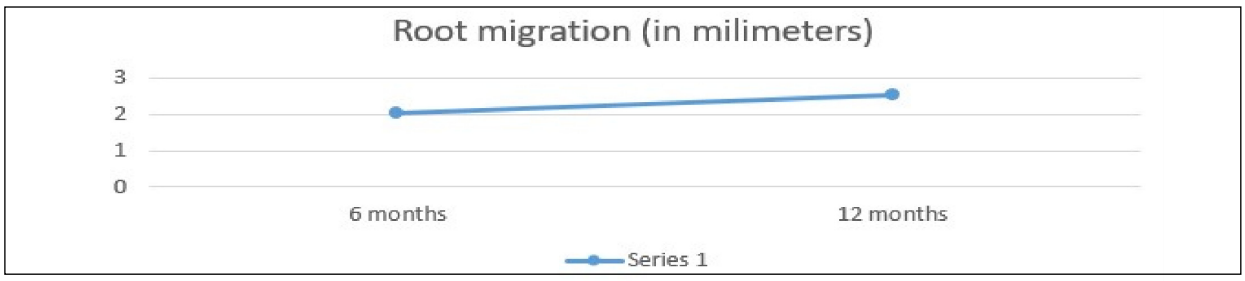
Age (years)		Statistic	Std. Error	95% Confidence Interval for Mean	
				Lower	Upper
Experimental Group (EG)	**Total**				
	Number (N)	15	1.32	24.17	29.83
	Mean ±SD	27,01±5,11			
	Min/ Max	19/36			
	Median (IQR)	28 (22-30)			
Control Group (CG)	**Total**				
	Number (N)	15	1.25	23.65	29.01
	Mean ±SD	26,33±4,83			
	Min/ Max	19/34			
	Median (IQR)	6 (22-31)			

EG/CG: Mann-Whitney U Test: Z=0,269; p=0,7875
*significant for p<0,05

gender ratio of 0.5:1. In the Control Group (CG), out of 15 (100%) male patients were 8 (53.33%), and 7 (46.67%) female patients with a gender ratio of 1.1:1. For p>0.05, no significant association was determined between gender and the group to which the respondents belong for the consequent Pearson Chi-square test: X2=1.221; df = 1; p=0.2691 (Table 1).

The mean age of EG patients was 27.01±5.11 [95% CI (24.2–29.3)] years with a min/max age of 19/36 years (Table 2). The analysis indicated that 50% of respondents in the EG were younger than 28 years for Median (IQR)=28 (22-30). Among CG subjects, the mean age was 26.33±4.83 [95% CI (23.6 – 29.0)] years, with a min/max age of 19/34, and 50% of subjects younger than 26 years for Median (IQR)=26 (22-31). The analysis indicated that for p>0.05, there was no significant difference between the patients of the two groups in terms of age (Mann-Whitney U Test Z=0.269; p=0.7875).

Root migration was evaluated by comparing the original root position with that after 6 and 12 months. The analysis of migration in the experimental group indicated that after 6 months its average value was 2.03±0.38mm, and after 12 months it was 2.52±0.46mm (Graph.1). For p<0.05, a significant difference was determined between the two points in time (6 and 12 months), regarding the migration in the EG, in addition to a significantly higher value after 12 months (Wilcoxon Matched Pairs Test: Z=3.407; p=0.0006)



Graph 1. *Average root migration in 6 months and 12 months after the surgery*

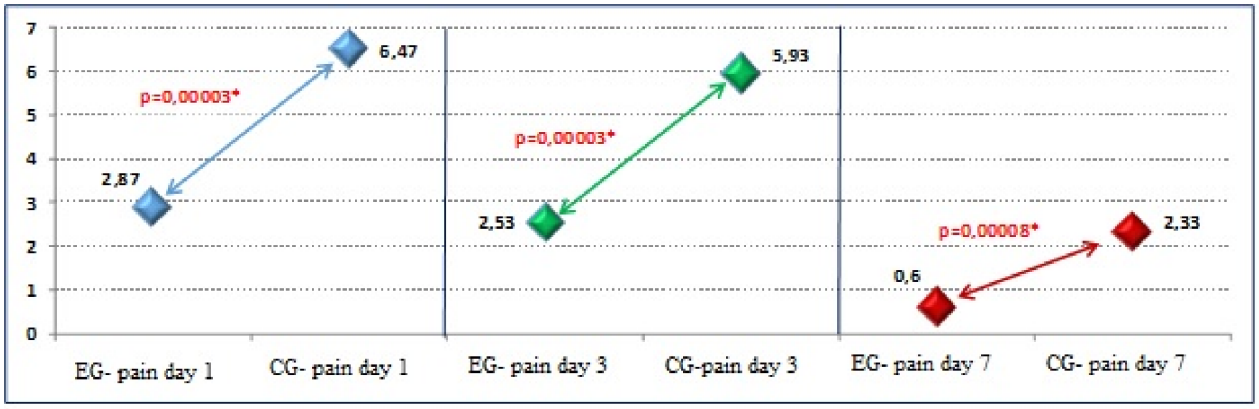
The average pain of the patients was evaluated on a scale from 1 to 10. The analysis indicated that for (Table 3 and Graph 2):

- **day 1** - the average pain intensity was as follows: a) EG -2.87±0.91 with a min/max intensity of ¼, and 50% of patients in whom the pain was greater than 3 for Median (IQR)= 3 (2-4); and in b) CG -6.47±1.3 with a min/max intensity of 5/9, and 50% of patients in whom the pain was greater than 6 for Median (IQR)=6 (5-8); For p<0.05, pain intensity in patients in CG was significantly higher compared to the same in patients in EG (Mann-Whitney U Test: Z=-4.655; p=0.00003).
- **day 3** - the average pain intensity was as follows: a) EG - 2.53±0.74 with a min/max intensity of ¼, and 50% of patients in whom the pain was less than 3 for Median (IQR)= 3 (2-4); and in b) CG – 5.93±1.0 with a min/max intensity of 5/8, and 50% of patients whose pain was less than 6 for Median (IQR)=6 (5-7); For p<0.05, pain intensity in patients in CG was significantly higher compared to the same in patients in EG (Mann-Whitney U Test: Z=-4.666; p=0.00003).
- **day 7** - the average pain intensity was as follows: a) EG – 0.60±0.51 with a min/max intensity of 0/1, and 50% of patients in whom the pain was less than 1 for Median (IQR)=1(0-1); and in, b) KG -2.33±1.0 with a min/max intensity of ¼, and 50% of patients whose pain was less than 2 for Median (IQR)=2 (1-3); For p<0.05, pain intensity in patients in CG was significantly higher compared to the same in patients in EG (Mann-Whitney U Test: Z=-3.919; p=0.00003).

Table 3. Comparison of groups according to pain for three periods

Pain	Number (N)	Mean	Standard Deviation (SD)	Min	Max	Median IQR	1p
Pain day 1							
EG	15	2.87	0.91	1	4	3 (2-4)	Z=-4.655; **p=0.00003***
CG	15	6.47	1.30	5	9	6 (5-8)	
Pain day 3							
EG	15	2.53	0.74	1	4	3(2-3)	Z=-4.666; **p=0.00003***
CG	15	5.93	1.03	5	8	6(5-7)	
Pain day 7							
EG	15	0.60	0.51	0	1	1(0-1)	Z=-3.919; **p=0.00008***
CG	15	2.33	1.04	1	4	2(1-3)	

EG=Experimental group; CG=Control group; [1]Z=Mann-Whitney U Test;
*significant for p<0,05

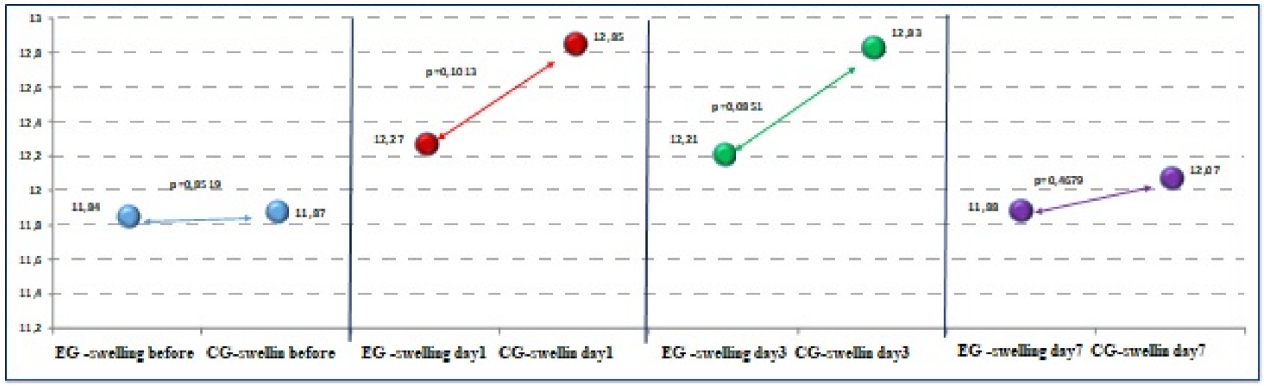


Graph 2. *Comparison of groups according to pain for three periods*

Table 4. Comparison of groups according to swelling for four periods

Swelling	Number (N)	Mean	Standard Deviation (SD)	Min	Max	Median IQR	1p
Swelling before operation (cm)							
EG	15	11.84	1.01	10.5	13.1	11.9 (10.7-12.9)	Z=-0.187; p=0.8519
CG	15	11.87	1.06	10.3	13.3	12.2 (10.8-12.9)	
Swelling day 1 (cm)							
EG	15	12.27	1.07	10.8	13.5	12.7 (11.1-13.3)	Z=-1.638; p=0.1013
CG	15	12.85	1.10	11.0	14.1	13.1 (11.9-13.9)	
Swelling day 3 (cm)							
EG	15	12.21	1.03	10.8	13.5	12.4 (11.1-13.2)	Z=-1.721; p=0.0851
CG	15	12.83	1.10	11.2	14.1	12.9 (11.9-13.9)	
Swelling day 7 (cm)							
EG	15	11.88	1.01	10.5	13.1	12.0 (10.8-12.9)	Z=-0.726; p=0.4679
CG	15	12.07	1.06	10.5	13.5	12.4 (11.0-13.1)	

EG=Experimental group; CG=Control group; [1]Z=Mann-Whitney U Test;
*significant for p<0,05



Graph 3. *Comparison of groups according to swelling for four periods*

The comparison of the size of the swelling between EG and CG indicated that in none of the four analysed periods (before surgery, on day 1, day 3, and day 7), for p>0.05, no significant difference was determined between the two groups. The analysis shows that in each of the three analysed periods after surgery (day 1, day 3, and day 7) the size of the swelling in the EG was insignificantly smaller compared to the one in CG (Table 4 and Graph 2).

Discussion

Coronectomy is a reasonable alternative procedure for reducing the risk of inferior alveolar nerve injury when the lower third molar roots are in close proximity to the IAN. Our finding is compatible with the conclusion of Geisler S.[10], Long H.[11], Monaco G.[12] and Quek Sl.[13] who consider coronectomy a safe treatment for patients who demonstrate an elevated risk of IAN injury with the removal of third molars.

Agbaje et al.[14] found out that the incidence of impacted mandibular third molar with close proximity to the IAN in this series was slightly higher in females, with a male to female ratio of 1:1.3. Similar to Agbaje, the result for the gender ratio in our study was 0.5:1 which shows a higher incidence of impacted third mandibular molars with close proximity to the IAN in females compared to males.

The reduction in the incidence of injury to the inferior alveolar nerve, found in our study, is in agreement with Renton et al.[14]. His results show that coronectomy preserves the damage of inferior alveolar nerve. The surgical skill of the operator has been indicated to be one of the main risk factors for developing permanent sensory dysfunction in the distribution of the IAN after coronectomy, Jerjes W. et al[15], Bataineh AB[16].

After coronectomy and complete mandibular third molar extraction, except IAN injury, morbidity includes pain. The comparison of pain between the experimental and the control group in the first, third and seventh day after surgery, based on VAS measurement, show significantly lower pain intensity in patients with performed coronectomy, the difference is 1:2. Leung Y. and Cheung L.[2] registered more patients with pain after complete removal of impacted third molar than after coronectomy. The studies are not homogeneous about pain, because some authors like Hatano Y.[21], Cilasun U.[22], reported increased pain in patients who underwent coronectomy versus complete extraction.

Our study aimed to determine the migration of the remaining roots after coronectomy. We obtained radiography analysis 6 and 12 months after the coronectomy, to observe whether root migration or inflammatory changes have occurred. In the studies of Gady J[17], Patel V.[18] migration of the roots has been reported as the most common situation for a long-term follow up of patients after coronectomy. This situation is confirmed by our findings too (Graph.1). We found out that analysis of root migration in experimental group indicated an average value of 2.03±0.38 mm after 6 months, and 2.52±0.46 mm after 12 months. We registered that the greatest migration occurred 6 months after coronectomy compared to the radiography analysis after 12 month follow-up. Our results are similar to Simons RN.[23] where the mean root migration was 2.53 mm 6 months after coronectomy .

We found out that the migration of the remaining roots was affected by the impaction depth and migration pattern, while it was not affected by gender, as mentioned above. Radiography analysis of our study showed that deeper impaction was associated with new bone forming above the cut surface, followed by less migration. Our finding correlates with Yan et al[24], Kouwenberg et al[25] who found that impaction depth affected root migration. Regarding migration pattern, an important moment, according to Hanisch M. et al.,[20] is that the migration mechanism is based on the removal of mechanical interferences along the eruption path.

According to these studies, our opinion is that a 12 month follow-up is sufficient for evaluating root migration and deciding whether a root removal is necessary in order to avoid extensive surgery.

Conclusions

The results indicate that coronectomy can be a safe treatment alternative for patients who show elevated risk for injury to the inferior alveolar nerve with removal of the mandibular third molar. Coronectomy, as a surgical technique, has fewer complications compared to complete extraction, in situations where the roots of the mandibular third molars are in close proximity to the mandibular canal.

References

1. 1. Knutsson K., Lysell L., Rohlin M.: Postoperative status after partial removal of the mandibular third molar, Swed Dent J;13:15-2, 1989
2. Leung Y.Y., BDS, MDS, and Cheung L.k., BDS, PhD :Coronectomy of the Lower Third Molar Is Safe Within the First 3 Years, American Association of Oral and Maxillofacial Surgeons J Oral Maxillofac Surg 70:1515-1522, 2012
3. Saverio Cosola, Young Sam Kim, Young Min Park, Enrica Giammarinaro and Ugo Covani, Coronectomy of Mandibular Third Molar: Four Years of Follow-Up of 130 Cases , 27 November 2020, Medicina 2020, 56, 654; doi:10.3390/medicina56120654
4. Rezaei F, Imani MM, Khavid A, Nabavi A. Patterns of mandibular third molar impaction in an Iranian subpopulation. Pesqui Bras OdontopediatriaClínIntegr. 20:e5411; 2020
5. Juodzbalys G, Daugela P. Mandibular third molar impaction: Review of literature and a proposal of a classification. J Oral Maxillofac Res 2013;4:e1
6. Vinay Kumar K, Maloth K, Ashwini P, Moni T, Rushira N, Kesidi S. Objectivity and reliability of panoramic radiographic signs and cone-beam computed tomography in the assessment of a superimposed relationship between the impacted mandibular third molars and mandibular nerve: A comparative study. J Indian Acad Oral MaxillofacRadiol 2017;29:100-5
7. ASA Physical Status Classification System Committee of Oversight: Economics (Approved by the ASA House of Delegates on October 15, 2014, and last amended on December 13, 2020)
8. Kaczmarzyk T, Wichlinski J, Stypulkowska J, Zaleska M, Woron J. Preemptive effect of ketoprofen on postoperative pain following third molar surgery. A prospective, randomized, double-blinded clinical trial. Int J Oral Maxillofac Surg 2010;39:647-52
9. Essam Ahmed Al-Moraissi, Elham Aziz Al-Zendani and Abeer Mohammed Al-Selwi: Efficacy of Submucosal Injection of Chymotrypsin, Oral Serratiopeptidase or Oral Dexamethasone in Reducing Postoperative Complications Following Impacted Lower Third Molar Surgery: A Prospective, Randomized, Double-Blind, Controlled Clinical Trial, Frontiers in Oral Health, Vol.1, Article number 575176, December 2020
10. Geisler S. Coronectomy is an effective strategy for treating impacted third molars in close proximity to the inferior alveolar nerve. J Am Dent Assoc. 2013 Oct;144(10):1172-3.
11. Long H, Zhou Y, Liao L, Pyakurel U, Wang Y, Lai W. Coronectomy vs. total removal for third molar extraction:a systematic review. J Dent Res. 2012 Jul;91(7):659-65.
12. Monaco G, de Santis G, Gatto MR, Corinaldesi G, Marchetti C.

Coronectomy: a surgical option for impacted third molars in close proximity to the inferior alveolar nerve. J Am Dent Assoc. 2012 Apr;143(4):363-9.
13. Quek SL, Tay CK, Tay KH, Toh SL, Lim KC. Pattern of third molar impaction in a Singapore Chinese population: a retrospective radiographic survey. Int J Oral Maxillofac Surg. 2003 Oct;32(5):548-52
14. Agbaje JO, Heijsters G, Salem AS, Van Slycke S, Schepers S, Politis C, Vrielinck L. ,Coronectomy of Deeply Impacted Lower Third Molar: Incidence of Outcomes and Complications after One Year Follow-Up, JOURNAL OF ORAL & MAXILLOFACIAL RESEARCH, 30 June 2015
15. Renton T, Hankins M, Sproate C, McGurk M. A randomised controlled clinical trial to compare the incidence of injury to the inferior alveolar nerve as a result of coronectomy and removal of mandibular third molars. Br J Oral Maxillofac Surg. 2005 Feb;43(1):7-12.
16. Jerjes W, Upile T, Shah P, Nhembe F, Gudka D, Kafas P, McCarthy E, Abbas S, Patel S, Hamdoon Z, Abiola J, Vourvachis M, Kalkani M, Al-Khawalde M, Leeson R, Banu B, Rob J, El-Maaytah M, Hopper C. Risk factors associated with injury to the inferior alveolar and lingual nerves following third molar surgery-revisited. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2010 Mar;109(3):335-45.
17. Bataineh AB. Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg. 2001 Sep;59(9):1012-7
18. Hatano Y, Kurita K, Kuroiwa Y, Yuasa H, Ariji E. Clinical evaluations of coronectomy (intentional partial odontectomy) for mandibular third molars using dental computed tomography: a case-control study. J Oral Maxillofac Surg. 2009
19. Cilasun U, Yildirim T, Guzeldemir E, Pektas ZO. Coronectomy in patients with high risk of inferior alveolar nerve injury diagnosed by computed tomography. J Oral Maxillofac Surg. 2011
20. Gady J, Fletcher MC. Coronectomy: indications, outcomes, and description of technique. Atlas Oral Maxillofac Surg Clin North Am. 2013 Sep;21(2):221-6
21. Patel V, Gleeson CF, Kwok J, Sproat C. Coronectomy practice. Paper 2: complications and long term management.Br J Oral Maxillofac Surg. 2013 Jun;51(4):347-52
22. Simons RN, Tuk JG, Ho JTF, Su N, Lindeboom JA. Early root migration after a mandibular third molar coronectomy. Oral Maxillofac Surg. 2023
23. Yan ZY, Wang F, Yan XY, Ge N, Guo CB, Liu K, Cui NH, Three-dimensional assessment of root migration and rotation patterns after coronectomy: bone-embedded roots versus soft tissuecovered roots. Int J Oral Maxillofac Surg 50:699–706, 2021
24. Kouwenberg AJ, Stroy LPP, Vree- vdRijt ED, Mensink G, Gooris PJJ, Coronectomy of the mandibular third molar: Respect for the inferior alveolar nerve. J Cranio-Maxillofacial Surg 44: 616-621, 2016
25. Hanisch, M., Hanisch, L., Kleinheinz, J. et al. Primary failure of eruption (PFE): a systematic review. Head Face Med 14, 5 (2018).