ORIGINAL PAPER

THE EFFECTIVENESS OF LIMITED FLAP DESIGN IN SURGICAL REMOVAL OF FULLY IMPACTED LOWER THIRD MOLARS: A COMPARATIVE CLINICAL STUDY

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ABSTRACT

Introduction: Surgical removal of impacted lower wisdom teeth is one of the most commonly performed procedures in oral and maxillofacial surgery.

Objectives: This study aimed to compare the operative and post-operative outcomes of 2 flap designs (limited vs. extended 2-sided flap) in surgical extractions of lower third molars (M3) regarding fully impacted teeth.

Material and methods: A prospective, randomized, controlled split-mouth trial was designed, and included 27 patients with bilateral (symmetrically positioned) impacted M3. Limited 2-sided flap was performed on one side (group 1) and extended 2-sided flap on the other side (group 2). The effect of flap design on intra-operative (visibility, accessibility, and duration of surgery) and post-operative sequelae (pain, trismus, swelling, alveolar osteitis, and wound dehiscence) were analyzed at different post-operative days. Any associated complications or side effects were also recorded.

Results: Regarding pain, no significant differences were observed between the two groups ($p > 0.05$). Trismus and facial swelling were significantly greater in the extended flap group in the early post-operative period ($p < 0.05$). Pain, trismus, and swelling were significantly correlated with operation time in both the groups ($p < 0.01$). Wound dehiscence occurred only in 3 cases in group 2.

Conclusions: Surgical and post-surgical outcomes obtained from the group 1 flap design are superior to the other group. The study findings indicated that trismus and swelling (not the pain) were significantly affected by the flap design.

Key words: flap design, impacted lower third molar, triangular flap, post-operative morbidity.

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INTRODUCTION

Surgical extraction of impacted mandibular third molars is frequently indicated. It is one of the most commonly performed procedures in oral and maxillofacial surgery unit, either for prophylactic or therapeutic purposes. It requires a flap to be raised, with a possibility of bone removal and tooth sectioning [1]. This procedure is often associated with intra-operative and/or post-operative complications, including bleeding, dry socket, pain, trismus, swelling, and infection, which are typically transient in nature [2]. These morbidities still pose a major problem for patients and surgeons [3]. Therefore, reducing these complications may have a great impact on enhancing patient outcome [4].

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Incision techniques used in M3 surgery and reflection of the muco-periosteal flap usually affect the frequency and intensity of post-operative complications [5]. Consequently, many surgical approaches with various flap designs have been suggested to minimize these problems [1, 3, 6-24].

OBJECTIVES

The aim of this study was to compare two flap designs, such as the limited and extended 2-sided flaps, regarding the surgical outcomes and their effect on post-operative sequelae after surgical removal of fully impacted M3. The study mainly focused on answering the following question: Is it reliable to surgically remove a completely impeded mandibular third molars with multiple roots at different depth patterns (various difficulties) using a limited flap design?

MATERIAL AND METHODS

STUDY DESIGN

A comparative, randomized, split-mouth study was conducted in oral and maxillofacial surgery unit. All methods were carried out according to human ethical principles of the Declaration of Helsinki and its' later amendments, and in compliance with consolidated standards of reporting trials (CONSORT) statement. Sample size was determined using G Power software (version 3.1.9.4). Inclusion criteria were any patient with a clinical indication for surgical removal of bilateral (symmetrically positioned for reliable comparison), fully impacted, and multi-rooted M3 with comparable angulation and surgical difficulty (identified clinically and radiographically). Any case with limited mouth opening, local infection or pathology (cyst/ tumor) at the site of surgery, a radiographic sign of inferior alveolar nerve (IAN) involvement, partially erupted and/ or single-rooted tooth were excluded from the study. A detailed flow diagram representing study participants is briefly illustrated in Figure 1.

A panoramic radiography with cone-beam computed tomography were obtained for all patients pre-operatively to assess the position (angulation) and depth of impacted M3, the presence of any pathology, and to exclude the possibility of IAN involvement. A written medical history was applied to ensure good medical health of the subjects and that they were fit for surgery. Prior to treatment, all patients were informed about the operation and possible complications, and then they had signed an informed consent regarding their approval for procedure. The side of operation (left/right) and flap design were randomly assigned into 2 groups by generating an arbitrary list (computer-based randomization), using a website software program. In group 1, a limited 2-sided (triangular) flap was performed, while group 2, underwent surgery using extended triangular flap. Facial measurements and maximum inter-incisal opening were recorded pre-operatively. All treatments were conducted by a single well-experienced specialist surgeon with more than 15 years of experience; the evaluation and subsequent follow-up for pain, facial swelling, and trismus were assessed by other author who was blinded to surgical technique (flap design) used. Institutional review board (research ethics committee) had approved the protocol of this clinical study, with a reference No. of 339121.

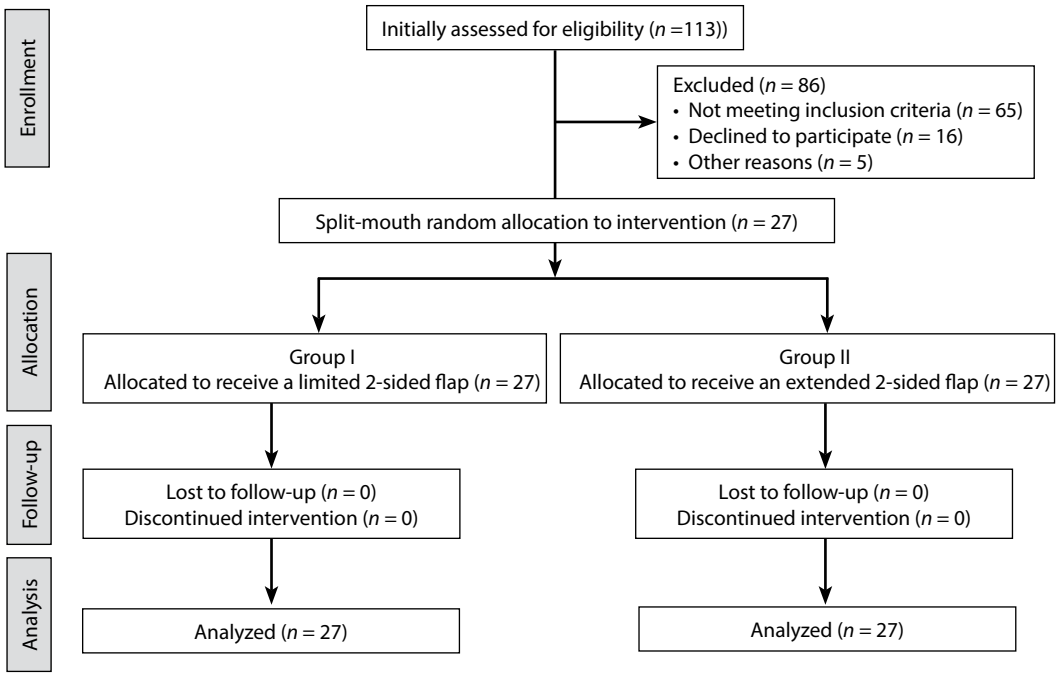

FIGURE 1. Flow diagram showing the participants of the study sample for both the groups

FLAPS DESIGN AND SURGICAL TECHNIQUE

All procedures were achieved following a standardized surgical protocol. One experienced and well-trained surgeon performed all treatments. Prior to surgery, patients were instructed to rinse their mouth with a diluted povidone iodine solution for 30 seconds. The local anesthetic used in all surgical procedures was 2% lidocaine hydrochloride with 1 : 100,000 adrenalin (Septodont, France). All operations started after securing a profound anesthesia. The impacted teeth for each patient were removed in two sessions, using the two different flap designs; the time interval between the two operations (sides) was at least 1 month.

In group 1, the limited 2-sided flap incision started in the ascending mandibular ramus, and then continued (descending) along the crest of the ridge over the impacted M3 till the distobuccal corner of the adjacent lower second molar (M2), followed by an oblique vertical (vestibular) incision that involved the papilla (Figure 2). Regarding group 2, the incision started in the same manner as in group 1, then it extended as a sulcular incision from the distobuccal corner of M2 to the distobuccal corner of the first mandibular molar (M1), followed by an oblique vestibular incision involving the papilla (Figure 3).

Reflection of a lingual flap was not attempted in both groups; gentle lingual reflection was done to expose the crown of the impacted tooth and/or the bone occlusally. After raising a full muco-periosteal flap and exposing the surgical site, a proper surgical round bur was used under copious irrigation with sterile saline for bone removal buccal to impacted M3. Distal and/or occlusal bone removal was also carried out as needed. Tooth sectioning with a fissure bur was performed one or more times as necessary. When the impacted tooth with the dental follicle remnants were completely removed, the socket was thoroughly irrigated, then the flap was approximated and sutured using 3/0 non-absorbable black silk (Dysilk; Dynek Pty Ltd., Hendon, Australia). Primary wound closure was achieved in all cases; two to three sutures were placed coronally in the limited flap group, whereas an additional suture was inserted distally to M1 in the extended flap group. Perpendicular incision was not sutured in both groups. The same antibiotics and analgesia were prescribed, and all patients were strictly informed to rinse with 0.12% chlorhexidine mouthwash and to maintain good oral hygiene post-operatively. Then, they were reviewed on days 2, 7, and 14 after surgery. The patients were followed-up until complete recovery of any abnormal sign and/or symptom. Suture removal was done after 1 week.

DATA COLLECTION AND STATISTICAL ANALYSIS

The studied variables included age, gender, visibility and accessibility at the surgical field, operative time

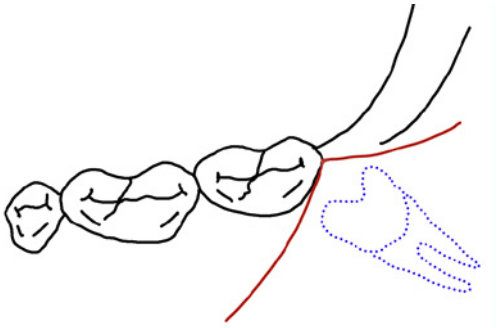

FIGURE 2. Limited 2-sided flap design (red line)

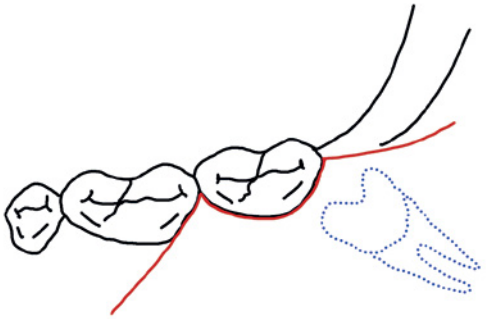

FIGURE 3. Extended 2-sided flap design (red line)

measured from flap incision till conclusion of suturing, alveolar osteitis (dry socket), pain, trismus, swelling, and wound dehiscence. The patients rated pain intensity in the morning of the first 7 days post-operatively using a visual analog scale (VAS) calibrated from 0 to an upper limit of 10 (0 = no pain, 1-3 = mild pain, 4-6 = moderate pain, 7-9 = severe pain, and 10 = worst pain). Trismus (degree of limitation in mouth opening) was evaluated by measuring the maximum inter-incisal distance (in millimeters) between the upper and lower central incisors using a standard rigid ruler [3]; two readings were recorded and the average (mean) value was taken.

Facial measurements were recorded by graduated tape (in millimeters). Distance from the corner of the mouth to the earlobe attachment represented the horizontal measurement (A), while the distance from the outer canthus (lateral corner) of the eye to the angle of the mandible represented the vertical measurement (B). Facial measurement was calculated as: (A + B)/2. Facial swelling (%) was calculated as [3]: [(post-operative measurement – pre-operative measurement)/ pre-operative measurement] × 100. Relationship between the duration of surgery and post-operative sequelae (pain, trismus, and swelling) was assessed on post-operative days 2 and 7. Wound dehiscence (gaping along the incision line) was measured in the 7th post-operative day; patients that had dehiscence were followed until complete healing. Any associated complication during surgery and/or an abnormal sign or symptom after surgery was also assessed and recorded.

The results were statistically analyzed using SPSS release 24.0 for Windows (SPSS Inc., Chicago, IL, USA).

Descriptive statistics were calculated for the study sample. Differences between groups were detected by Mann-Whitney *U*-test, χ^2 test, and independent sample *t*-test. Pearson's correlation coefficient (*r*) test was applied to assess the statistical relationship between two variables. Probability level was considered significant if *p*-value was ≤ 0.05.

RESULTS

Fifty-four lower third molars from 27 patients were surgically extracted in this study; 8 males and 19 females with age range between 18 and 33 years, and a mean age of 23.22 ± 4.14 years were enrolled. Bone removal was performed in all cases; teeth were sectioned in 38 cases (70.4%) of the study sample. The mean operative time was 20.6 ± 5.4 min for the limited flap group (group 1), and 22.1 ± 6.1 min for the extended flap group (group 2), although the difference was not statistically significant between the 2 groups ($p = 0.34$). Regarding the angulation and depth, different patterns of impaction were included (Table 1).

TABLE 1. Descriptive statistics regarding angulation and depth of impacted M3s in relation with operative time for each study group

Impaction pattern		*n* (%)	Operative time min (mean ± SD)	
			Group I	Group II
Angulation†				
	Mesioangular	14 (51.9)	19.0 ± 5.3	20.1 ± 5.9
	Distoangular	5 (18.5)	21.8 ± 4.3	23.5 ± 4.6
	Vertical	3 (11.1)	25.0 ± 6.2	27.6 ± 6.6
	Horizontal	5 (18.5)	21.0 ± 5.7	22.2 ± 6.1
	Aberrant	0 (0)	0	0
	Total	27 (100)		
Depth‡				
	A	6 (22.2)	15.8 ± 2.8	16.5 ± 3.0
	B	13 (48.2)	18.7 ± 3.0	20.2 ± 3.4
	C	8 (29.6)	27.1 ± 3.6	29.3 ± 4.0
	Total	27 (100)		

†Winter classification; ‡Pell and Gregory classification.

Concerning severity of pain, no significant differences were observed on the first 7 post-operative days (Table 2). Comparison between mean VAS scores of the two groups showed similar results (Table 3). Statistically, there was no significant difference ($p = 0.13$) between the 2 groups regarding the pre-operative inter-incisal measurements (group 1: mean = 41.31 ± 1.96; group 2: mean = 42.07 ± 1.69). The extended flap design resulted in a greater reduction in maximum inter-incisal mouth opening, which was significantly observed on post-operative days 2 ($p = 0.02$) and 14 ($p = 0.001$) (Table 4).

Table 5 shows the results of comparison between the two flap designs with respect to post-operative facial swelling. Significant difference in the mean percentage of swelling was observed on post-operative day 2 only ($p = 0.01$). The extended flap design resulted in greater post-operative facial swelling; the differences on days 7 and 14 were not significant. Pearson's correlation coefficient analysis showed a significant correlation between duration of surgery and pain, trismus, and swelling on days 2 and 7 in both the groups ($p < 0.01$).

All impacted M3s were successfully extracted without any complication during surgery; the visibility and accessibility were adequate for teeth removal in both the groups. Wound dehiscence occurred in 3 cases (11%) of group 2.

TABLE 2. Comparison between the 2 groups regarding severity of pain on the first 7 days after surgery

Postoperative day	Group	Postoperative pain (N)				*P*-value[a]
		None	Mild	Moderate	Severe	
1	I	2	9	12	4	0.71[ns]
	II	2	11	8	6	
2	I	2	10	12	3	0.95[ns]
	II	2	11	10	4	
3	I	4	13	8	2	0.98[ns]
	II	3	13	9	2	
5	I	4	14	8	1	0.34[ns]
	II	5	9	13	0	
5	I	6	14	7	0	0.82[ns]
	II	8	13	6	0	
6	I	7	15	5	0	0.37[ns]
	II	11	10	6	0	
7	I	14	7	6	0	0.19[ns]
	II	13	12	2	0	

[a]Using χ^2 test. ns – non-significant

TABLE 3. Comparison between the 2 groups regarding score of pain (VAS) on the first 7 days after surgery

Postoperative day	VAS (mean ± SD)		*P*-value[a]
	Group I	Group II	
1	3.74 ± 2.41	3.52 ± 2.39	0.72ns
2	3.52 ± 2.19	3.48 ± 2.44	0.93ns
3	2.89 ± 2.08	2.85 ± 2.16	0.91ns
4	2.48 ± 2.08	2.37 ± 1.69	0.96ns
5	1.96 ± 1.79	1.81 ± 1.57	0.80ns
6	1.59 ± 1.45	1.44 ± 1.65	0.53ns
7	1.15 ± 1.61	0.89 ± 1.15	0.98ns

[a]*Using Mann-Whitney U-test; VAS – visual analog scale, ns – non-significant*

Alveolar osteitis or post-operative infection was not observed in either flap group. Regarding post-operative complications, one patient in the limited flap group experienced bleeding from the extraction site on the second post-operative day. Neuro-sensory disturbances of the lingual or IAN were not reported in this study.

TABLE 4. Comparison between the 2 groups regarding post-operative limitation in mouth opening at 2, 7, and 14 days after surgery

Postoperative day	Maximum inter-incisal opening mm (mean ± SD)		*P*-value[a]
	Group I	Group II	
2	25.81 ± 3.59	23.81 ± 2.09	0.02*
7	32.09 ± 3.20	31.06 ± 2.31	0.21[ns]
14	38.96 ± 1.80	36.94 ± 2.28	0.001**

[a]*Using independent sample t-test; *significant; **highly significant; ns – non-significant*

TABLE 5. Comparison between the 2 groups regarding mean swelling (%) at 2, 7, and 14 days after surgery

Postoperative day	Percentage facial swelling (mean ± SD)		*P*-value[a]
	Group I	Group II	
2	4.98 ± 3.53	6.87 ± 4.37	0.01*
7	1.95 ± 1.61	2.53 ± 2.07	0.23[ns]
14	0.42 ± 0.54	0.54 ± 0.72	0.87[ns]

[a] *Using Mann-Whitney U-test; *significant; ns – non-significant*

DISCUSSION

It is beneficial in any surgery that a flap design provides good access to the surgical field without compromising adjacent vital structures as well as associated with minimal complications. Up to date, there is still no consensus whether or not the flap design applied in M3 surgery affects the post-operative period. Majority of previous studies had compared between different flap designs and envelope flap regarding post-operative morbidities in the surgical removal of impacted M3 [6-8, 10-13, 15-23, 25, 26]. However, this flap has been reported to be associated with several complications and side effects, such as sever post-operative pain [6, 19], significant swelling [15], more periodontal difficulties [13, 16], greater percentage of wound dehiscence [11, 18], infection [6], and higher incidence of alveolar osteitis [12, 15, 26]. Furthermore, primary closure of the wound was not allowed in most of the cases [12]. As a result, the envelope flap was not planned to be performed in this study.

It is well-known that the angulation and depth of impacted M3 would highly affect the surgical difficulty and post-operative outcomes. Several studies have evaluated the effect of different flap designs on just selected patterns and depths of impaction [9, 10, 13, 15, 16, 18, 23]. The current study compared the intra-operative and post-operative outcomes of two different flap designs in the surgical removal of multi-rooted and fully impacted (unerupted) M3, including different patterns (angulations) and depths (A, B, and C), as shown in Table 1. To our knowledge, such comparison with similar variables has not been studied in the literature.

It is supposed that the extended triangular flap provides more surgical access, easier reflection, efficient surgical handling by the operator, lesser operative time, and better healing, as its' vertical incision lies completely on sound bone away from the surgical site. Nevertheless, the study results revealed no important difference between the two groups regarding the mean operative times; the extended flap group surgeries reported higher time of duration than the limited flap group. Concerning angulations and depths, the extended flap group resulted in higher operative times in all patterns of impaction compared with the other group, with the highest scores reported in vertical and type C impaction for both the groups (Table 1). This may be due to an additional suture required with the extended triangular flap rather than the impaction pattern, and in some cases, the difficulty of inserting the needle between tightly contacted M1 and M2 was time-consuming. These results contrast with those of Mobilio *et al.* [17], who affirmed that more extended flap achieving a better surgical view may potentially reduce the time necessary for the intervention. Another interesting observation in the current study is wound healing. It was uneventful at the last follow-up time in both flaps, although part of the vertical incision in group 1 lied on or near the socket.

Previous investigations have shown variable results regarding the effect of flap design on post-operative sequelae (pain, facial swelling, and trismus) [3, 6, 8, 10, 12, 14, 15, 19, 23, 26] and recovery [7, 9, 11, 13, 18, 20-22] following surgical removal of impacted M3. We disagree with few studies [17, 25] that indicated the insignificant

effect of flap design on the severity of post-operative signs and symptoms. When compared to the extended triangular flap group, the limited flap group exhibited comparable severity of pain with higher mean VAS scores, although they were statistically not significant (Tables 2 and 3); inferior reduction in maximum inter-incisal mouth opening, which was significant on post-operative days 2 and 14 (Table 4); and lesser post-operative facial swelling that was significant on post-operative day 2 only (Table 5). These findings indicated that trismus and swelling, and not the pain, were significantly affected by the flap design. This could be explained due to the fact that pain is subjective in nature and more complex to be evaluated than trismus and swelling, which can be objectively assessed. Furthermore, pain is considered to be influenced by other factors; the inner characteristics of a patient (pain expectation or pain tolerance) may play a role in subjective symptoms, such as pain [27].

There is no consensus in the literature about the relationship between duration of surgery and post-operative morbidities after M3 surgery. Baqain *et al.* [7] observed no significant correlation between operative time and post-operative swelling on days 2, 7, and 14. Mobilio *et al.* [17] found no association between duration of surgery and post-operative pain, trismus, and swelling at 7-day interval. Our results are inconsistent with these findings, as there was a strong correlation between the time of operation and post-surgical pain, trismus, and swelling on days 2 and 7 in both the groups. The longer the time of surgery, the more the tissue trauma, and consequently, the higher inflammatory response.

Wound dehiscence after M3 surgery may cause long-standing pain and usually extends post-operative treatment period [18]. In the present study, wound dehiscence occurred in 3 cases (11%) of group 2 on day 7, while group 1 did not report such complication. This gaping is usually presented at the distobuccal gingival rim of M2, where the distal vertical incision leads into the sulcular incision, involving the papilla between M1 and M2. Nearby outcomes were observed by Koyuncu *et al.* [14], who recorded wound dehiscence in 11.1% and 8.3% of patients in a 3-cornered (2-sided) and a modified triangular flaps, respectively. Our results contrast with those of Yolcu and Acar [3], who reported a high percentage (68%) of dehiscence at the buccally-based triangular flap on day 7. Upon analysis, more post-operative facial swelling was observed in the extended flap group compared with the limited group, and the difference was significant during early post-surgical period (day 2; Table 5). Such greater amount of hematoma may increase soft tissue tension during the first few post-operative days and compromise the sutures (rupture of the wound margins) [11], especially in the area between the M1 and M2, where it was very difficult, in some cases, to be performed, particularly with the presence of delicate lingual gingiva (i.e., tearing at the lingual part of the suture). On the contrary, this problem did not occur with the limited triangular flap cases. Interestingly, these were left to heal by secondary intension (without suturing), and all of them closed completely after 7-14 days.

Prophylactic antibiotics with or without steroids, and non-steroidal anti-inflammatory drugs were prescribed through different routes (oral/parenteral) for patients prior to surgical procedure of impacted M3 to decrease the incidence of wound infection and relieve post-operative morbidities [6, 7, 10, 12, 20]. However, these drugs were not taken in the majority of studies [1, 3, 8, 9, 11, 13-19, 21-23]. Our results were consistent with the later protocol, where alveolar osteitis or post-operative infection were not observed in either flap group, although the patients did not receive any medication before surgeries. This indicates that prophylactic antibiotics may have no role in post-operative infections after M3 operations. This finding was supported by the fact that infection, manifested as suppuration or dry socket, was reported in previous studies, in which antibiotics were prescribed prior to surgeries [6, 12].

Operative hemorrhage [28], post-operative ecchymosis [25], and fever [16] are possible complications in the impacted M3 surgery. In the present study, all impacted M3s were successfully extracted without any complication during operation. In the limited flap group, one case presented with bleeding from the extraction site on the second post-operative day. The history revealed that the patient did not follow post-operative instructions properly, and was managed effectively without any side effects. Similar observation was reported by Sandhu *et al.* [6] in the bayonet flap group.

Even though sensory impairment of the lingual nerve after surgical removal of impacted M3 is a rare complication, the incidence of nerve damage shows variability among different clinical studies [28-33]. Bataineh [34] reported a highly significant increase in the incidence of post-operative lingual nerve paresthesia associated with raising of a lingual flap. This finding was consistent with our study, in which there was no reflection of the lingual flap, and neuro-sensory disturbances of the lingual nerve did not occur in any case. Similar results were obtained by other studies [1, 3, 8]. Injuries to the IAN following M3 extractions, with either transient or permanent impairment, were also reported in the literature [4, 31-38]. Gülicher and Gerlach [28] recorded mandibular canal breaking in 11.9% (132/1,106) of cases following removal of impacted M3s. Multirooted third molar is one of the main predictors of IAN damage [39]. Other important risk factors for IAN injury include radiographic proximity of the tooth to IAN [31, 38], increasing age (≥ 25 years old), general anesthesia, type of impaction (mesio-angular/horizontal), and surgery performed by staff dentists [32, 36]. In a recent study, Khojastepour *et al.* [40] concluded that the possibility of an intersection of the apex into the inferior alveolar canal was greater in mesio-angular teeth and level C in depth. In the current study, despite that most

of the impaction patterns were mesio-angular (51.9%) and the majority of the impacted teeth (77.8%) were in positions B or C (Table 1); IAN paresthesia or anesthesia was not reported by any patient. This could be attributed to the surgeon's experience that has played a vital role in the surgical maneuvers. We agree with Jerjes *et al.* [31] and others [32-34, 36, 37], who specified that surgical skills/experience of the operator is a significant factor contributing to the development of sensory dysfunction of IAN after impacted M3 surgery.

CONCLUSIONS

The effect of flap design appeared to be more significant on swelling and trismus rather than pain. The limited triangular flap design was superior to the extended type regarding post-operative morbidities. It provided adequate access and visibility for surgical removal of different patterns of impacted M3s. In addition, wound dehiscence was not reported in this flap compared with the extended type. A limited 2-sided buccal flap without reflection of a lingual flap might be considered as the preferred surgical protocol during extraction of impacted M3. Within limitations of this study, further comparative studies with a larger sample size are recommended.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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