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A Surgeon's Dilemma: Evidence Based Selection of Suturing Technique to Minimize Post-Operative Complications Following Lower Third Molar Surgical Extraction

Abstract :

Background : Lower third molar extraction is usually associated with multiple stigmae that deters the patients in most cases to postpone or not seek appropriate surgical care. It is also one of the most feared procedure amongst dentists and dental students. However, evidence has been reported suggesting that the choice of suturing technique can have a profound effect on post-operation complications and thereby can improve the overall outlook and comfort of the patient. In the past, multiple techniques like Mattress, Continuous etc have been compared with tissue glues, staples however, a comparative clinical study amongst the simplest and most commonly used suturing techniques have not been reported.

Material and Methods : Sixty patients with impacted mandibular third molars fulfilled the inclusion criteria and were randomly divided into three groups of 20 each. All patients underwent third molar extraction and sutures were placed using different techniques – Simple Interrupted (Group A), Continuous (Group B) and Figure of eight (Group C). Patients were evaluated pre-operatively as well post-operatively (at different time points) for five parameters - Pain, Swelling, Trismus, Periodontal health of second molar and Wound infection. Kruskal-Wallis (non-parametric ANOVA) with post-hoc and effect size was used for statistical analysis with $P< 0.05$ as statistically significant.

Results : Statistically significant differences were obtained in terms of pain and trismus between Groups A and C post-operatively ($P < 0.05$). There were also significant differences in pain between Groups B and C post-surgery ($P < 0.05$). No significant differences were found between groups for swelling, periodontal health of second molar and wound infection.

Conclusions : Figure of eight suturing presents with better patient outlook and is associated with lower pain, swelling and trismus. Continuous and simple interrupted suturing can be preferred as second-in-line techniques. Final choice of technique shall be made based on wound anatomy, patient history and surgeon's expertise.

Keywords: Mandibular third molar, Post-operative complications, Primary closure, Surgical extraction, Suture

Introduction:

Removal of impacted mandibular third molars (or wisdom teeth), generally considered as a minor surgical procedure, represents one of the most common surgical procedures in oral surgery [1-3]. The term "impaction", since its inception in early 1954 by Mead [4] has undergone many revisions [5-6] but a commonly accepted interpretation accounts impaction as the failure of teeth to reach normal occlusal and functional position following completion of chronological age and two-thirds root formation [3]. Multiple local factors contributing to third molar impaction have been described including crowding, ectopic position of the tooth germ, supernumerary teeth, and soft tissue or bony lesions [7]. Further, since the wisdom teeth are last to erupt, usually erupting between 17 and 21 years of age [8-9], their chances of being impacted are also relatively high [5].

Since the impacted mandibular third molars don't reach its normal functioning position, it is considered as pathology and requires treatment [7,10]. If not removed, the wisdom teeth can cause pain, swelling, and infection, and may destroy adjacent teeth and bone [11]. The surgical removal of diseased and/or symptomatic wisdom teeth alleviates pain and discomfort along with improving oral health

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and function [11]. However, as with any other surgical procedure, the extraction procedure is also associated with varying degree of difficulty and inherent risks of complications [12]. Pain, swelling and trismus represent the most common post-operative tissue mediated sequelae to third molar surgery [3]. These sequelae are directly related to the difficulty factor associated with impacted teeth, age of patient, duration of surgery, expertise of the surgeon and the operative trauma [3].

An important aspect for the success of surgical procedure is the proper closure and stabilization of the wound margins in their desired position [13] for proper wound healing to occur. Disturbed wound healing can have various clinical manifestations like excessive bleeding, formation of granuloma, fistula, ulcers, wound dehiscence, chronic infections, fibrosis, trismus etc. [14-17] Hence, for proper wound management after extraction of impacted lower third molars, primary and secondary closure techniques are commonly used [2]. A wound heals by primary or first intention when socket is covered and sealed hermetically by the mucosal flap and by secondary or second intention when socket remains in communication with the oral cavity [18]. There exists no particular consensus as to which type of healing is better than the other. Primary wound closure is advocated and preferred by authors like Howe, Archer, Giralnick, Krugar etc [19-24]. Although recent studies advocate secondary wound closure to be associated with less post-operative pain and swelling [25-27], the healing process is slower due to delayed epithelial closure and has a higher rate of granulation tissue formation [28-30].

Different suturing techniques for primary closure of wound have been described in literature and used in the clinical practice. However, a comparative analysis has not been reported comparing the suturing techniques after surgical removal of mandibular third molars. Previously, studies were undertaken comparing suture vs suture-less wound closure [31-32], different types of flaps [33-34], different suture knot techniques [35], or comparing sutures with other adhesives like tissue glue [36-37] etc. In the present study, we have hence, compared Simple Interrupted, Continuous and Figure of Eight suturing techniques in terms of pain, swelling, trismus, periodontal health of second molar, and wound infection after lower third molar surgical removal. Further, in the study we have described and provided effect size for each statistical test performed for clinical interpretation of the results whilst paving way for meta-analysis studies. Effect size reporting is also helpful for sample size estimations in future studies.

Material and Methods:

Study Design

The study represents a randomized clinical study which was conducted at the Department of Oral and Maxillofacial Surgery, Maharaja Ganga Singh Dental College and Research Centre, Sri Ganganagar, Rajasthan, India from August 2018 to March 2019. Approval for the study design and methodology was granted by the Institution's Ethical and Scientific Committee. The study complied with the Helsinki Declaration of 1975, as revised in 2008. Patients were briefed about the objectives, terms, and scope of the study. Written as well as oral informed consent were obtained from each patient in the language of their understanding (English, Hindi, Punjabi). The patients were given the option to withdraw from the study at any point without giving any previous declaration or reasons for the same. The data for such patients was removed from the study and destroyed in accordance with the protocol.

Screening of the Patients:

History and intra-oral clinical examination were carried out for all the patients who reported in the department during the study period for surgical intervention of mandibular third molar to determine their eligibility in the study. Standard procedure of visualization of intra-oral periapical radiographs (IOPA) and orthopantomogram (in patients where it was necessary) of the impacted third molar was done for every participant. Routine hematological investigations were also conducted. In total, 73 patients reported in the study period in the department who fulfilled the inclusion criteria as described ahead. Out of 73 patients, 60 patients completed the study. The major reasons cited for non-participation included prior family commitments, inability to afford travel expenses to-from the institute and/or distance from the patient's residence to the institute.

Inclusion Criteria

- All Patients above 18 years of age.
- All Patients who met ASA PS 1 (American Society of Anesthesiologists Physical Status classification system) grading level [38].
- All Patients who met WHARFE's Assessment Index as easy and/or moderate.
- All Patients with good oral hygiene and non-smokers with no to minimum alcohol intake.

Exclusion Criteria

- Patients who didn`t meet the inclusion criteria for ASA PS grading levels 2-6 [38].
- Patients who met WHARFE's Assessment Index as difficult.
- Pregnant and/or lactating women patients.
- Patients with a history of allergy to drugs or anesthetic agents in the surgical protocol.
- Immuno-compromised patients or patients with systemic or bleeding disorders.
- Radiographs showing pathology like cysts, tumors etc.

Grouping of Patients

All 60 patients were assigned into three equal groups of 20 patients each using the envelope method (as shown in Figure 1). Labeled, folded sheets of papers were labelled from 1-60 and placed in an opaque envelope. The patients were then asked to pull out one single sheet of paper. If the patient picked a number from 1-20, the patient was assigned to Group A; number from 21-40 were assigned to Group B and 41-60 to Group C. The patients were instructed not to

share the number with the operating surgeon. A single surgeon performed all mandibular third molar extractions and re-approximated the flap with different suturing techniques. The surgeon was also kept blind to suturing technique for the patient until the time for wound closure to eliminate any bias that may have been introduced in the methodology. The groups were as follow: -

- Group A – Primary closure with Simple Interrupted sutures;
- Group B – Primary closure with Continuous sutures;
- Group C – Primary closure with Figure of Eight sutures.

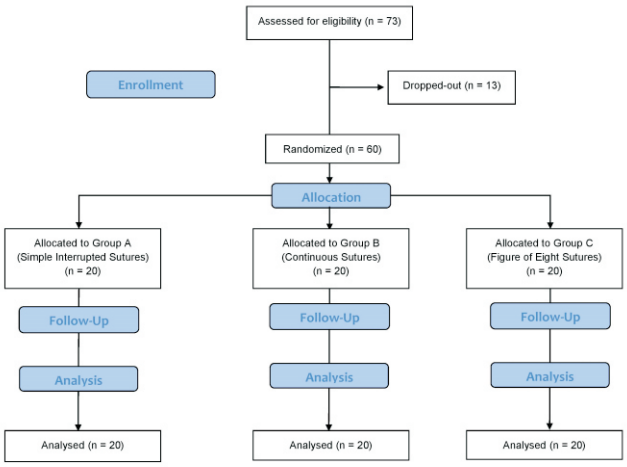


Figure 1. CONSORT flow diagram for the present study.

Parameters Analyzed in the Study:

Patients were educated on each of the following parameters and on how to complete the subjective measurements. Each of the participant was evaluated by the same surgeon pre-, intra-, and post-operatively to maintain one to one communication and avoid confusions. The following parameters were analyzed in the study :-

1) Operation Time: Operation time was defined as the time from administration of local anaesthesia to placement of sutures for each patient. It was measured using a mobile stop watch. The time was measured in minutes.
2) Pain: Degree of pain as felt by an individual was assessed and recorded using the Visual Analogue Scale (VAS). The pain scale used was 10 cm long, with number 0 symbolizing no pain and number 10 symbolizing unbearable worst possible pain. The measurements were recorded pre-operatively, 2 hours and 4 hours post-operatively. Measurements were then taken on 1st, 2nd, and 7th day post-operatively.
3) Facial Swelling: Swelling was measured in terms of facial width (in mm) vertically from lateral outer Canthus to the Gonion/angle of mandible. Horizontally, it was measured from Tragus to Gnathion. Finally, an oblique measurement from Tragus to oral lateral commissure using a flexible measuring tape. The mean of the three measurements for a side was considered as the baseline for that side of the face. The difference between postoperative and preoperative baseline measurements was taken as the amount of facial swelling for the respective postoperative day. The measurements were recorded pre-operatively and on 1st, 2nd, 3rd, and 7th day post-operatively.
4) Mouth Opening (Trismus): Trismus was evaluated as the maximum distance between mesial incisal edges of upper and lower central incisors in the midline with the help of Vernier caliper in millimeters (mm). In case of missing incisors, the edentulous ridge was measured with the frenum of lip as a guide for centrality. The measurements were recorded pre-operatively and on 1st, 2nd, and 7th day post-operatively.
5) Periodontal Health of the second molar: The probing depth of the subject tooth indicated the periodontal health of the second molar. It was measured on the distobuccal surface of second molar as the distance from the free gingival margin to the bottom of the gingival pocket. It was measured using a Williams periodontal probe marked with millimeter markings. The measurements were recorded pre-operatively and in 4th, 8th and 12th week post-operatively.
6) Wound Infection: Infection at the site of wound was checked and confirmed if there was a purulent inflammation and discharge from the wound or if patient presented with fever, lymphadenopathy or persistent swelling or any other infection related signs and symptoms (bad breath, swollen gums etc.) that could not be explained by surgical trauma [39]. The wound was checked pre-operatively as well as on all subsequent visits/follow-ups. The wound infection was assessed as a dichotomous measure (absent/present).

Surgical Procedure:

Under complete sterile and aseptic conditions, mandibular third molar was removed by the standard surgical procedure. The surgery was performed by the same surgeon on every patient to avoid variability. Patients were given 0.12% chlorhexidine solution prior to the surgery. Inferior Alveolar Nerve block along with Long Buccal nerve block was given. Lingual nerves were also anesthetized with the help of 2% lidocaine hydrochloride with epinephrine (1:80,000). Ward's triangular flap incision was given, and osteotomy was performed using buccal guttering technique under copious irrigation using 0.9% normal saline solution. Straight fissure bur was used if sectioning of tooth was necessary. Once the extraction was complete, socket curettage was done using double ended bone curette, and sharp ends of bone were smoothened using double ended bone file. Finally, the socket was irrigated again with 0.9% normal saline.

Suturing and Wound Closure

After the completion of surgical procedure, the flap was re-approximated using a sterile, disposable non-resorbable 3-0 black braided silk surgical suture (TRUSILK, Sutures India, A division of Healthium Medtech Pvt Ltd, Bangalore, India). In Group A primary

closure was done with simple interrupted sutures. Group B had undergone primary closure with continuous sutures and Group C had primary closure with figure of eight sutures (Figure 2).

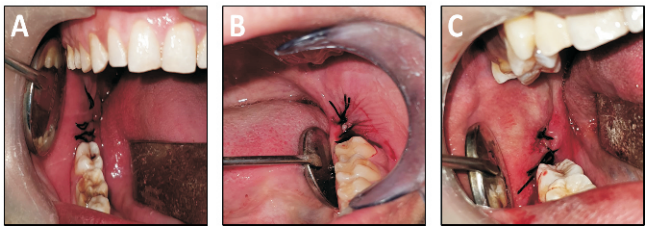


Figure 2. Primary wound closure after surgical extraction of mandibular third molar using different suturing techniques; (A) Simple Interrupted suturing in lower right quadrant, (B) Continuous suturing in the lower left quadrant and (C) Figure of Eight suturing in the lower right quadrant.

Post-operative Care and Medication:

All the patients were given standard post-operative instructions including adhering to a soft diet, avoiding consumption of alcohol or spicy food, and trying not to use the operated side for mastication for the immediate 24 hours post-surgery. To maintain oral hygiene, 0.12% chlorhexidine di-gluconate mouth-rinse (ICPA Health Products Ltd, Mumbai, India) was also recommended. Brushing was advised from the next day of surgery with extra care to be taken to avoid brushing over the stitches. Warm saline mouth rinses were advised following 24 hours of the surgery. Identical medication was given to each patient which included antibiotic - Caps. Amoxicillin (GlaxoSmithKline, UK) 500mg three times a day (8 hourly) for 5 days and Tab. Combiflam (Sanofi, India), a combination of Ibuprofen (400mg) and Paracetamol (325mg) three times a day for 5 days. Patients were instructed to return after the stipulated time to record postoperative measurements. Sutures were removed on the 7th day postoperatively.

Data Management and Statistical Analysis:

G*Power v3.1.9.6 (for Windows 10) was used to calculate the sample size (N) needed for the present study. The software was used to determine the sample size for using F tests (ANOVA) because of three groups (Group A,B and C) envisaged in the study. The software suggested 48 participants were sufficient for the study (with 85% power [β], alpha level [α] = 0.05 for a moderate to large effect size). However, we decided to include 60 patients in the study to accommodate for any potential dropouts, missed follow-ups etc. The data was recorded and stored in the form of Spreadsheets using MS Excel (Microsoft Office 365). Statistical Analysis were done using IBM SPSS for Windows (IBM Corp. Released 2017. Version 25, Armonk, NY, USA) and R v4.0.2. Critical P value (α) for all tests was kept at 0.05. It was also used in calculation of Bonferroni correction to account for inflated Type I errors. A non-normal distribution was found (Shapiro Wilk test $P < 0.05$) for all parameters assessed.

Hence, non-parametric Kruskal-Wallis test with Mann-Whitney U test as post-hoc and Vargha and Delaney's A (Â12) for effect size estimation were used.

Effect size and P value

As explained by Coe R., effect size represents the size of difference between groups and may therefore be said to be a true measure of the significance of difference [40]. Statistical significance (given as P value) on the other hand, is the likelihood that the difference between the groups could be just an accident of sampling. Simply put, statistically significant differences just address the question of whether to accept or reject the null hypothesis but doesn't reflect the magnitude of difference [41]. From a clinical prospective, statistical significance is usually of limited value because firstly, the P value cut-off is usually considered arbitrarily and secondly, sample size and measurement variability can affect statistical results [42]. Therefore, P values should be considered along with effect size, sample size and study design before application to patient care [43]. The interpretation of the different effect sizes used in the present study is shown in Table 1.

Table 1. Interpretation ranges of different effect sizes used in the present study

Effect size	ω^2 (omega squared)	Cramer's V	ε^2 (epsilon squared)	Vargha and Delaney A ($\hat{A}_{12}$)
Negligible	0.00 – 0.01	0.00 – 0.10	0.00 – 0.01	0.44 – 0.56
Small	0.01 – 0.59	0.10 – 0.20	0.01 – 0.04	0.56–0.64 or 0.34 – 0.44
Medium/Moderate	0.59 – 0.138	0.20 – 0.40	0.04 – 0.16	0.64 – 0.71 or 0.29 – 0.34
Relatively strong	-	0.40 – 0.60	0.16 – 0.36	-
Large/Strong	= 0.138	0.60 – 0.80	0.36 – 0.64	= 0.71 or = 0.29
Very Strong	-	0.80 – 1.00	0.64 – 1.00	-

Results:

Demographic Profile of the Patients:

All 60 patients who fulfilled the inclusion criteria, consented, and completed the study. The patients were randomly divided in three equal groups comprising 20 patients each. Table 2 summarizes the patient demographics and clinical characteristics. No significant differences in distribution of patients based on age were observed. A moderate association between gender of patients and groups (V = 0.296) was noted, most likely due to random distribution, however, it was not statistically significant (P = 0.072). Distribution of patients based on side of impacted wisdom tooth was also found to be non-significant with a weak association (Table 2).

Table 2. Demographic Profile and Clinical Characteristics of Patients

Characteristic	Group A	Group B	Group C	P value	Effect Size
Age (in years)					
Mean	29.70	29.50	32.25	0.391	-0.001*
S.D	7.31	7.08	6.63		
Minimum	18	20	18		
Maximum	45	45	48		
Gender, n (%)					
Male	15 (75%)	10 (50%)	8 (40%)	0.072	0.296**
Female	5 (25%)	10 (50%)	12 (60%)		
Side of Impacted Wisdom Tooth, n (%)					
Right	9 (45%)	13 (65%)	10 (50%)	0.419	0.170**
Left	11 (55%)	7 (35%)	10 (50%)		

* Effect size calculated for one-way ANOVA using ω2 (negative effect size should be rounded to 0.00 for interpretation indicating no relationship)

** Effect size calculated for chi-squared test (degrees of freedom = 2) using Cramer's V (V > 0.20 indicates a moderate association and V > 0.10 indicates weak association)

S.D – Standard Deviation

P value less than 0.05 is statistically significant.

Operation Time Analysis:

To keep operation time bias-free, the surgeon was not informed about the type of suture that was selected for the particular patient. The operation time so measured in all the three groups hence also reflected the same. The mean operation time in all groups ranged between 30 mins to 60 mins depending upon the position of the lower third molar in relation to the position of the second molar and patient compliance. No statistically significant difference between the groups was found (P > 0.05).

Analysis of Pain (VAS Scale):

As seen in Table 3, no significant differences amongst groups in terms of pre-operative pain was found (P = 0.276). There were moderately strong significant differences in pain experienced by patients in different groups 2 hours after the surgery (P = 0.000; ε2 = 0.271).

Post-hoc test with Bonferroni correction revealed significant differences between Groups B and C and Group A and C. There exists an 82.5% (Â12 = 0.825) chance for patients with continuous sutures (Group B) and 77% (Â12 = 0.773) chance for patients with simple interrupted sutures (Group A), that a randomly selected patient from these groups would experience significantly more pain than a randomly selected patient with figure of eight sutures (P = 0.000 and 0.002 respectively).

Table 3. Inter-Group (Between Groups) Variations in Pain VAS Scores

Characteristic	Overall	A vs B	B vs C	A vs C
Pre-operative				
Mean ± S.D	1.15 ± 0.66	A = 1.00 ± 0.65	B = 1.15 ± 0.67	C = 1.30 ± 0.66
P value	0.276	0.322	0.598	0.094
Effect Size †	0.044	0.423	0.458	0.375
2 hours Post-operatively				
Mean ± S.D	3.95 ± 1.03	A = 4.25 ± 0.85	B = 4.45 ± 0.60	C = 3.15 ± 1.09
P value	0.000*	0.393	0.000**	0.002**
Effect Size †	0.271	0.428	0.825	0.773
4 hours Post-operatively				
Mean ± S.D	4.60 ± 1.29	A = 5.45 ± 0.60	B = 4.15 ± 1.50	C = 4.20 ± 1.19
P value	0.001*	0.001**	0.911	0.000**
Effect Size †	0.258	0.789	0.490	0.814
1st day Post-operatively				
Mean ± S.D	4.43 ± 1.13	A = 4.95 ± 1.46	B = 4.60 ± 1.05	C = 3.75 ± 0.85
P value	0.003**	0.411	0.011**	0.001**
Effect Size †	0.199	0.572	0.724	0.786
2nd day Post-operatively				
Mean ± S.D	3.28 ± 1.19	A = 3.65 ± 0.59	B = 3.70 ± 1.45	C = 2.50 ± 0.99
P value	0.001*	0.764	0.000**	0.006**
Effect Size †	0.255	0.526	0.853	0.745
7th day Post-operatively				
Mean ± S.D	0.43 ± 0.59	A = 0.40 ± 0.50	B = 0.60 ± 0.75	C = 0.30 ± 0.47
P value	0.445	0.497	0.217	0.513
Effect Size †	0.027	0.445	0.598	0.550

† Effect size calculated for Kruskal-Wallis test using epsilon squared ε2 while for the post-hoc tests (Mann-Whitney U), effect size was calculated using Vargha and Delaney's A (Â12)

* The P value is significant at P < 0.05

** The P value is significant for Bonferroni adjusted α = 0.016 (0.05/3)

A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight).

Similarly, 4 hours after surgical extraction of lower third molar, there were moderately strong significant differences amongst the groups (P = 0.001; ε2 = 0.258). There was significantly more pain experienced in patients in Group A as compared with Group B or C (P = 0.001 and 0.000 respectively). Further, there was 79% chance and 81% chance that a randomly selected patient in Group A had experienced significantly more pain when compared with a randomly selected patient in Group B and C, respectively (Table 3). On and after 1st day post-operatively, a decrease in overall pain experienced by the patients was observed (Figure 3). On both 1st and 2nd day post-operatively, there were significant differences in pain scores amongst the groups (P = 0.003 and 0.001 respectively). On 7th day post-operatively, there were no significant differences reported amongst the groups (P = 0.445).

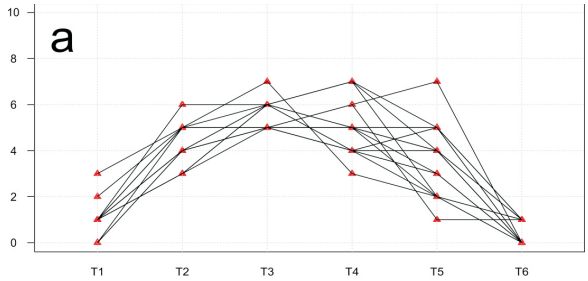
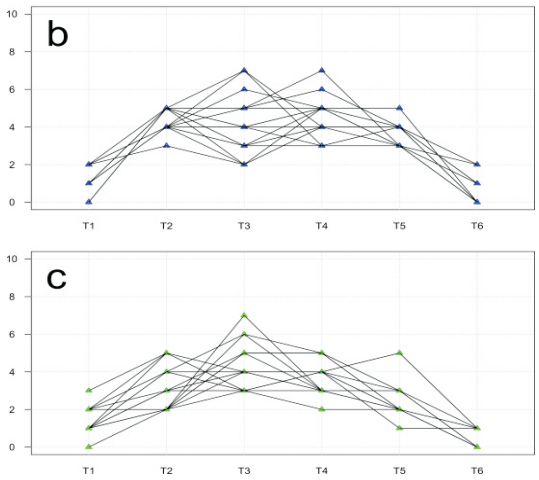


Figure 3. Figure showing distribution and relation of the pain scores (VAS) for (a) Group A; (b) Group B and (c) Group C. VAS scores are represented on y axis while time of measurement at x axis; T1 – Pre-operative; T2 – 2 hours post-operatively, T3 – 4 hours post-operatively; T4 – 1st day post-operatively; T5 – 2nd day post-operatively and T6 – 7th day post-operatively

Analysis of Facial Swelling:

No significant differences in facial swelling were observed amongst groups (Table 4 and Figure 4). As expected under normal conditions, there was observed an increase in facial swelling till 1st day post-operatively followed by reduction till 3rd day post-operatively and finally getting to pre-operative levels by the end of week (7th day post-operatively).

Table 4. Inter-Group (Between Groups) Variations in Facial Swelling (in mm)



Characteristic	All Groups	A vs B	B vs C	A vs C
Pre-operative				
Mean ± S.D	119.00 ± 9.28	A =118.87 ± 5.71	B = 119.81 ± 10.99	C = 118.32 ± 10.62
P value	0.700	0.560	0.515	0.524
Effect Size †	0.012	0.446	0.440	0.558
1st day Post-operatively				
Mean ± S.D	126.05 ± 8.71	A = 126.03 ± 6.01	B = 125.55 ± 10.32	C = 125.37 ± 9.51
P value	0.756	0.914	0.756	0.372
Effect Size †	0.009	0.510	0.472	0.582
2nd day Post-operatively				
Mean ± S.D	124.30 ± 8.72	A = 125.05 ± 6.09	B = 124.42 ± 10.40	C = 123.43 ± 9.43
P value	0.614	0.807	0.394	0.409
Effect Size †	0.017	0.477	0.579	0.576
3rd day Post-operatively				
Mean ± S.D	121.80 ± 9.42	A = 122.15 ± 7.35	B = 122.98 ± 10.42	C = 120.30 ± 10.43
P value	0.504	0.440	0.285	0.570
Effect Size †	0.023	0.447	0.599	0.571
7th day Post-operatively				
Mean ± S.D	119.45 ± 8.55	A =119.70 ± 5.44	B = 120.20 ± 10.06	C = 118.45 ± 9.71
P value	0.475	0.569	0.337	0.291
Effect Size †	0.025	0.593	0.585	0.453

† Effect size calculated for Kruskal-Wallis test using epsilon squared ε2 while for the post-hoc tests (Mann-Whitney U), effect size was calculated using Vargha and Delaney's A (Â12)

* The P value is significant at P < 0.05

** The P value is significant for Bonferroni adjusted α = 0.016 (0.05/3)

A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight).

Although negligible effect size was obtained in most of the intra-group comparisons, there were some instances when small effect size was also observed. On 1st, 2nd, and 3rd day post-operatively a small effect was noted in Groups A and C where there was about 57% chance that a patient in Group A experienced more swelling than patient in Group C however, it was found to be non-significant (P > 0.05). Similarly, on 2nd, 3rd, and 7th day post-operatively there was a non-significant small effect noted with about 58% chance that a patient in Group B experienced more swelling than patient in Group C (Table 4).

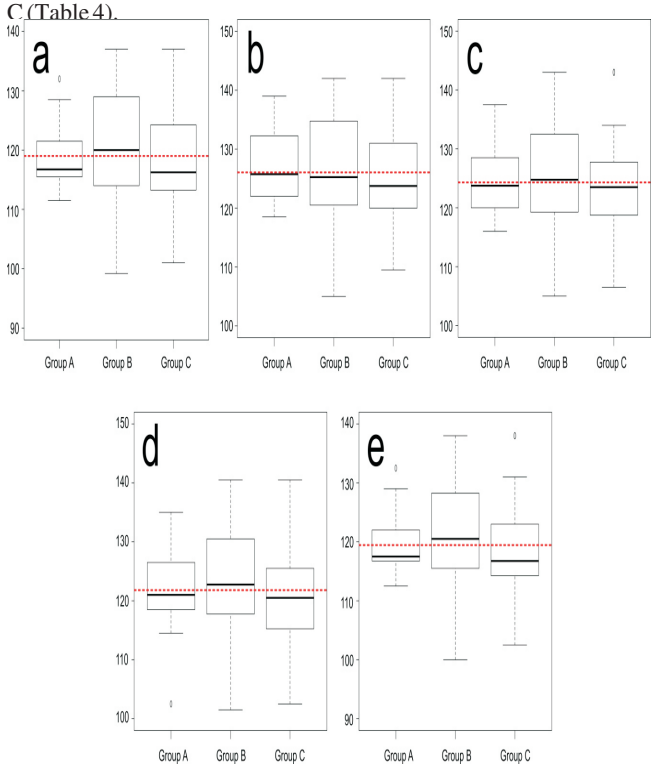


Figure 4. Figure showing distribution of measured facial swelling (in mm) for all groups. Facial swelling (in mm) is represented on y axis while groups on x axis; A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight). (a) Pre-operative; (b) 1st day post-operatively; (c) 2nd day post-operatively (d) 3rd day post-operatively and (e) 7th day post-operatively. Red dashed line represents the overall mean for facial swelling at respective time of measurement (a-e) for all groups combined.

Analysis of Mouth Opening (Trismus)

Similar to other assessed parameters, no pre-operative differences were noted amongst the groups (Table 5 and Figure 5). On 1st and 2nd day post-operatively, there were moderate significant differences noted amongst the groups (Table 5).

Table 5. Inter-Group (Between Groups) Variations in Trismus/Mouth Opening (in mm)

Characteristic	All Groups	A vs B	B vs C	A vs C
Pre-operative				
Mean ± S.D	40.35 ± 7.27	A = 42.05 ± 7.49	B = 39.75 ± 6.17	C = 40.60 ± 7.35
P value	0.493	0.238	0.569	0.533
Effect Size †	0.024	0.608	0.447	0.557
1st day Post-operatively				
Mean ± S.D	30.16 ± 6.86	A = 26.95 ± 5.99	B = 31.23 ± 7.18	C = 32.33 ± 6.46
P value	0.011*	0.032	0.673	0.003**
Effect Size †	0.154	0.303	0.461	0.226
2nd day Post-operatively				
Mean ± S.D	33.26 ± 6.33	A = 30.70 ± 5.98	B = 33.25 ± 6.54	C = 35.85 ± 6.05
P value	0.008*	0.208	0.068	0.002**
Effect Size †	0.162	0.384	0.331	0.219
7th day Post-operatively				
Mean ± S.D	38.20 ± 6.43	A = 38.90 ± 7.13	B = 38.00 ± 6.34	C = 37.85 ± 6.12
P value	0.889	0.694	0.903	0.664
Effect Size †	0.004	0.536	0.478	0.533

† Effect size calculated for Kruskal-Wallis test using epsilon squared ε2 while for the post-hoc tests (Mann-Whitney U), effect size was calculated using Vargha and Delaney's A (Â12)

* The P value is significant at P < 0.05

** The P value is significant for Bonferroni adjusted α = 0.016 (0.05/3)

A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight).

On both these days, there was a chance of about 77% that the mouth opening was significantly more in randomly selected patient with figure of eight sutures (Group C) than a randomly selected patient with simple interrupted sutures (P = 0.003 and 0.002 respectively). There were negligible (and non-significant) differences in mouth opening between patients of Group B and C on 1st day post-operatively while moderate differences were found on 2nd day post-operatively which remained non-significant. Between Group A and B, there were no significant differences on both these days and a medium and small effect size was noted for 1st and 2nd day post-operatively respectively (Â12 = 0.303 and 0.384 respectively). In both cases, mouth opening was more in Group B patients than in Group A patients. On 7th day post-operatively, there were no significant differences noted amongst the groups (P = 0.889).

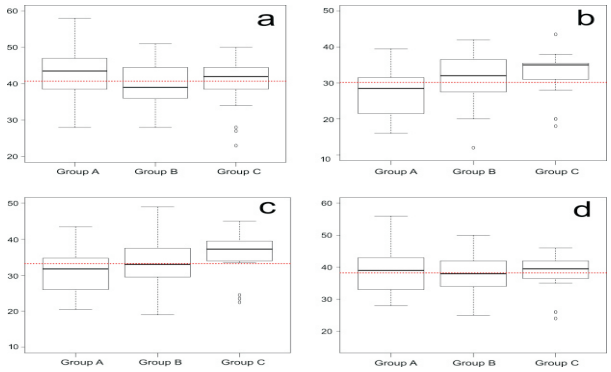


Figure 5. Figure showing distribution of measured mouth opening (in mm) for all groups. Mouth opening (in mm) is represented on y axis while groups on x axis; A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight). (a) Pre-operative; (b) 1st day post-operatively; (c) 2nd day post-operatively and (d) 7th day post-operatively. Red dashed line represents the overall mean for facial swelling at respective time of measurement (a-d) for all groups combined.

Analysis of Periodontal Health of Second Molar:

No significant differences amongst the groups were found pre-operatively and in 4th and 8th week post-operatively (Table 6 and Figure 6). However, small significant differences were found in 12th week post-postoperatively (P = 0.029; ε2 = 0.120). Post-hoc tests revealed that there were significant differences between Groups A-B and Groups B-C, however, when Bonferroni correction was applied (to account for Type I inflation) these differences were found to be non-significant.

Table 6. Inter-Group (Between Groups) Variations in Periodontal Health of Second Molar (in mm)

Characteristic	All Groups	A vs B	B vs C	A vs C
Pre-operative				
Mean ± S.D	3.81 ± 0.48	A = 3.69 ± 0.50	B = 3.80 ± 0.38	C = 3.92 ± 0.55
P value	0.254	0.238	0.448	0.140
Effect Size †	0.046	0.391	0.430	0.364
4th week Post-operatively				
Mean ± S.D	3.36 ± 0.39	A = 3.36 ± 0.38	B = 3.38 ± 0.36	C = 3.34 ± 0.46
P value	0.822	0.655	0.634	0.635
Effect Size †	0.007	0.458	0.543	0.544
8th week Post-operatively				
Mean ± S.D	2.93 ± 0.38	A = 2.95 ± 0.35	B = 2.98 ± 0.35	C = 2.86 ± 0.44
P value	0.562	0.464	0.330	0.616
Effect Size †	0.020	0.432	0.590	0.546
12th week Post-operatively				
Mean ± S.D	2.00 ± 0.82	A = 2.49 ± 0.28	B = 2.69 ± 0.36	C = 2.41 ± 0.41
P value	0.029*	0.032	0.021	0.350
Effect Size †	0.120	0.302	0.712	0.586

† Effect size calculated for Kruskal-Wallis test using epsilon squared ε2 while for the post-hoc tests (Mann-Whitney U), effect size was calculated using Vargha and Delaney's A (Â12)

* The P value is significant at P < 0.05

** The P value is significant for Bonferroni adjusted α = 0.016 (0.05/3)

A = Group A (Simple Interrupted); B = Group B (Continuous) and C = Group C (Figure of eight).

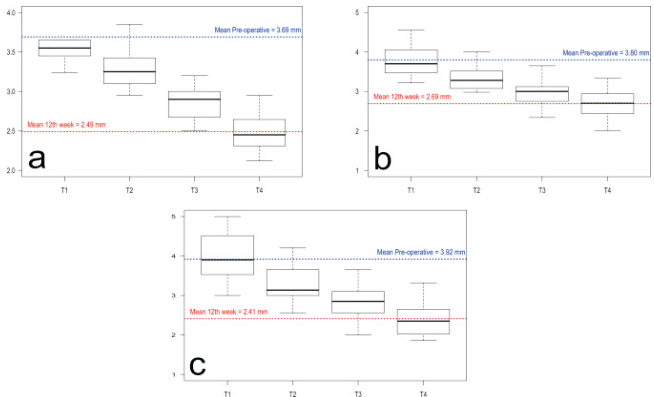


Figure 6. Figure showing distribution of measured periodontal health of second molar (in mm) for all groups. Probing depth (in mm) is represented on y axis while time of measurement on x axis; (a)

Group A (Simple Interrupted); (b) Group B (Continuous) and (c) Group C (Figure of eight). T1 - Pre-operative; T2 – 4th week post-operatively; T3 – 8th week post-operatively and T4 - 12th week post-operatively.

Analysis of Wound Infection:

After one to two weeks of extraction, some patients complained of a sudden onset of bad breath which didn't go away after brushing which was accompanied with a weird taste sensation resembling bitterness in mouth (as described by the patients). Some patients also reported increased sensitivity to hot food and liquids in the region of extraction. On examination of the wound area, signs of inflammation were noted along with swollen gums, confirming wound infection. The wound area was properly irrigated with normal saline and Betadine solution (Standardized Microbicidal solution 5%, Win-Medicare Pvt. Ltd, India). Patients were advised to continue warm saline rinses for a week and were prescribed Caps. Amoxicillin and Tab. Combiflam. Patients were followed up until the resolution of the infection. Distribution of patients based on wound infection and type of suturing technique used is shown in Table 7. There were no significant differences noted however, there was a moderate association between the suturing technique and wound infection (P = 0.208; V = 0.209).

Table 7. Inter-Group (Between Groups) Variations in wound infection

Characteristic	Group A	Group B	Group C	P value	Effect Size
Wound infection, n (%)					
Present	5 (25%)	3 (15%)	1 (5%)	0.208	0.209
Absent	15 (75%)	17 (85%)	19 (95%)		

* Effect size calculated for chi-squared test using Cramer's V
P value less than 0.05 is statistically significant.

Discussion & Clinical Significance:

Pain, swelling, trismus are the chief indicators for patient discomfort after the surgical extraction of lower third molar and hence, were analyzed for differences when Simple Interrupted, Continuous and Figure of Eight suturing techniques are used. In our knowledge, this is the first time such a comparative analysis has been undertaken and reported. In context of the present study, it is important to briefly revisit the key events in oral wound healing after tooth extraction. The extraction of the tooth initiates a complex cascade of physiological reparative responses involving both hard tissue (like bone) and soft tissue (like periodontal ligament, gingiva) [44]. Immediately after extraction, the socket gets filled with blood which is followed by formation of blood clot which fills the socket space [44]. The blood clot consists of erythrocytes and leukocytes embedded within a fibrin network. Formation and attachment of this blood clot is an essential prerequisite for every wound closure [45]. Within a week, the blood clot gets replaced with granulation tissue which is followed by re-epithelialization and formation of connective tissue matrix [15]. Lastly, the contraction phase occurs which involves the distance between wound edges being closed and reduction in the wound surface [15]. After 8th week, the socket gets filled with bone and the bone remodeling process continues for up to 6 months [46].

The main goal of suturing is to position and secure the surgical flaps (creating flap-to-root seal) to promote the stabilization and maturation of the blood clot in a biologic environment protected from the biochemical and microbiological challenge [45,47]. Hence, choice of suturing technique used is of utmost importance for proper soft tissue management that usually comes with understanding of wound anatomy and surgeon's preference [48-49]. Various techniques are used in different dental procedures with each associated with its own advantages and drawbacks. Simple Interrupted sutures (shown in Figure 2a and represented by Group A), also known as Simple Loop Suturing technique, is the most widely used suturing technique in dentistry [50]. As the name suggests, individual stitches are not connected to the adjacent stitch and are placed separately. The suture goes through one side of the wound, comes up through the other side and is then tied with a surgeon's knot [51-52]. The excess length of suture thread is cut off whilst leaving 2-3 mm of thread [50].

Continuous sutures on the other hand, are more useful when the wound is longer. For continuous suturing (shown in Figure 2b and represented by Group B), a simple interrupted suture is placed but instead of cutting the thread, the needle is reinserted in a continuous fashion with the needle passing perpendicular to the incision line below and obliquely above [51]. The suture is finished by passing the knot over the untightened end of the suture. Two different sub-techniques have been described namely running (or non-locking) and locking [52]. In the present study, the first stich was placed as a locking stich (locking done by withdrawing the suture through the first loop), followed by running suturing and finally ending the continuous suture with another locking stitch.

Figure of eight suturing technique (shown in Figure 2c and represented by Group C) is another commonly used technique in oral surgery with the same indications for use as simple interrupted suturing [50]. The suture is placed by piercing the outer surface of buccal flap with the needle. The needle is threaded under the interproximal contact whilst piercing the outer aspect of the lingual flap with the suture needle. The needle is passed through the interproximal contact and the remaining thread is cut off whilst leaving about 2-3 mm of thread [50]. The advantages and disadvantages of each of these three suturing techniques are shown in Table 8.

Table 8. Advantages and Disadvantages of the three suturing techniques

Suturing Technique	Advantages	Disadvantages
Simple Interrupted	• Easy to place and remove • Strong and can be used in areas of stress • If multiple are placed to close large wound, the tension is shared • Each is independent and loosening of one doesn't compromise entire flap • Free of interferences between each stitch and can be cleaned easily • Quick placement (if single stitch)	• Each stitch must be knotted individually • If knot is not properly tied, damage can happen to surrounding tissue including wound infection • Can be time consuming if multiple stitches are to be placed • Proper alignment of the stitches is important for complete flap closure • Are not effective enough when closing deeper incisions • Increased risk of stitch opening
Continuous	• Involves as many teeth as required • Minimizes the number of knots • Uses teeth to anchor the flap • No need for periosteal sutures • Less time for placement & removal • Enables independent placement of buccal, lingual, or palatal flaps • More water-tight closure • Rapid technique • Distributes tension uniformly • Prevents excessive tightening	• If break or resorption occurs anywhere along the length of suture, entire flap may loosen, thereby exposing the socket • Prevents adjustment of tension over suture line as swelling occurs
Figure of Eight	• Provides easier access to teeth • Allows for proper closure of deep incisions • Provides rapid wound closure • Doesn't cause ischemia at edge of suture • Any length difference between flaps can be evened up and sutured	• Difficult to master • There is interposed suture material between the flaps • Can cause some discomfort to patient during removal • Leaves some amount of suture threads inside the socket

Pain is one of the most common post-operative complication of extraction and is usually caused by the release of pain mediators like bradykinin, histamine and prostaglandins from the injured tissue [53-54]. It can be a crucial deciding factor in clinical practice and can discourage the patient from seeking dental treatment [54-55]. The patient usually starts to feel pain as the effects of anesthesia subsides which usually reach its peak during the first post-operative day itself [54,56]. The results from our study support this statement. We also noticed the peak of pain experienced in all groups reach within first day post-operatively (Table 3; Figure 3) followed by a decline in pain experienced by the patients. While patients in Group A and C reported their peak pain 4 hours after surgery, patients in Group B reported their peak on 1st day post-surgery. A group-wise comparison (Table 3) reveals that after surgical removal of mandibular third molar, patients with interrupted sutures experienced significantly more pain at least 74% of the times when compared with patients with figure of eight sutures. Similarly, patients with continuous sutures reported significantly more pain at least 72% of the times when compared with patients with figure of eight sutures (except 4 hours post-operatively). No significant differences were reported between Group A and B patients except 4 hours post-operatively ($P = 0.001$; Table 3).

Facial Swelling occurs as a direct result of tissue damage which is characterized by hyperemia, vasodilation, increased capillary permeability with liquid accumulation in the interstitial space. This happens due to the increased osmotic pressure in the capillaries (explained by Starling's law) [57-58]. In our study, although no significant differences were noted amongst the groups, Group C patients had least swelling. According to many authors, tight closure creates an unidirectional valve that allows food particles to enter the cavity but doesn't allow an easy escape leading to local inflammation, infection, pain and edema formation [59-61]. Since continuous sutures forms a tight closure, this can explain why more swelling is seen in Group B when compared with figure of eight and simple interrupted sutures (Figure 4).

Trismus following surgical extraction is secondarily due to pain and facial swelling [3]. Like edema, the jaw stiffness (causing trismus) is said to usually reach its peak on 2nd day post-surgery and revolves by the end of 1st week [62]. However, some authors have found that pain and swelling developed simultaneously contributing in trismus [63]. Further, other authors have reported a strong interrelation between pain and trismus describing pain as the primary cause of reduced mouth opening post-surgery [64-65]. In our study as well, we have found that pain and swelling both peaked by 1st day post-operatively and that resulted in trismus also peaking by the same time. Another potential factor is that, mouth opening post-removal is painful and is consequently avoided to its full extent [64]. This was confirmed by an electromyographic based study in 1969 that mandibular movements after lower third molar extraction are restricted due to voluntary act of the patient in order to avoid pain [65]. Since patients in Group A reported more pain when compared with Group C, there was also seen a significantly decreased mouth opening on 1st and 2nd day post-surgery in Group A when compared with Group C. Although significant differences in pain were observed between Group B and C, mouth opening showed no significant differences. However, another important fact to consider is that a small to moderate effect size was established between both groups in mouth opening (Table 5). On 2nd day postoperatively, there was 66% chance that Group C patients had more mouth opening that patients in Group B.

Periodontal Health of the 2nd molar showed no significant differences amongst the groups at all times of measurements. There was seen an overall improvement in probing depth after extraction in all groups. Studies in the past have also reported improvement in probing depth after lower third molar extraction [66-67]. The improvement in the probing depth is usually attributed to the presence of food particles in hard to clean areas (like space between impacted mandibular 2nd and 3rd molar) that lead to local inflammation and alterations in the gingival tissue around the third molar and sextant [68-69]. Removal of the third molar can explain the improvement in periodontal health.

Wound infection occurs usually due to food debris accumulated under the flap and/or plaque deposits on the suture material itself, that provides an opportunity for oral bacteria to thrive and infect inside the wound. Patients in Group A were found to have more cases of wound infection when compared with other groups. A plausible explanation for the reason as to why simple interrupted suturing technique showed more cases of wound infection cannot be formulated. We speculate two reasons contributing to this. Firstly, we believe that poor adherence to post-operative instructions (warm saline rinses, mouthwash use, brushing technique etc.) could have led to increased cases in Group A. Reasons for such non-adherence to post-operative instructions could stem from the pain and swelling experienced by the patient coupled with lesser mouth opening. Secondly, we speculate that the gap between the interrupted sutures could work as an entrance for bacteria as well as food to get trapped under the flap causing wound infection (though this would need further evidence in future studies).

In cases of elective dental procedures such as third molar removal, patients demand to know the risks, benefits as well as change in quality of life post-operatively [54,70]. These factors play a key role in determining the level of patient cooperation, patient anxiety as well as motivation to undergo surgery. The post-operative

complications have clinical implications in treatment planning, patient management and prognosis [54,70]. The present study provides the clinicians and surgeons with a more descriptive outlook on the use of these suturing techniques for flap closure after lower third molar surgery. We advise that a case-by-case approach is necessary in determining the efficacy or superiority of one technique over the other. Since all parameters like pain, swelling, trismus, probing depth and wound infection are either subjective and/or affected by personal factors like age, gender, weight etc., the readers can argue about the need for validation of results in different patient groups (like medical conditions etc.). to develop an universal suggestion. However, the authors would like to point out that a strict inclusion and exclusion criteria coupled with comparable baseline demographics in all groups can help eliminate some of the cofounding variables. Further, the reporting of effect size in the present study will aid in better clinical interpretation as well as aid future researchers to do meta-analysis studies. We advise for more multicentric clinical studies to be undertaken which consider and reflect upon limiting other cofounding variables (like age, gender etc.)

In summary, the selection of appropriate suturing technique is pivotal and directly influences in different phases of healing and post-operative complications. We suggest that for patients who fulfill the inclusion criteria whilst keeping in mind the limitations in the present study, figure of eight suturing technique should be the first preference/alternative. The technique proved to be less uncomfortable for patients in terms of pain, swelling and trismus with lower reporting of wound infection and better improvement in periodontal health of second molar. Mostly in clinics and hospitals, suturing is left in least expert hands. Since the Figure of eight technique is difficult to master, continuous sutures can also be used as a second-in-line preference, though only in cases where there are low chances of wound infection and patient maintains strong adherence to post-operative instructions. In case, the surgeon has doubts on patient adherence and patient's oral hygiene, it would be better to consider simple interrupted sutures in place of continuous sutures as second-in-line.

Conclusions:

Surgical removal of mandibular third molars is the most common minor oral surgery procedure yet is also amongst the procedures associated with high levels of anxiety and feeling of dread with the patients. The suturing technique used can have a reasonable impact on the level of discomfort experienced by the patient. Figure of Eight suturing technique presents with significantly less pain and trismus with less chances of wound infection. Further, it is associated with less swelling and better periodontal health of second molar. The final choice of suturing technique shall of course, rest with the surgeonbased on the wound anatomy, patient medical and dental history, as well as clinical experience.

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We are extremely grateful to all the participants and supporting staff in the department for their contributions that led to the successful completion of the present study. Approval for the study design and methodology was granted by the Institution's Ethical and Scientific Committee. The study complied with the Helsinki Declaration of 1975, as revised in 2008. Patients were briefed about the objectives, terms, and scope of the study. Written as well as oral informed consent were obtained from each patient in the language of their understanding (English, Hindi, Punjabi).

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References:

1. Yuasa H. and Sugiura M. Clinical postoperative findings after removal of impacted mandibular third molars: Prediction of postoperative facial swelling and pain based on preoperative variables. Br J Oral Maxillofac Surg. 2004;42:209–14.
2. Gay-Escoda C, Gómez-Santos L, Sánchez-Torres A, Herráez-Vilas JM. Effect of the suture technique on postoperative pain, swelling and trismus after removal of lower third molars: A randomized clinical trial. Med Oral Patol Oral Cir Bucal. 2015 May 1;20(3):e372-7. doi: 10.4317/medoral.20307. PMID: 25662551; PMCID: PMC4464926.
3. Syed KB, AlQahtani FH, Mohammad AH, Abdullah IM, Qahtani HS and Hameed MS. Assessment of pain, swelling and trismus following impacted third molar surgery using injection dexamethasone submucosally: A prospective, randomized, crossover clinical study. J Int Oral Health 2017;9:116-21. doi: 10.4103/jioh.jioh_65_17.
4. Archer WH. Oral Surgery: A Step-By-Step Atlas of Operative Techniques, 4th ed. Philadelphia: W.B. Saunders Company; 1966. p. 507-10.
5. Peterson LJ. Principles of Management of Impacted Teeth. In: Peterson LJ, Ellis E III, Hupp JR, Tuker MR, editors. Contemporary Oral and Maxillofacial Surgery, 3rd ed. St. Louis: Mosby; 1998. p. 184-248.
6. Agarwal KN, Gupta R, Faridi MM, Kalra N. Permanent dentition in Delhi boys of age 5-14 years. Indian Pediatr. 2004 Oct;41(10):1031-5.
7. Syed KB, Zaheer KB, Ibrahim M, Bagi MA, Assiri MA. Prevalence of Impacted Molar Teeth among Saudi Population in Asir Region, Saudi Arabia - A Retrospective Study of 3 Years. J Int Oral Health. 2013 Feb;5(1):43-7. Epub 2013 Feb 26. PMID: 24155577; PMCID: PMC3768082.

8. Elsey MJ, Rock WP. Influence of orthodontic treatment on development of third molars. Br J Oral Maxillofac Surg. 2000 Aug;38(4):350-3.
9. Pahkala R, Pahkala A, Laine T. Eruption pattern of permanent teeth in a rural community in northeastern Finland. Acta Odontol Scand. 1991 Dec;49(6):341-9.
10. Frost DE, Hersh EV, Levin LM. Management of impacted teeth. In: R Fonseca, editor. Oral and Maxillofacial Surgery. Vol. I. Philadelphia: Saunders; 2000. p. 245-80.
11. Dodson TB, Susarla SM. Impacted wisdom teeth. BMJ Clin Evid. 2010 Apr 8;2010:1302. PMID: 21729337; PMCID: PMC2907590.
12. Juodzbalys G, Daugela P. Mandibular third molar impaction: review of literature and a proposal of a classification. J Oral Maxillofac Res. 2013 Jul 1;4(2):e1. doi: 10.5037/jomr.2013.4201. PMID: 24422029; PMCID: PMC3886113.
13. Burkhardt R, Lang NP. Influence of suturing on wound healing. Periodontol 2000. 2015 Jun;68(1):270-81. doi: 10.1111/prd.12078. PMID: 25867989.
14. Adell R, Eriksson B, Nylén O, Ridell A. Delayed healing of fractures of the mandibular body. Int J Oral Maxillofac Surg. 1987 Feb;16(1):15-24. doi: 10.1016/s0901-5027(87)80026-7. PMID: 3104491.
15. Politis C, Schoenaers J, Jacobs R, Agbaje JO. Wound Healing Problems in the Mouth. Front Physiol. 2016 Nov 2;7:507. doi: 10.3389/fphys.2016.00507. PMID: 27853435; PMCID: PMC5089986.
16. Roy S., Das A., Sen C. K. (2013). Disorder of localized inflammation in wound healing: a systems perspective, in Complex Systems and Computational Biology Approaches to Acute Inflammation, eds Vodovotz Y., An G.(New York, NY: Springer;), 173–183.
17. Guo S, Dipietro LA. Factors affecting wound healing. J Dent Res. 2010 Mar;89(3):219-29. doi: 10.1177/0022034509359125. Epub 2010 Feb 5. PMID: 20139336; PMCID: PMC2903966.
18. Emin E, Ferda T, Okan A. Determination of the anti-inflammatory effect of methyl prednisolone on the sequelae of third molar surgery. J Oral Maxillofac Surg. 1999;57:1201–1206. doi: 10.1016/S0278-2391(99)90486-X.
19. Howe GL: Minor Oral Surgery. Bristol, England, John Wright & Sons Ltd, 1971.
20. Archer WH: Oral and Maxillofacial Surgery, 5th ed. Philadelphia, WB Saunders Co, 1975.
21. Guralnick WC (Ed): Textbook of Oral Surgery. Boston, Little Brown & Co, 1968.
22. Kruger GO (Ed): Textbook of Oral Surgery. St Louis, CV Mosby Co, 1974.
23. Thoma KH: Oral Surgery, 5th ed. St Louis, CV Mosby Co, 1969, Vol 1.
24. Killey HC, Kay LW: The Impacted Wisdom Tooth, 2nd ed. London, Churchill Livingstone Co, 1975.
25. Maria A, Malik M, Virang P. Comparison of primary and secondary closure of the surgical wound after removal of impacted mandibular third molars. J Maxillofac Oral Surg. 2012 Sep;11(3):276-83. doi: 10.1007/s12663-011-0287-9. Epub 2011 Sep 23. PMID: 23997477; PMCID: PMC3428443.
26. Pasqualini D, Cocero N, Castella A, Mela L, Bracco P. Primary and secondary closure of the surgical wound after removal of impacted mandibular third molars: a comparative study. Int J Oral Maxillofac Surg. 2005;34:52–57. doi: 10.1016/j.ijom.2004.01.023.
27. Dubois DD, Pizer ME, Chinnis RJ. Comparison of primary and secondary closure techniques after removal of impacted mandibular third molars. J Oral Maxillofac Surg. 1982;40:631–634. doi: 10.1016/0278-2391(82)90111-2.
28. Cohen I. K., Diegelmann R. F., Lindblad W. J. (eds.). Wound Healing: Biochemical and Clinical Aspects. 1992.Philadelphia: WB. Saunders Company; Harcourt Brace Jovanovich, Inc.
29. Sørensen L. T. (2012). Wound healing and infection in surgery: the pathophysiological impact of smoking, smoking cessation, and nicotine replacement therapy: a systematic review. Ann. Surg. 255, 1069–1079. Doi:10.1097/SLA.0b013e31824f632d.
30. Glim J. E., van Egmond M., Niessen F. B., Everts V., Beelen R. H. (2013). Detrimental dermal wound healing: what can we learn from the oral mucosa? Wound Repair Regen. 21, 648–660. 10.1111/wrr.12072.
31. Hashemi HM, Beshkar M, Aghajani R. The effect of sutureless wound closure on postoperative pain and swelling after impacted mandibular third molar surgery. Br J Oral Maxillofac Surg. 2012;50:256–8.
32. Osunde OD, Adebola RA, Saheeb BD. A comparative study of the effect of suture-less and multiple suture techniques on inflammatory complications following third molar surgery. Int J Oral Maxillofac Surg. 2012;1:1275–9.
33. Dolanmaz D, Esen A, Isik K, Candirli C. Effect of 2 flap designs on postoperative pain and swelling after impacted third molar surgery. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;116:244–6.
34. Sandhu A, Sandhu S, Kaur T. Comparison of two different flap designs in the surgical removal of bilateral impacted mandibular third molars. Int J Oral Maxillofac Surg. 2010;39:1091–6.
35. Ege B., and Najafov E. Comparison of two different suture knot techniques on postoperative morbidity after impacted mandibular third molar surgery. J Stomatol Oral Maxillofac Surg. 2020; 121(3):206-212.

36. Joshi AD, Saluja H, Mahindra U, Halli R. A comparative study: efficacy of tissue glue and sutures after impacted mandibular third molar removal. J Maxillofac Oral Surg. 2011 Dec;10(4):310-5. doi: 10.1007/s12663-011-0241-x. Epub 2011 May 17. PMID: 23204746; PMCID: PMC3267907.
37. Ghoreishian M, Gheisari R, Fayazi M. Tissue adhesive and suturing for closure of the surgical wound after removal of impacted mandibular third molars: a comparative study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Jul;108(1):e14-6. doi: 10.1016/j.tripleo.2009.03.001. Epub 2009 May 22. PMID: 19464207.
38. American Society of Anesthesiologists website. Available at: https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system. Accessed 16 Aug 2020.
39. Ren Y-F, Malmstrom HS. Effectiveness of antibiotic prophylaxis in third molar surgery: a meta-analysis of randomized controlled clinical trials. J Oral Maxillofac Surg. 2007 Oct; 65(10):1909–21.
40. Coe R. It's the effect size, stupid: What effect size is and why it is important. 2002. Available at: https://www.leeds.ac.uk/educol/documents/00002182.htm. Accessed 16 Aug 2020.
41. Page P. Beyond Statistical significance: clinical interpretation of rehabilitation research literature. Int J Sports Phys Ther. 2014; 9(5):723-36. PMID: 25328834.
42. Batterham AM, and Hopkins WG. Making meaningful inferences about magnitudes. Int J Sports Phys Ther. 2006; 1(1):50-57.
43. Sainani KL. Putting P values in perspective. PM & R: the journal of injury, function and rehabilitation. 2009; 1(9):873-877.
44. Larjava H. Oral Wound Healing: Cell Biology and Clinical Management. West Sussex: John Wiley & Sons, Inc. 2012.
45. Burkhardt, R., & Lang, N. P. Influence of suturing on wound healing. Periodontology 2000. 2015; 68(1), 270–281. doi:10.1111/prd.12078.
46. Discepoli N., Vignoletti F., Laino L., de Sanctis M., Muñoz F., Sanz M. Early healing of the alveolar process after tooth extraction: an experimental study in the beagle dog. J. Clin. Periodontol. 2013; 40, 638–644. 10.1111/jcpe.12074.
47. Takei, H.H. Surgical techniques for reconstructive periodontics. Dental Clinics of North America. 1991; 35, 531–539.
48. Mormann W, Ciancio SG. Blood supply of human gingiva following periodontal surgery. A fluorescein angiographic study. J Periodontol 1977; 48:681-692.
49. Reiser GM, Bruno JF, Mahan PE, Larkin LH. The subepithelial connective tissue graft palatal donor site: Anatomic considerations for surgeons. Int J Periodontics Restorative Dent 1996;16: 130-137.
50. Griffin, T. J., Hur, Y., & Bu, J. Basic Suture Techniques for Oral Mucosa. Clinical Advances in Periodontics. 2011;1(3), 221–232. doi:10.1902/cap.2011.110053.
51. Koshak H.H. Dental Suturing Materials and Techniques. Glob J Otolaryngol. 2017; 12(2):27-37. doi: 10.19080/GJO.2017.12.555833.
52. Hupp J.R (ed). Guide to suturing with sections on diagnosing oral lesions and post-operative medications. J Oral Maxillofacial Surg. Aug 2015; 73(S1). Available at: https://www.aaoms.org/docs/education_research/dental_students /joms_guide_to_suturing.pdf
53. Nazar. M.N, Puthiriraj.V. Analgesics Following Mandibular Third Molar Surgery. IJPCR, 2014; 6(1):13-19.
54. Haraji A, Rakhshan V. Chlorhexidine gel and less difficult surgeries might reduce post-operative pain, controlling for dry socket, infection and analgesic consumption: a split-mouth controlled randomised clinical trial. J Oral Rehabil. 2015;42:209–219.
55. Wardle J. Dental pessimism: negative cognitions in fearful dental patients. Behav Res Ther. 1984;22:553–556.
56. Susarla SM, Blaeser BF, Magalnick D. Third molar surgery and associated complications. Oral Maxillofac Surg Clin North Am. 2003;15:177–186.
57. Messer EJ and Keller JJ. The use of intraoral dexamethasone after extraction of mandibular third molars. Oral Surg Oral Med Oral Pathol. 1975; 40:594-598.
58. Sortino F and Cicciu M. Strategies used to inhibit postoperative swelling following removal of impacted third molar. Dent Res J (Isfahan). 2011; 8(4):162-171. Doi: 10/4103/1735-3327.86031.
59. Holland CS and Hinole MO. The influence of closure or dressing of third molar sockets on post-operative swelling and pain. Br J Oral Maxillofac Surg. 1984; 22:65-71.
60. De Brabander EC and Cattaneo G. The effect of surgical drain together with a secondary closure technique on post-operative trismus, swelling and pain after mandibular 3rd molar surgery. Int J Oral Maxillofac Surg. 1988; 17:119-121.
61. Waite PD and Cherala S. Surgical outcomes for suture-less surgery in 366 impacted third molar patients. J Oral Maxillofac Surg. 2006;64:669-673.
62. Ten Bosch JJ and van Gool AV. The interrelation of postoperative complaints after removal of the mandibular third molar. Int J Oral Surg. 1977; 6:22-28.
63. Balakrishnan G, Narender R, Kavin T, Venkataraman S and Gokulanathan S. Incidence of trismus in trans-alveolar extraction of lower third molar. J Pharm Bioallied Sci. 2017; 9(Suppl 1):S222-S227. Doi: 10.4103/jpbs.JPBS_161_17. PMID:29284968.
64. Pederson A. Interrelation of complaints after removal of impacted mandibular third molars. Int J Oral Surg. 1985; 14:241-244.

65. Greenfield BE and Morre JR. Electromyographic Study of postoperative trismus. J Oral Surg. 1969; 27:92-98.
66. Montero J and Mazzaglia G. Effect of removing an impacted mandibular third molar on the periodontal status of the mandibular second molar. J Oral Maxillofac Surg. 2011; 69:2691-2697.
67. Stella PEM, Falci SGM, de Mederios LEO, Douglas de Oliveira DW, Goncalves PF, Felcha OD and Santos CRRD. Impact of mandibular third molar extraction in the second molar periodontal status: A prospective study. J Indian Soc Periodontol. 2017;21(4):285-290. Doi: 10.4103/jisp.jisp_79_17. PMID:29456302.
68. Blakey GH, Jacks MT, Offenbacher S, Nance PE, Phillips C, Haug RH et al. Progression of periodontal disease in the second/third molar region in subjects with asymptomatic third molars. J Oral Maxillofac Surg. 2006;64:189-193.
69. White RP Jr, Offenbacher S, Blakey GH, Haug RH, Jacks MT, Nance PE et al. Chronic Oral Inflammation and progression of periodontal pathology in the third molar region. J Oral Maxillofac Surg. 2006; 64:880-885.
70. Rakhshan V. Common risk factors for postoperative pain following the extraction of wisdom teeth. J Korean Assoc Oral Maxillofac Surg. 2015 Apr;41(2):59-65. doi: 10.5125/jkaoms.2015.41.2.59. Epub 2015 Apr 23. PMID: 25922816; PMCID: PMC4411729.