Are antibiotics necessary after lower third molar removal?

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Objective. Patients (n = 110) free of antibiotics, operated on by 3 surgeons ranging in clinical experiences, were evaluated for infection.
Study Design. In the preoperative period and during the second and seventh postoperative days, the following parameters were analyzed: pain, infection, swelling, trismus, body temperature, C-reactive protein levels (CRP), and salivary neutrophil counts (SNC). During surgery, the following parameters were analyzed: systolic, diastolic, and mean arterial pressure; oximetry; heart rate; anesthesia quality; local anesthetic amount; bleeding; surgery difficulty; and surgery duration.
Results. There were some differences in the surgery duration, local anesthetic amount, anesthesia quality, bleeding, pain experienced, trismus, CRP, and SNC, and no changes in hemodynamic parameters, rescue analgesic medication, wound healing, swelling, body temperature, confirmed case of dry socket, or any other type of local infection. Particularly, no systemic infections were found after lower third molar removal (LTMR).
Conclusions. This study suggests that antibiotic prescriptions are unnecessary after LTMR when preoperative infections are absent. (Oral Surg Oral Med Oral Pathol Oral Radiol 2012;114(suppl 5):S199-S208)

Lower third molar removal is a common surgical procedure performed in dentistry that often results in pain, swelling, trismus, bleeding, nerve dysfunction, and postoperative infection. In addition, antibiotic therapy after impacted lower third molar removal (LTMR) is common and, until recently, universally accepted. Some evidence exists supporting routine prophylactic use of antibiotics to reduce postoperative complications after third molar surgery,[1-6] yet several studies have revealed an insignificant gain in a patient's postoperative condition after using antibiotics.[7-10] In this context, in an effort to reduce the development of drug-resistant and cross-resistant bacteria, clinicians must carefully consider the prophylactic use of antibiotics for invasive procedures. That is, antimicrobials should be administered only to treat bacterial infections or prevent bacterial infections in patients who are either immunocompromised or have a significant risk of postoperative infection.[8]

One factor that can contribute to postoperative complications is the surgeon's experience.[11-15] Some studies documented a negative correlation between the surgeon's experience and postoperative complications,[13,16] including infection, but others, such as Handelman et al.,[11] have shown no correlation. In addition, these studies did not assess the necessity of antibiotics based on the surgeon's experience. Thus, some hypothesized that clinical inexperience may cause a greater degree of tissue manipulation, duration of surgery, and bone removal, thus resulting in an increased risk of postextraction infection requiring antibiotics compared with clinically experienced surgeons.

Local tissue responses to injury or infection include acute inflammation.[17] The major clinical manifestations of this process reflect changes in vascular caliber and flow, increased vascular permeability, and the attraction of leukocytes to the site of injury. In addition to local responses, a vast number of systemic and metabolic changes occur.[17] Alterations in serum levels of acute-phase proteins is a nonspecific response that is observed whenever inflammation is present.[18] Thus, elevation of any or a combination of acute phase proteins can be used as a diagnostic test for infectious diseases.[17,19] C-reactive protein (CRP) is one such acute-phase protein. More specifically, a measurable increase in this protein occurs 6 hours after surgical trauma and these levels peak between 24 and 48 hours after tissue injury.[20,21]

CRP production is acutely triggered by disease, and it reliably indicates an inflammatory response, isch-

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emia, and bacterial infection.[20] Although CRP can be influenced by surgical trauma, the increased levels of CRP associated with surgical trauma are much less than what is observed in cases of bacterial infections. In general, CRP levels below 25 mg/L indicate signs of inflammation and not systemic infections.[22,23] In addition, Ren and Malmstrom[24] studied patients who visited the dental emergency clinic of the University of Rochester, Eastman Dental Center, for treatment of acute odontogenic infections, including acute alveolar abscess, acute periodontal abscess, and postoperative alveolar osteitis (AO). This study asserted that the quantification of serum CRP concentration can be used to monitor the therapeutic efficacy of different treatment regimens of infections.[25,26] Patients with signs of AO had increased CRP levels, but these patients seldom needed antimicrobial treatment, because AO not only results from bacterial infection, but from acute inflammation of denuded bone surfaces subsequent to surgical trauma.[24] Bisoendial et al.[27] also demonstrated that leukocyte activation by CRP with subsequent releases of mediators promotes plaque destabilization. This might, in part, explain the intricate relationship between infection and the increased onset of cardiovascular manifestations.

The purpose of this study was to test the necessity of routine antibiotic use after lower third molar surgeries with osteotomy. It was hypothesized that volunteers without preoperative infections and antibiotics would not develop postoperative complications after LTMR. The aim of this study was to evaluate numerous indicators of infection before LTMR and 2 and 7 days after surgery.

MATERIAL AND METHODS

The Institutional Ethics Committee approved the protocol of this study (#107/2007). The authors also confirm that they have read the Helsinki Declaration and have followed these guidelines in this investigation. All volunteers provided written informed consent during the pretreatment screening period. Eligibility criteria included volunteers aged 18 years or older with at least one lower third molar needing extraction with the necessity of bone removal based on panoramic radiography. Exclusion criteria included systemic illness and inflammation or infection at the extraction sites, use of antibiotic therapy, gastrointestinal bleeding or ulceration, cardiovascular and kidney diseases, and any known allergies to the following: the local anesthetic (4% articaine with 1:200,000 epinephrine), aspirin, piroxicam, or any other nonsteroidal anti-inflammatory drugs (NSAIDs). Pregnant women were also excluded from this study. Volunteers were instructed not to use antidepressants, diuretics, aspirin, or antibiotics 1 week before surgery and during the entire duration of the experiment to avoid possible unwanted interactions.[28-31]

Each volunteer's relevant third molar position was radiographed. In brief, the specific indications for extractions in this study were impacted third molars with limited or no space for eruption. Each third molar was then classified by its position into 5 categories: mesioangular, vertical, distoangular, horizontal, and vestibule-lingual. Some volunteers required 2 extractions, and, in this case, their surgeries were separated by at least 2 months. In particular, Meechan et al.[32] found that when the duration between 2 molar extractions was more than 2 months, the patients had only a vague sense of the surgical details and pain. Next, surgeries in each category were randomly assigned to 1 of 3 surgeons via a random drawing of the surgeon's name out of a box by the PhD student. Each of these surgeons had varying levels of experience with LTMR: 1 oral surgeon specialist, more than 10 years of experience with LTMR; 1 PhD student in oral biology, 5 years of experience with LTMR; and 1 senior dental student, no experience with LTMR, from the Bauru School of Dentistry at the University of São Paulo. Each surgeon performed surgery on 50 molars and followed the same standard surgical protocol.

It was necessary to obtain consenting adults requiring third molar extraction meeting the eligibility criteria set forth in the protocol. With this aside, the subjects enrolled were a random sampling of visitors to our institution from March 2009 to October 2009. As in most clinical studies, it was necessary to balance the available resources, such as volunteers, time, and cost, with obtaining a sample size large enough to both represent the population at large and have enough statistical power to detect a clinically significant difference. Therefore, the sample size used in this study was determined by similar previously published clinical studies and a balance of the available resources for this study.[29,33-35]

The NSAID administration protocol was 20-mg tablets of piroxicam taken orally once daily for 4 days after surgery. Oral rescue analgesic medication was also available to any volunteer as needed throughout the study; for this purpose, 750-mg tablets of paracetamol were provided to all volunteers.[28,29,31] Volunteers recorded the date and time at which rescue medication was consumed and were instructed not to interrupt the use of piroxicam. In all cases, before and after surgery no antibiotics and no antiseptic washes were used.

The following parameters were collected and assessed in this study. Surgery duration (minutes) after anesthetic administration; specifically, the period between the first incision and the last suture was re-

corded.[28,29,33,36] Subjective postoperative pain evaluations were documented, with the aid of a 100-mm-long visual analogue scale, with 0 representing "no pain" and 100 representing "worst pain imaginable."[28,31] The postoperative pain intensity was chronicled by each volunteer at 15-minute intervals for the first 60 postoperative minutes, and 1.5, 2, 3, 4, 5, 6, 7, 8, 10, 12, 16, 24, 48, 72 and 96 hours after the end of the surgery.[13,29] Time to first rescue analgesic medication and total amount of rescue analgesic medication ingested during the postoperative period were documented by each volunteer. Volunteers' temperatures were recorded before surgery and 2 and 7 days after surgery. Mouth opening (mm) between the mesial–incisal corners of the upper and lower right central incisors at maximum opening of the jaws was measured and recorded before the surgery and during the second and seventh postoperative days. The postoperative ability to open the mouth was expressed as a percentage of preoperative measurements.[29] Facial swelling was measured and recorded before surgery and during the second and seventh postoperative days.[29] This method produces a single value for each volunteer and it is the sum of the following distances (mm): the lateral corner of the eye to the angle of the mandible, the tragus to the outer corner of the mouth, and the tragus to the soft tissue pogonion. The preoperative sum of these 3 measurements was considered the baseline value. The difference between the sum of the postoperative measurements and the baseline values indicated the facial swelling. Incidence, type, and severity of adverse reactions were documented by each volunteer.[31,37] Global evaluation of the postoperative period (seventh postoperative day) by each volunteer was noted using "excellent," "very good," "good," "fair," or "poor."[38]

All hemodynamic parameters were collected noninvasively. Systolic, diastolic, and mean arterial blood pressure (mm Hg); heart rate (bpm); and oxygen saturation (pO_2) before, during, and after each surgery were performed and recorded with a monitoring system (DX2010, Dixtal Biomedica Ind. Com Ltd., Marília/SP, Brazil). Specifically, measurements were recorded during the following steps: immediately before the surgery, after injection of the first cartridge of local anesthetic solution, after tissue incision, after flap reflection, after bone removal, after tooth extraction, after cleaning of the operated site, and immediately after the suture placement.

Each surgeon evaluated the anesthetic latency and quality by using a standard 3-point scale: no reported discomfort (1); some discomfort reported, no additional local anesthetic required (2); and any discomfort requiring additional local anesthetic (3).[13,30,31] Each surgeon documented the total amount of anesthesia used. Surgical difficulty was also noted by each surgeon based on a common 3-point scale: easy (1), normal (2), and complicated (3).[13,30,31] The PhD student removed all the sutures and at this time each surgical site was evaluated by this person for signs of infection or other complications. In addition, the presence or absence of dry sockets with or without pus on both the second and seventh postoperative days was assessed and recorded.[13,31] CRP levels were measured (Single Test NycoCard CRP; Axis-Shield, Dundee, UK) before the surgery and during the second and seventh postoperative days.[17] Salivary neutrophils were counted before the surgery and during the second and seventh postoperative days.[39]

An independent statistician blinded to the details of the 3 surgical groups analyzed all the data. Briefly, all data were tested for normal distribution using the Shapiro-Wilk test, Anderson-Darling test, and Jarque-Bera test and visually inspected using *Q-Q* plots. Data regarding mouth opening, facial swelling, total amount of anesthetic, pain, surgery duration, trismus, edema, and hemodynamic parameters were statistically analyzed using analysis of variance followed by Tukey's test for multiple comparisons. Kruskal-Wallis 1-way analysis of variance was used for rescue medication, salivary neutrophil count, quality of anesthesia, and bleeding. For the salivary neutrophil count and CRP experiments, the Friedman test was used to detect differences among the volunteers treated by each surgeon. Statistical significance was established at 5%. The results are presented as a mean ± 1 SD.

RESULTS

Each of the 110 total volunteers, 67 females and 43 males, needed surgery for one or both lower third molars with some removal of bone necessary. The mean age of these randomly assigned volunteers was 22.7 ± 5.5 years. Each of the 3 surgeons removed 50 lower third molars. Forty volunteers required 2 extractions. Positions of the third molars were determined by panoramic radiography, and, with the exception of the vestibular-lingual lower third molar position, each surgeon removed lower third molars from each type of lower third molar position.

All parameters were tested for statistical differences among the surgeons. No significant differences were found between all parameters, with the exceptions of the following parameters: total number of volunteers with single extractions or double extractions, surgery duration, local anesthesia used during surgery, the number of volunteers who took rescue medication, CRP levels measured on the second day, number of neutrophils measured during the second day, the absolute swelling values measured during the second postoper-

ative day, and the change in swelling on the seventh day (Tables I and II). The distribution of lower third molar angulations randomly allocated to each surgeon is shown in Table I.

The total number of volunteers with single extractions or double extractions was significantly different among the surgeons ($P < .05$, Table I). More specifically, the oral surgeon extracted lower third molars from 38 volunteers of the 70 volunteers who had LTMR performed only once, whereas the dental student and the PhD student extracted lower third molars from 17 and 15 volunteers respectively. Accordingly, the oral surgeon had operated on a single volunteer only twice, whereas both the dental student and the PhD student operated on 8 and 10 volunteers twice, respectively ($P < .05$, Table I). Last, the oral surgeon removed a single lower third molar in 10 volunteers who were also operated on by one of the other surgeons, and this was not significantly different from the numbers of volunteers who were operated on by the dental student (17 volunteers) and PhD student (15 volunteers) in which each lower third molar was extracted by a different surgeon ($P > .05$, Table I).

The average duration of surgery for LTMR varied by as much as 15.7 minutes; the average surgery durations for the dental student, the PhD student, and the oral surgeon were 33.2 minutes ± 15.2, 28.5 minutes ± 13.7, and 17.5 minutes ± 5.4, respectively (Table I). Although surgery durations significantly varied among the surgeons, no correlation was found between surgery duration and postoperative infection. Indeed, no signs of postoperative infection were found in any of the volunteers. Furthermore, no dry sockets were detected in any volunteers during the second and seventh postoperative days. In addition, no significant differences in the surgeon's mean rating of surgical difficulty were observed among the 3 surgeons ($P > .05$, Table II).

Local anesthesia used during surgery was significantly different among the surgeons. Briefly, the dental student used significantly more local anesthetic, 3.4 ± 1.0 mL, than the PhD student and the oral surgeon, who used only 2.8 ± 0.2 mL and 2.7 ± 0.2 mL of local anesthetic, respectively ($P < .05$, Table I). In all cases, the amount of local anesthetic was not atypical and no correlations were found between local anesthesia used during surgery and postoperative infection. The latency of the local anesthetic was 1.73 ± 0.11 minutes (data not shown). The surgeon's quality of anesthesia rating indicated that the dental student was significantly different from the oral surgeon specialist ($P < .05$, Table II). Overall, the mean scores attributed to quality of anesthesia were very close to 1, suggesting that all of the volunteers felt no discomfort during their surgeries.

In general, CRP levels remained normal throughout the study. More specifically, during no point were average CRP levels higher than 20 mg/L (Table I). During the second postoperative day, the CRP levels of volunteers operated on by the PhD student were significantly less than the CRP levels of volunteers operated on by the other surgeons (Table I). Moreover, the average CRP levels in volunteers treated by all the surgeons before surgery was 8 ± 2 mg/L, and during the seventh postoperative day average CRP levels were 9 ± 7 mg/L (Tables I and II).

Briefly, the average number of salivary neutrophils in volunteers treated by the surgeons were not significantly different among volunteers before surgery, $2.28 \times 10^6 \pm 3.07 \times 10^6$, and during the seventh postoperative day, $5.13 \times 10^6 \pm 5.29 \times 10^6$ (Tables I and II). During the second postoperative day, the average numbers of salivary neutrophils of volunteers treated by the dental student were significantly increased from the PhD student (Table II), although both values could be considered normal. The number of salivary neutrophils in volunteers during the second postoperative day operated on by the dental student, the PhD student, and the oral surgeon were $6.20 \times 10^6 \pm 7.00 \times 10^6$, $1.96 \times 10^6 \pm 2.48 \times 10^6$, and $3.02 \times 10^6 \pm 2.67 \times 10^6$, respectively (Table II). Significant differences in the number of neutrophils during the second postoperative day existed between volunteers operated on by the dental student and the volunteers operated on by the PhD student. When data from each surgeon were pooled together, no significant differences were detected among any of the time points tested. Overall, the average numbers of salivary neutrophils in volunteers treated by the surgeons throughout this study were near or below the average number of salivary neutrophils in control volunteers reported in other studies.[40]

Before surgery, no significant differences were detected among the volunteers operated on by any of the surgeons and the average facial contour of all the volunteers was 124 ± 7 mm ($P > .05$, Table I). During the second postoperative day, the swelling measured in the volunteers operated on by the dental student, 124 ± 6 mm, was significantly less than the volunteers operated on by the PhD student and oral surgeon, 127 ± 7 mm and 129 ± 8 mm, respectively ($P < .05$, Table II). The change in swelling on the seventh day, was significantly less in volunteers operated on by the PhD student, 0 ± 3 mm when compared with dental student and oral surgeon, 2 ± 3 mm and 1 ± 3 mm, respectively ($P < .05$, Table II). No correlations were found between swelling and any postoperative infection.

Body temperatures were measured before, and 2 and 7 days after surgery and there were no cases of tem-

Table I. Study variables

	Dental student (A)	*PhD student (B)*	*Oral surgeon (C)*	*Total*	*P value*	
Total no. teeth	50	50	50	150	—	
Total no. patients	42*	40*	49*	110*	.018	B vs C
Age range, y	16–39	16–56	17–34	16–56	—	
Mean age, y	22.1 ± 4.9	23.4 ± 7.2	22.7 ± 4.5	22.7 ± 5.5	.654	
No. females	27	18	22	67	.458	
Age range, y	17–39	16–56	17–34	16–56	—	
Mean age, y	22.9 ± 5.1	23.4 ± 8.8	23.0 ± 4.7	23.1 ± 6.2	.829	
No. males	15	11	17	43	.458	
Age range, y	16–29	18–29	18–30	16–30	—	
Mean age, y	20.7 ± 4.0	23.4 ± 3.5	22.4 ± 4.2	22.1 ± 4.1	.897	
Third molar position						
Mesioangular	16	15	12	43	.639	
Vertical	15	8	17	40	.123	
Distoangular	10	16	7	33	.105	
Horizontal	9	10	14	33	.459	
Vestibule-lingual	0	1	0	1	.368	
Single extractions	17	15	38	70	<.0001	C vs A and B
One of two extractions	17	15	10	21	.261	
Two of 2 extractions	8	10	1	19	.029	C vs A and B
Osteotomy necessary	50	50	50	150	—	
Mouth opening, mm—preoperative period	46 ± 7	49 ± 8	46 ± 9	47 ± 8	.181	
Facial contour, mm—preoperative period	120 ± 6	125 ± 7	126 ± 8	124 ± 7	.164	
Temperature, °C—preoperative period	36.1 ± 0.6	36.2 ± 0.6	35.9 ± 0.7	36.1 ± 0.7	.183	
C-reactive protein levels—preoperative period	8 ± 2	8 ± 3	8 ± 2	8 ± 2	.993	
Neutrophils—preoperative period	$2.71 \times 10^6 \pm 3.17 \times 10^6$	$1.40 \times 10^6 \pm 2.67 \times 10^6$	$2.57 \times 10^6 \pm 3.13 \times 10^6$	$2.28 \times 10^6 \pm 3.07 \times 10^6$	.055	
Local anesthesia used during surgery, mL†	3.4† ± 1.0	2.8 ± 0.2	2.7 ± 0.2	3.0 ± 0.7	<.0001	A vs B and C
Surgery duration, min	33.2 ± 15.2	28.5 ± 13.7	17.5 ± 5.4	26.4 ± 13.9	<.0001	C vs A and B
Hemodynamic parameters before surgery						
Systolic blood pressure, mm Hg	118.1 ± 12.1	120.5 ± 12.7	119.6 ± 12.7	119.4 ± 12.5	.621	
Diastolic blood pressure, mm Hg	67.8 ± 8.3	71.3 ± 9.5	70.1 ± 8.2	69.8 ± 8.8	.136	
Mean arterial blood pressure, mm Hg	89.0 ± 17.7	91.3 ± 11.4	89.2 ± 10.4	89.8 ± 13.6	.649	
Heart rate, bpm	84.2 ± 11.3	81.1 ± 14.2	79.2 ± 16.0	81.5 ± 14.1	.200	
Oxygen saturation (pO_2)	97.4 ± 0.7	97.0 ± 1.3	97.4 ± 0.8	97.3 ± 1.1	.079	
Surgeon's surgical evaluation						
Surgery difficulty (1-5)	2.3 ± 1.0	2.2 ± 0.7	2.2 ± 0.6	2.2 ± 0.8	.992	
Anesthesia quality (1-3)	1.5 ± 0.7	1.2 ± 0.4	1.1 ± 0.4	1.3 ± 0.6	.001	A vs C
Bleeding (1-3) @ 7 stages	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	.578	

A few significant differences were found among the volunteers treated by each surgeon ($P > .05$). —, indicates that statistical analysis was not performed.
*Some volunteers were treated by 2 surgeons; note the number of single, 1 of 2, and 2 of 2 extractions.
†Local anesthesia 1.8-mL cartridges of 4% articaine with 1:200,000 epinephrine.

Table II. Outcome variables during the second and seventh day after lower third molar extraction

	Dental student (A)	*PhD student (B)*	*Oral surgeon (C)*	*Total*	*P value*	
Signs of infection, no. of patients	0	0	0	0	—	
No. of dry sockets, 2nd day postop. period	0	0	0	0	—	
No. of dry sockets, 7th day postop. period	0	0	0	0	—	
C-reactive protein levels, 2nd day postop. period	20 ± 19	9 ± 5	19 ± 27	16 ± 19	<.0001	A vs B and C
C-reactive protein levels, 7th day postop. period	9 ± 5	10 ± 9	8 ± 3	9 ± 7	.939	
No. of neutrophils, 2nd day postop. Period	$6.20 \times 10^6 \pm 7.00 \times 10^6$	$1.96 \times 10^6 \pm 2.48 \times 10^6$	$3.02 \times 10^6 \pm 2.67 \times 10^6$	$3.61 \times 10^6 \pm 4.61 \times 10^6$	.006	A vs B
No. of neutrophils, 7th day postop. period	$6.57 \times 10^6 \pm 7.42 \times 10^6$	$3.62 \times 10^6 \pm 3.64 \times 10^6$	$5.18 \times 10^6 \pm 4.18 \times 10^6$	$5.13 \times 10^6 \pm 5.29 \times 10^6$	.321	
Mouth opening, mm, 2nd day postop. period	26.3 ± 9.2	36.5 ± 10.8	32.3 ± 12.1	31.7 ± 11.5	<.0001	
Mouth opening, mm, 7th day postop. period	36.3 ± 11.1	46.6 ± 9.5	40.0 ± 10.7	41.0 ± 11.3	.519	
Mouth opening, %, 2nd day postop. period	57.9 ± 19.0	74.5 ± 15.9	69.9 ± 20.1	67.4 ± 19.7	.242	
Mouth opening, %, 7th day postop. period	79.5. ± 21.3	95.9 ± 11.7	86.9 ± 14.4	87.4 ± 17.6	.517	
Swelling, mm, 2nd day postop. period	124 ± 6	127 ± 7	129 ± 8	126 ± 7	<.0001	A vs C and B
Swelling, mm, 7th day postop. period	122 ± 5	125 ± 7	126 ± 7	124 ± 7	.053	
Δ Swelling, mm, 2nd day postop. period	4 ± 3	2 ± 2	3 ± 3	3 ± 3	.118	
Δ Swelling, mm, 7th day postop. period	2 ± 3	0 ± 3	1 ± 3	1 ± 3	<.0001	A vs C
Temperature, °C, 2nd day postop. period	36.0 ± 0.9	36.1 ± 0.6	35.9 ± 0.5	36.0 ± 0.7	.125	
Temperature, °C, 7th day postop. period	35.9 ± 0.8	36.1 ± 0.5	36.0 ± 0.6	36.0 ± 0.6	.731	
Time to first rescue medication, h	18.4 ± 31.3	23.4 ± 30.7	24.6 ± 42.2	21.7 ± 35.0	.921	
Total amount of rescue medication, mg*	2060 ± 1740	1380 ± 1590	1430 ± 1490	1620 ± 1640	.064	
Patients who took rescue medication	41/50	30/50	32/50	103/150	.013	A vs B and C
Wound-healing evaluation†	1.26 ± 0.5	1.06 ± 0.2	1.26 ± 0.5	1.19 ± 0.5	.044	B vs A and C
Reports of adverse reactions (during/postop.)	0/0	1/2	0/4	1/6	.135	

postop., postoperative.

*Rescue medication provided was paracetamol (750 mg tablets).

†Wound healing was evaluated by a PhD student during the seventh postoperative day.

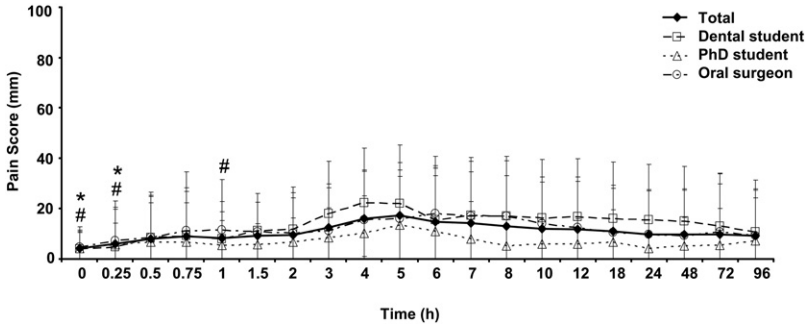

Fig. 1. Mean pain scores (mm) recorded by volunteers (n = 110) with the aid of a 100-mm-length visual analogue scale at 0.25, 0.50, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 10, 12, 16, 24, 48, 72 and 96 h after the end of the surgery for lower third molar extraction. At each time point studied there were no significant differences detected among the 3 groups of volunteers ($P > .05$, Tukey's test). # Significantly different from the dental student group at time 4 hours and the time point noted for the dental student group ($P < .05$); * significantly different from the dental student group at time 5 hours and the time point noted for the dental student group ($P < .05$). Data are presented as means ± 1 SD.

peratures higher than 38°C. Specifically, average preoperative body temperatures were 36.1 ± 0.7°C, and average postoperative body temperatures were 36.0 ± 0.7°C during the second day and 36.0 ± 0.6°C during the seventh day (Tables I and II). Overall, body temperatures of all the volunteers throughout this study remained notably stable. In addition, all hemodynamic parameters tested showed little variation among all volunteers and the hemodynamic parameters tested remained clinically normal.

No adverse reactions were observed by the surgeons or reported by the volunteers during the surgery or the first postoperative hour. Regarding piroxicam use during the second and seventh postoperative days, 2 volunteers noted nausea, 1 volunteer noted stomach ache, and 1 volunteer noted sleepiness and trembling. One volunteer presented hemorrhage on the second and seventh postoperative days. Another volunteer presented pericementitis in the second molar and a third had lingual paresthesia. None of these volunteers had any clear sign of infection during postoperative inspection.

According to the volunteers' global evaluations of their postoperative period, most volunteers classified their postoperative period as "good," "very good," or "excellent." A significant difference was found between the volunteers operated by the PhD student and the other surgeons; these patients evaluated this postoperative period more positively than the volunteers operated on by the oral surgeon specialist and the senior dental student ($P < .05$, Figure 1).

Wound healing was assessed and recorded by the PhD student during suture removal. More specifically, wounds were evaluated close to a score of 1 in almost all surgeries performed by all of the surgeons. In addition, the volunteers operated on by the PhD student had a significantly lower rating than volunteers operated on by both the dental student and the oral surgeon ($P < .05$, Table II, Figure 2). Thus, the average wound-healing rating for the patients operated on by the PhD student was slightly but significantly better than the patients operated on by the other surgeons. Notably there were no signs of complications in or around the surgical sites in any of the volunteers.

DISCUSSION

The prescription of antibiotics after lower third molar surgeries involving bone removal is still a controversial topic. Besides other factors, it has been speculated that surgical experience with LTMR surgery could affect the occurrence of infection at the site of surgery. In this study, volunteers operated on by any of the surgeons did not experience postoperative infection.

Among the 3 surgeons, there were some differences in the surgery duration, local anesthetic amount, CRP levels during the second postoperative day, salivary neutrophil counts, and swelling values. Because no signs of postoperative infection were found in all of the volunteers it appears that none of the statistically significant differences found among the surgeons were correlated with infection. Furthermore, even considering some significant differences in the CRP values and the salivary neutrophil counts, all of these values were not indicative of infection. In addition, among the 3 surgeons many differences were not significant. In particular, there were no significant changes between pre- and postoperative parameters measured in hemodynamic parameters, rescue analgesic medication, wound healing, mouth opening, body temperature, confirmed cases of dry socket, or any other type of local infection in the volunteers. These results suggest that antibiotic prescriptions were unnecessary after LTMR. That is, average CRP levels, an indicator of tissue damage, measured preoperatively and during the second and

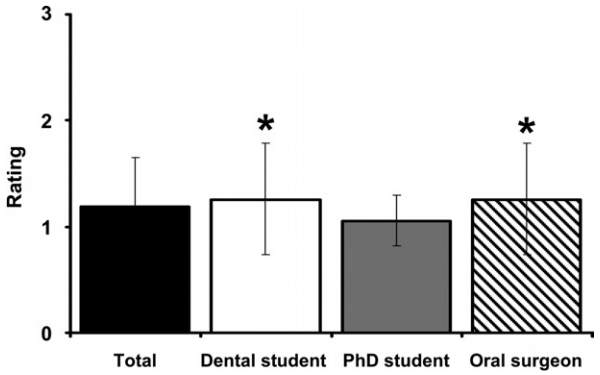

Fig. 2. Global evaluations of wound healing during the seventh postoperative day were rated using a 3-level Likert scale by the PhD student (n = 110) who received surgery from each of the surgeons. The format of the Likert items was "1," normal healing, without inflammation; "2," delayed healing; or "3," deficient healing with inflammation or local infections. The PhD student's ratings of each volunteer were averaged together and are represented by as the solid black bar (total). Data are presented as means ± 1 SD. *Significantly different from PhD student ($P < .05$, Kruskal-Wallis test).

seventh days, did not show levels higher than 20 mg/L,[22,23] supporting other data in this investigation that showed no signs of systemic infection. Likewise, overall, the average numbers of salivary neutrophils in volunteers treated by the surgeons were near or below the average number of salivary neutrophils in control volunteers as reported by other studies.[39,40] In sum, no volunteer had CRP levels or average numbers of salivary neutrophils that indicated infection or systemic signs of alveolitis installation. All these parameters investigated indirectly indicated no oral infection, corroborating the surgeon's evaluation of volunteers being free of oral infections.

Tests showed significant differences on the second day between the senior dental student and the oral surgeon and the PhD student, with the PhD student's values being significantly lower when compared with the other surgeons. This decreased average CRP level might have resulted from the generally smaller incision made by the PhD student surgeon. The duration of surgery did not affect the amount of tissue damage, as indicated by the CRP values. Therefore, it was hypothesized that the decrease in surgical trauma could be a result of the length of the incision, which tended to be longer in the surgeries performed by the senior dental student and shortest in surgeries performed by the PhD student, and not a result of the increase in surgical duration.

Bulut et al.,[17] in 2001, showed that routine administration of antibiotic prophylaxis is not always beneficial in volunteers who underwent LTMR. More specifically, CRP levels were compared between one group given amoxicillin during pre- and postoperative periods and a second control group given a placebo, and by 168 and 172 hours after LTMR the CRP levels had returned to levels considered normal with no significant differences between these 2 groups. There was a significant difference, however, between the experimental group and control group 24 hours following surgery resulting from the trauma of these surgeries. These findings corroborate the results observed in this study, as there was a mild increase of CRP levels during the second postoperative day, which was then followed by a tendency for the CRP levels to return to baseline levels on the seventh postoperative day. This elevation of CRP levels during the second postoperative day may be a result of surgery-induced aseptic traumatic inflammation.[17] These findings indicate that CRP levels can be used for early detection of bacterial infections. In addition, these levels are also useful for monitoring the clinical course of the volunteers who underwent LTMR with the necessity for bone removal.

Acute infections may initiate cardiovascular events by unknown mechanisms. Bisoendial et al.,[27] in 2009, showed that leukocytes were activated by CRP with liberation of mediators that promote plaquetary destabilization, which could explain, in part, the increased risk of cardiovascular events in humans.

Regarding adverse reactions with the medication, there were isolated cases of nausea, stomach pain, sleepiness, and trembling. One volunteer presented pericementitis in the second molar. A second volunteer presented lingual paresthesia during 1 month and another volunteer experienced hemorrhage on the second and the eighth postoperative days.

In this study, intraoperative bleeding was evaluated during the surgery protocol by each surgeon using a subjective method based on a scale of 3 points. Although this method is subjective, it is accepted and has been widely used.[13,30,31] Values close to 1, indicating minimal bleeding, were reported during most of the standard surgery protocol. More specifically, the senior dental student was significantly different compared with the other surgeons during the first incision, probably a result of his need to make an extensive flap during the surgery.

Constantly monitoring vital signs of volunteers is required to rapidly correct possible hypoxia in volunteers subjected to oral surgery.[30] Minor fluctuations in vital signs are common during administration of local anesthetics.[41] In this study, the cardiovascular parameters analyzed were arterial pressure levels (systolic, diastolic, and mean), heart rate, and oxygen saturation before and during the surgery and after suturing; body temperature was also measured. There were no consistent changes in vital signs observed during baseline

measurements, immediately after the injection of the first local anesthetic cartridge, 3 minutes later, or at the end of the surgical procedure for all groups (data not shown). Transient increases and decreases in blood pressure, heart rate, and oxygen saturation were observed, but they were not clinically significant.

During the second postoperative day, volunteers experienced swelling, which tended to cease by the seventh postoperative day. These observations may have resulted from the administration of piroxicam used in this study. Correspondingly, several studies have confirmed piroxicam's efficacy in reducing or eliminating swelling during the postoperative period when bone removal was necessary during LTMR.[30,31,34,35]

Body temperatures exceeding 39°C for 2 or more days suggest infection.[3,10] Body temperature in this study measured before surgery and on the second and seventh postoperative days remained unchanged in all volunteers. Thus, in this study the body temperature parameter indicated no general infection. These results support the hypothesis that antibiotics should not be prescribed to volunteers who undergo LTMR.

The PhD student evaluated wound healing for all the surgeries performed in this study when the sutures were removed 7 days after surgery. In almost all cases, the score attributed was close to normal (near a score of 1) for all surgeries performed by each of the surgeons. Thus, the surgical experience in LTMR of each surgeon did not affect the healing of the wound created by the surgery. Only one volunteer needed irrigation. In this case, the volunteer was operated on bilaterally, with each molar being removed at 2 distinct times. One side was operated on by the oral surgeon, and the other side was operated on by the dental student, and in both surgeries irrigation of the surgical area was necessary. Most likely, the necessity for irrigation was a result of this individuals' poor hygiene rather than the surgeon's experience with LTMR.

CONCLUSIONS

In the limited number of cases in this study, not prescribing preoperative or postoperative antibiotics did not create a significant infection rate. This was also noted to be unrelated to the experience of the surgeon or the time the surgery took.

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