ARTICLE IN PRESS

Journal of Cranio-Maxillo-Facial Surgery xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Le fort I osteotomy with or without concomitant removal of upper third molars: A prospective cohort study of intraoperative findings, related complications, and level of pterygomaxillary separation after down-fracture

A. Valls-Ontañón [a,b,*], M. Ghuloom [c], T. Starch-Jensen [d], Ö. Kesmez [d], M. Giralt-Hernando [b], F. Hernández-Alfaro [a,b]

[a] *Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Barcelona, Spain*
[b] *Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain*
[c] *Fellow, Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Barcelona, Spain*
[d] *Department of Oral and Maxillofacial Surgery, Aalborg University Hospital, Aalborg, Denmark*

ARTICLE INFO

Handling editor: Emeka Nkenke

Keywords:
Algorithm
Cone-beam computed tomography
Le fort osteotomy
Maxillary osteotomy
Orthognathic surgery
Third molar
Wisdom teeth

ABSTRACT

The main objective of our study was to assess the clinical implications of concomitant intraoperative removal of maxillary third molars (M3M) with the Le Fort I osteotomy 'twist' technique (LF1twist). A prospective comparative study was carried out regarding the necessity of bone trimming around the pedicle, intra- and postoperative complications, surgery time, and the level of pterygomaxillary junction (PMJ) separation following LF1twist with concomitant intraoperative removal of M3M (test group) versus LF1twist alone (control group). Outcome parameters were assessed from clinical and radiographic measurements. In total, 100 surgery sites were included (50 in each group). The mean surgery time was 53.4 ± 7.8 min, with nonsignificant differences between groups. The frequency of intraoperative complications was negligible, with no significant differences between groups — though all bleeding events ($n = 4$) occurred when M3M was not removed concomitantly. No postoperative complications were recorded. Percentages of disarticulations occurring at the PMJ were similar in both groups. In conclusion, the results demonstrate that removal of M3M in conjunction with LF1twist does not imply additional surgery time, or differences regarding the level of PMJ separation or perioperative complications. Furthermore, the concomitant procedure reduces the amount of maxillary and palatal bone in the disjunction area, which facilitates down-fracture and field clearing for maxillary repositioning.

1. Introduction

Le Fort I osteotomy (LF1) is the most frequent surgical procedure for correcting dentofacial deformities of the maxilla (Obwegeser, 1969). Pterygomaxillary disjunction with separation of the maxillary tuberosity from the anterior pterygoid plates is mandatory to achieve sufficient mobilization of the maxilla during LF1 osteotomy. Ideally, pterygomaxillary junction (PMJ) separation should begin laterally in the pterygomaxillary groove and progress medially through the PMJ, although separation frequently occurs in front of the PMJ at the level of the posterior wall of the maxillary sinus, or behind it at the level of the pterygoid plate (Chin et al., 2017). While separation involving the pterygoid plate is more often related to potential neurovascular complications (Eshghpour et al., 2018; Kramer et al., 2004; Politis, 2012), fracture patterns occurring in front of the PMJ jeopardize successful maxillary mobilization, since effective separation of the maxilla from the pterygoid process of the sphenoid bone is required.

Multiple technical modifications as well as the development of instruments tailored to the operation have been described, seeking to improve accuracy and predictability (Ueki et al., 2004), as well as to reduce the potential morbidities associated with inadequate separation or unfavorable propagation of the fractured bones (Eshghpour et al., 2018; Kramer et al., 2004; Robinson and Hendy, 1986). These include the LF1 'twist' technique (LF1twist), described by the author's team in 2013 (Hernández-Alfaro and Guijarro-Martínez, 2013a, b).

The presence of impacted maxillary third molars (M3M) can exert an influence upon posterior maxillary anatomy and the pterygomaxillary disjunction patterns during LF1 osteotomy. Cheung et al. demonstrated

* Corresponding author. Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Barcelona, Spain.
E-mail address: avalls@institutomaxilofacial.com (A. Valls-Ontañón).

https://doi.org/10.1016/j.jcms.2024.01.006
Received 20 January 2023; Received in revised form 3 November 2023; Accepted 9 January 2024
Available online 13 January 2024

that impacted M3M-modified posterior maxillary anatomy makes it advisable to change the angulation of LF1 osteotomies in order to avoid greater palatine artery damage (Cheung et al., 1998). Posteriorly, Balaji reported that the removal of M3M in conjunction with LF1 located at the vertical osteotomy line appeared to have favorable effects, due to lessened bone reduction and a clear field for maxillary repositioning — thus also reducing the risk of bleeding due to surgical manipulation (Balaji, 2011). Lastly, Steinbacher et al. reported no increased risk of adverse perioperative outcomes or differences in the hospital course when both procedures were performed simultaneously (Steinbacher and Kontaxis, 2016). However, to the best of our knowledge, the influence of impacted M3M and their removal in conjunction with LF1twist upon the level of the PMJ disjunction has not been analyzed to date.

Although controversial, there is substantial evidence for the pros and cons of concomitant lower wisdom teeth removal during bilateral sagittal split osteotomy (BSSO) (Steinbacher and Kontaxis, 2016; Morton and Downie, 2017; Shoshani-Dror et al., 2018). In this respect, while some authors advocate their removal at least 6 months prior to BSSO in order to lessen the risk of a bad split, other investigators have recommended simultaneous procedures in order to avoid the need for additional surgery and its associated recovery period. However, there is a lack of data in the literature on the suitability of simultaneous procedures in the upper jaw and their possible related complications, such as their influence upon the level of PMJ separation, or the risk of increased rates of oroantral communication, infection, or bleeding.

Our study was therefore designed to assess clinical implications, such as the necessity of bone trimming around the pedicle, the level of PMJ disarticulation, as well as intra- and postoperative complications, following LF1 osteotomy in conjunction with M3M removal (test group) compared with LF1 without M3M removal (control group).

2. Materials and methods

2.1. Study design and sample selection

A prospective study was made of consecutive patients undergoing LF1, either as a single procedure or as part of bimaxillary surgery, at the Institute of Maxillofacial Surgery (Teknon Medical Center, Barcelona, Spain). The study design involved two cohorts defined according to the M3M extraction protocol used (test group: uni- or bilateral concomitant M3M removal and LF1; control group: LF1 without M3M removal). Patients were operated upon between January and December 2020. The study inclusion and exclusion criteria are described in Table 1.

The study was approved by the Ethics Committee of Teknon Medical Center (Barcelona, Spain) (ref. LF1-WT), and was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and later amendments).

2.2. Surgical procedure

The surgical procedure was performed by the same surgeon (FHA) under general anesthesia with nasotracheal intubation, supplemented with local anesthesia. The mandible was operated first in all cases, when necessary. All M3M were removed immediately before LF1 in the test group, while the M3M were absent or removed at least 6 months months prior to LF1 in the control group. After socket irrigation, primary closure of the socket, regardless of the degree of molar eruption into the oral cavity, was performed, using a mucoperiosteal pedicle flap when necessary, with a 5-0 polyglactin suture. The LF1 osteotomy was carried out using the minimally invasive 'twist' technique (Hernández-Alfaro and Guijarro-Martínez, 2013a, b).

Maxillary rigid internal fixation was the same in both groups, involving two preformed Lindorf miniplates (prebent maxillary advancement miniplates) fixed with monocortical screws. All patients wore a closed-circuit cold mask (17 °C) during hospital admission, and were discharged 24 h after surgery. Identical postoperative recommendations and antibiotic and analgesic medications were prescribed in both groups. Functional training using light guiding elastics was performed for 1 month, with a soft diet during the same period in both groups.

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Age >18 years in non-growing status • Dentofacial deformity in need of LF1 osteotomy • Signed informed consent	• Isolated bilateral sagittal split osteotomy • Segmented LF1 osteotomy • Upper wisdom teeth with concomitant pathology — cyst or infection • Craniofacial syndrome • Previous fracture of the maxilla • Compromised bone healing • Missing follow-up visits

Abbreviation: LF1, Le Fort I.

2.3. Data acquisition and evaluation of study variables

Cone-beam computed tomography (CBCT) (iCAT; Imaging Sciences International, Hatfield, PA, USA) was performed prior to surgery (T0) and 1 month after surgery (T1) in all patients, as part of our center's protocol for subjects undergoing orthognathic surgery (Hernández-Alfaro and Guijarro-Martínez, 2013b). The patients were instructed to breathe calmly, sitting in natural head position with the tongue relaxed and the mandible in centric relation, with a 2 mm wax bite in place to avoid direct contact between teeth.

The following variables were recorded: patient age and gender, concomitant M3M removal, and the degree of M3M impaction according to Archer's classification (Archer, 1966) (type A — M3M is at or below the occlusal plane; type B — M3M is between the occlusal plane and the cervical line; type C — M3M is between the cervical line of the second molar and the middle third of its root; type D — M3M is at or above the apical third of the root of the second molar).

The duration of LF1 osteotomy (from incision to the last suture of the maxillary mucosa) was documented, as well as any peri- and postoperative complications, such as bleeding, prolongation of hospital stay, vascular and neurological damage, infection, oroantral communication, and secondary soft tissue and bone healing problems.

In order to assess the level of disjunction at the posterior maxilla, both CBCT volumes from the two intervals were superimposed using Dolphin Imaging 3D software (Dolphin Imaging, Chatsworth, CA, USA) with a voxel-based protocol consisting of three successive steps ('side-by-side superimposition') (Haas Junior et al., 2019). Two examiners (MG and AVO) evaluated the level of PMJ separation twice and compared their results, with new evaluations taken after a 2-week interval, to ensure accuracy and reproducibility. The intrarater and interrater agreements were evaluated using the kappa concordance index. The location of PMJ disjunction was assessed at the level of the posterior nasal spine (Fig. 1) on the axial view of the images (Ueki et al., 2009), and was classified as follows.

- In front of the PMJ, at the maxillary tuberosity, where part of the posterior wall of the maxillary sinus remains attached to the PMJ after separation (Fig. 2a).
- At the pterygomaxillary suture (Fig. 2b).
- Behind the PMJ, at the pterygoid plate (Fig. 2c).

2.4. Statistical analysis

Descriptive analysis was carried out for the study variables, with calculation of the mean, standard deviation (SD), minimum and maximum values, and median for continuous variables. Absolute and relative frequencies (percentages) were reported for qualitative variables. Ninety-five per cent confidence intervals (95%CI) were calculated

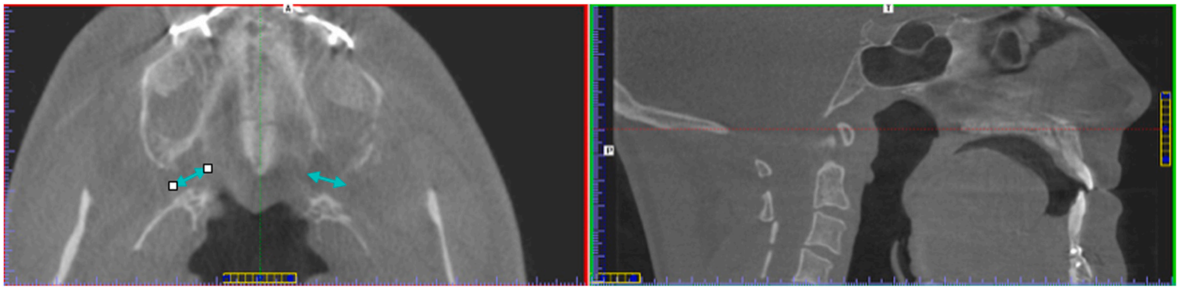

Fig. 1. Pterygomaxillary separation assessment at the level of the posterior nasal spine.

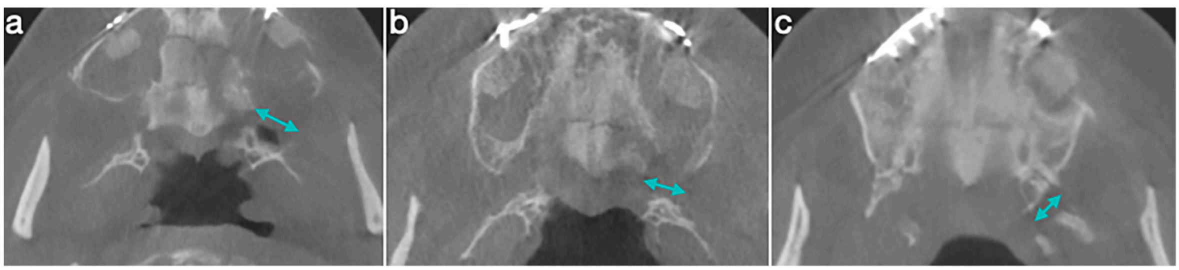

Fig. 2. Levels of pterygomaxillary separation: (a) at the level of the posterior wall of the maxillary sinus; (b) at the level of the pterygomaxillary junction; and (c) at the level of the pterygoid plates.

to estimate the location of PMJ separation in both groups, using a binomial distribution.

Regarding the inferential analysis, simple logistic regression was used to assess the association between level of separation and group. Non-adjusted odds ratios (OR) and 95%CI were obtained. The influence of demographic profiles was also assessed using the same method. Multiple logistic regression was used to establish an adjusted model including all independent factors. Adjusted odds ratios (OR) and 95%CI were recorded.

The McNemar test was used to analyze the symmetry of the level of PMJ disarticulation on both sides. Two-sample *t*-testing and the Mann-Whitney *U* test were used to compare mean values and distributions, respectively, of normal and non-normal variables between two groups. The chi-square test and Fisher's exact test were used to assess dependence between categorical variables (complications).

The chi-square test afforded a statistical power of 89% in identifying differences in PMJ separation at suture levels of 20% and 50% in both groups ($n = 100$ laterals) as being significantly different, assuming a confidence level of 95%. Power was corrected because symmetry between both sides was observed (dependence between sides). After correcting for the duplicity of observations for each patient and assuming a moderate intraclass correlation coefficient (ICC) ($\rho = 0.5$), the effective statistical power dropped to 73.5%.

3. Results

A total of 50 patients (25 with bilateral M3M removal and 25 without M3M removal) and 100 surgery sites (50 in the test group and 50 in the control group) were included in the study. The types of M3M impaction according to Archer's classification are summarized in Table 2. There were 35 females (70%) and 15 males (30%), with a mean age of 29.4 ± 8.1 years (range: 18–50). Most patients were operated upon according to the surgery late protocol (76%), followed by the surgery first (20%) and surgery early (4%) protocols (Hernández-Alfaro and Guijarro-Martínez, 2014).

The group homogeneity analysis found both groups to be homogeneous. Regarding patient gender, no significant differences were detected on the right or left sides ($p = 0.355$ for both; chi-square test).

Table 2
Degree of maxillary third molar impaction according to Archer's classification.

		N	%
Right M3M	**Total**	25	100.0
Archer class	**b**	4	16.0
	c	17	68.0
	d	4	16.0
Left M3M	**Total**	25	100.0
Archer class L8	**b**	3	12.0
	c	17	68.0
	d	5	20.0

With regard to age, patients without M3M removal were slightly older, but no significant differences were observed ($p = 0.060$ and $p = 0.255$, respectively; Mann-Whitney *U* test). Intrarater concordance was excellent (AVO = 0.808 and MG = 0.800), as was the interrater kappa index (0.800).

The need for bone trimming around the pedicle was significantly greater on both sides when LF1 was performed alone without simultaneous M3M removal ($p < 0.001$; chi-squared test).

The percentage of PMJ disarticulation occurring at the pterygomaxillary suture was similar in both groups (Fig. 3). The analysis of dependence between the level of PMJ disarticulation and the independent variables revealed no significant influences between them on both sides: presence of M3M (right side $p = 0.278$, left side $p = 0.966$), gender (right side $p = 0.576$ and left side $p = 1.000$), age (right side $p = 0.305$ and left side $p = 0.957$) (Fig. 4). Multiple model analysis to control for potential confounder effects showed a lack of effect of independent variables with regard to level of PMJ disarticulation (Table 3). Moreover, PMJ disarticulation occurring at the pterygomaxillary suture proved similar on both sides, and not related to the presence or absence of M3M (OR = 1.54; $p = 0.498$). Thus, according to the McNemar test, the outcome 'symmetry' could be accepted ($p = 1.000$) (Table 4).

The mean surgery time was 53.4 ± 7.8 min (range 42–75), with the distribution in both groups being extremely similar, with no significant differences (right side $p = 0.642$, left side $p = 0.314$) (Fig. 5). However, a strong tendency relating to age was noted ($p = 0.070$), with each additional year implying an increase in surgery time of 0.27 min. In

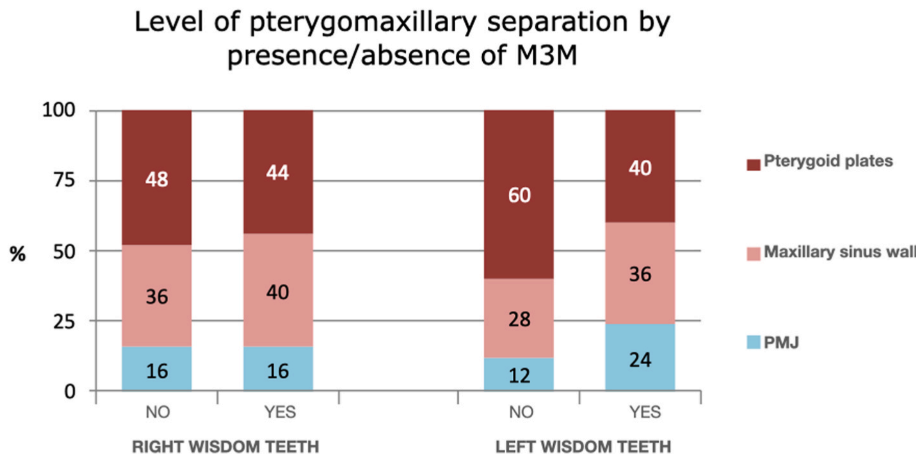

Fig. 3. Level of pterygomaxillary separation according to the presence/absence of maxillary third molars.

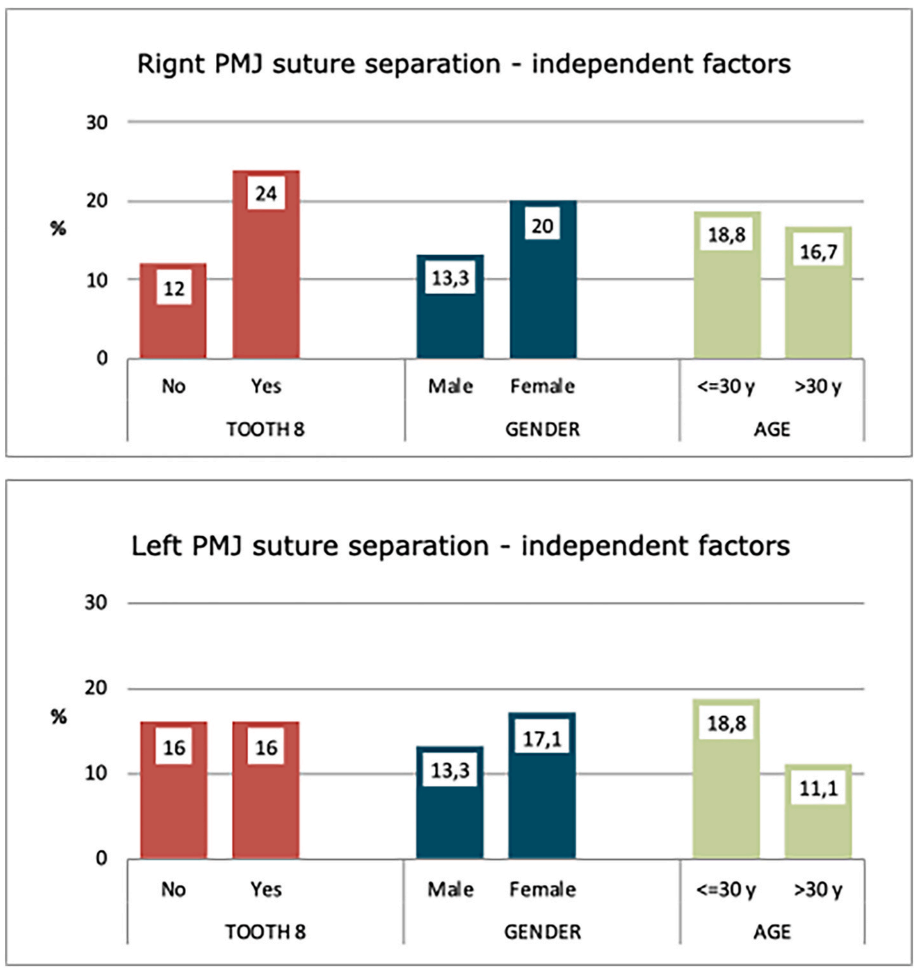

Fig. 4. Pterygomaxillary separation at the suture level according to independent factors.

other words, +10 years implied +2.7 min (Fig. 6). All patients were discharged the day after surgery.

Lastly, overall intraoperative complications were minor on both the right and left sides, with bleeding in two patients per side (4%). Although all bleeding events ($n = 4$) occurred when M3M removal was not required, no significant differences were recorded between the groups ($p = 0.117$). No postoperative complications were reported.

4. Discussion

Our prospective study showed that the intraoperative removal of M3M in conjunction with LF1twist osteotomy does not interfere with the level of PMJ disarticulation, overall surgery time, or the risk of intra- and perioperative complications; moreover, the necessity to trim bone around the pedicle is reduced.

According to the protocol used at our center, with over 20 years of

Table 3
Data on the number of surgical sites (one or two) per patient and group (control and test), studied side, or extracted molar and its position according to Winter's and Pell & Gregory's classifications.

Patient-level evaluation (n = 50)	Variable	Statistical analysis	p-value (right side)	p-value (left side)
Group homogeneity analysis → control and test groups were homogeneous	Sex	Chi-squared test	0.355	0.355
	Age	Mann-Whitney test	0.060	0.255
Simple model analysis — dependence between the level of PMJ disarticulation and independent variables → only influenced by bone trimming	Presence of M3M	Simple binary logistic regression	0.278	0.966
	Gender		0.576	1.000
	Age		0.305	0.957
	Bone trimming		0.008	0.071
Multiple model analysis — to control for potential confounder effects → only influenced by bone trimming on the right side	Presence of M3M	Multiple binary logistic regression	0.247	0.966
	Gender		0.716	0.737
	Age		0.259	0.978
	Bone trimming		0.007	0.054
Symmetry of the level of PMJ disarticulation on both sides → similar results on both sides: symmetry	Right/left sides	McNemar's test	1.000	
Association between intraoperative complications and group → not related to M3M	Intraoperative complications	Fisher's exact test	0.490	0.490
Association between postoperative complications and group → no postoperative complications were reported	Postoperative complications	Fisher's exact test	1.000	1.000
Association between operative time and independent variables → not related to any variable	Presence of M3M	Two-sample *t*-test	0.642	0.314
	Gender		0.708	0.708
	Age		0.060	0.060
	Bone trimming		0.080	0.509
Side-level evaluation (n = 100)	**Variable**	**Statistical analysis**	***p*-value**	
Simple model analysis: dependence between the level of PMJ disarticulation and independent variables → only influenced by bone trimming	Presence of M3M	Simple binary logistic regression using GEE	0.498	
	Gender		0.528	
	Age		0.476	
	Bone trimming		<0.001	
Multiple model analysis: to control for potential confounder effects → influenced by bone trimming and presence of M3M	Presence of M3M	Simple binary logistic regression using GEE	0.014	
	Gender		0.305	
	Age		0.474	
	Bone trimming		<0.001	
Association between intraoperative complications and group → not related to M3M	Intraoperative complications	Fisher's exact test	0.117	
Association between postoperative complications and group → no postoperative complications were reported	Postoperative complications	Fisher's exact test	1.000	
Association between operative time and independent variables → not related to any variable	Presence of M3M	Multiple linear regression using GEE	0.596	
	Gender		0.907	
	Age		0.079	
	Bone trimming		0.160	

Abbreviation: GEE, generalized estimation equations.

experience in orthognathic surgery, M3M removal concomitant to LF1twist is always performed when required, regardless of the degree of impaction of the M3M or the surgical timing protocol involved (surgery first or late) (Fig. 7). Therefore, no additional surgeries for M3M removal are performed before orthognathic surgery unless M3M removal is required for orthodontic purposes or presents associated pathology, such as infection or cysts. In our sample, 20% of the patients were subjected to the surgery first approach, being equally distributed across both groups. Consequently, the surgical timing protocol did not influence the timing of M3M removal.

Likewise, orthognathic surgery is never delayed for M3M extraction 6 months prior to surgery (unless pathological signs are detected), as this would jeopardize overall treatment timing and the degree of patient satisfaction (Morton and Downie, 2017). Moreover, surgical removal of M3M prior to LF1 osteotomy implies a risk of infection, fracture of the maxillary tuberosity (including bleeding), root fracture, and accidental displacement of a maxillary third molar into adjacent anatomical regions — including the maxillary sinus or infratemporal fossa (Chiapasco et al., 1993; Barbosa-Rebellato et al., 2011). Some of these intraoperative complications could be difficult to manage under local anesthesia, whereas they can be easily resolved when M3M are removed in conjunction with the down-fractured maxilla and under general anesthesia.

In cases where M3M removal is not necessary, the presence of the tooth during LF1twist may vary the angulation of the tuberosity cut in relation to the mid-palatal plane (Cheung et al., 1998). On the other hand, when both procedures are carried out during the same surgery, it is advisable to first perform M3M removal followed by the LF1twist osteotomy, because the M3M in place could interfere with the pathway of the saw and deviate the osteotomy (Cheung et al., 1998). Moreover, once the maxilla is free and movable, performing M3M removal could prove troublesome. Even in fully impacted and high apically located M3M, which remain in the proximal segment of the maxilla, removal of the M3M after LF1twist is not recommended, in order to preserve the minimally invasive anterior approach used with the 'twist' technique (Hernández-Alfaro and Guijarro-Martínez, 2013b). Instead, non-pathologically involved M3M could be left in place, especially those located very high apically.

For the purposes our study, it was decided to exclude patients requiring segmented LF1 osteotomy, in order to ensure a homogeneous sample when evaluating surgery time — not because segmentation could be impeded by the presence of M3M. Therefore, from our point of view, concomitant M3M removal can also be carried out when maxillary segmentation is required. Moreover, using a minimally invasive approach does not damage maxillary vascularization through the buccal corridors, so it should not increase the risk of vascular compromise.

In contrast to M3M extraction concomitant with BSSO, the upper third molars or their levels of impaction do not seem to be associated with poor fracture in LF1twist. Instead, concomitant M3M removal just before LF1twist may facilitate the latter, since less maxillary and palatal bone needs to be ruptured, and there is reduced need to clear the field for maxillary repositioning (Balaji, 2011). This is consistent with our findings with regard to surgery time, with no difference between the groups being observed. In theory, we might have expected surgery time

Table 4
Level of pterygomaxillary separation according to group.

		Separation level: left side							
		Total		PMJ		Maxillary sinus		Pterygoid plate	
		N	%	*N*	%	*N*	%	*N*	%
Separation level: right side	**Total**	50	100.0	8	16.0	19	38.0	23	46.0
	PMJ	9	18.0	4	8.0	2	4.0	3	6.0
	Maxillary sinus	16	32.0	3	6.0	10	20.0	3	6.0
	Pterygoid plate	25	50.0	1	2.0	7	14.0	17	34.0

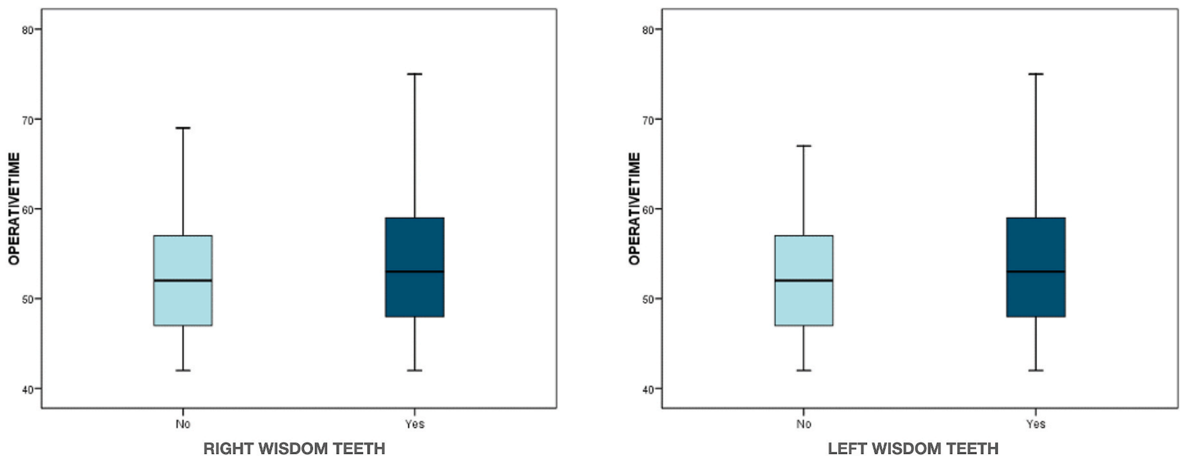

Fig. 5. Comparison of surgery times between groups according to side.

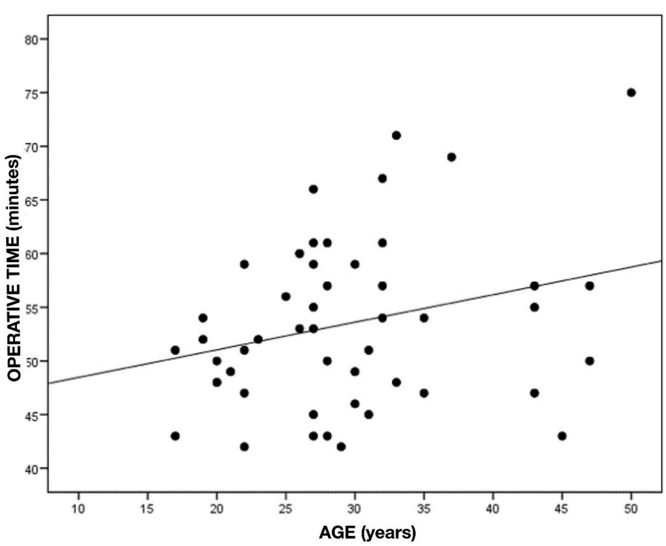

Fig. 6. Correlation between surgery time and patient age.

to be increased in the test group, since bilateral M3M removal takes some time. However, the reduced need for bone trimming around the pedicle when M3M are simultaneously removed probably accounted for no significant difference being observed ($p < 0.001$; chi-squared test). The suggestion that concomitant M3M removal eases maxillary osteotomy, down-fracture, and repositioning maneuvers is very relevant for clinicians. In the same context, as reported by Balaji, the risk of bleeding due to surgical manipulation around the neurovascular bundle is also reduced (Balaji, 2011). This is in line with our results regarding the intraoperative bleeding rates — although insignificant, the recorded bleeding events only appeared in the control group. Thus, we can assume that in the four patients who presented intraoperative bleeding, further manipulation of bone surrounding the neurovascular bundle was probably required. Hence, although few data can be found in the literature regarding the suitability of M3M removal concomitant with LF1twist, there is consensus regarding its safety. However, it is essential to perform primary closure of the socket after M3M removal in order to avoid the risk of postoperative oroantral communication (Ramanathan et al., 2020; Iwata et al., 2021). For this purpose, when M3M are erupted or partially erupted, a mucoperiosteal pedicle flap may be required (Rey-Santamaría et al., 2006). No oroantral communications were recorded in our study, and wound healing was uneventful in all cases.

Although maxillary osteotomy is facilitated by the low-density nature of the cancellous bone, separation of the posterior part of the maxilla is the key point of LF1twist; this is a hard and complicated anatomical region formed by the fusion of the maxillary and palatine bones, and the pterygoid plates of the sphenoid bone. In our sample, the percentage of patients achieving PMJ separation just at the suture level was rather low, but it did not differ between groups, and independent variables such as concomitant M3M removal did not interfere. Its occurrence, albeit infrequent, was probably attributable to the 'twist' down-fracture technique rather than to the presence of M3M.

Demographically, our results showed that those subjects requiring M3M removal at the time of LF1 tended to be younger ($p = 0.060$). This finding was to be expected, since M3M removal is generally advised for teenagers or young adults, due to the reported lower risk of complications (Shoshani-Dror et al., 2018). Moreover, although patient age did not influence the incidence of complications, it did affect overall surgery time, with each additional year implying an increase in surgery time of 0.27 min (Fig. 6). This could be related to a higher rate of synostosis of the PMJ in the older population.

Our study had some limitations, such as its single-center design, with the inherent bias involved. Furthermore, only the 'twist' technique (Hernández-Alfaro and Guijarro-Martínez, 2013b) for maxillary down-fracture was evaluated, which might have influenced the level of PMJ disarticulation. Therefore, various maneuvers need to be evaluated to rule out any differences between them.

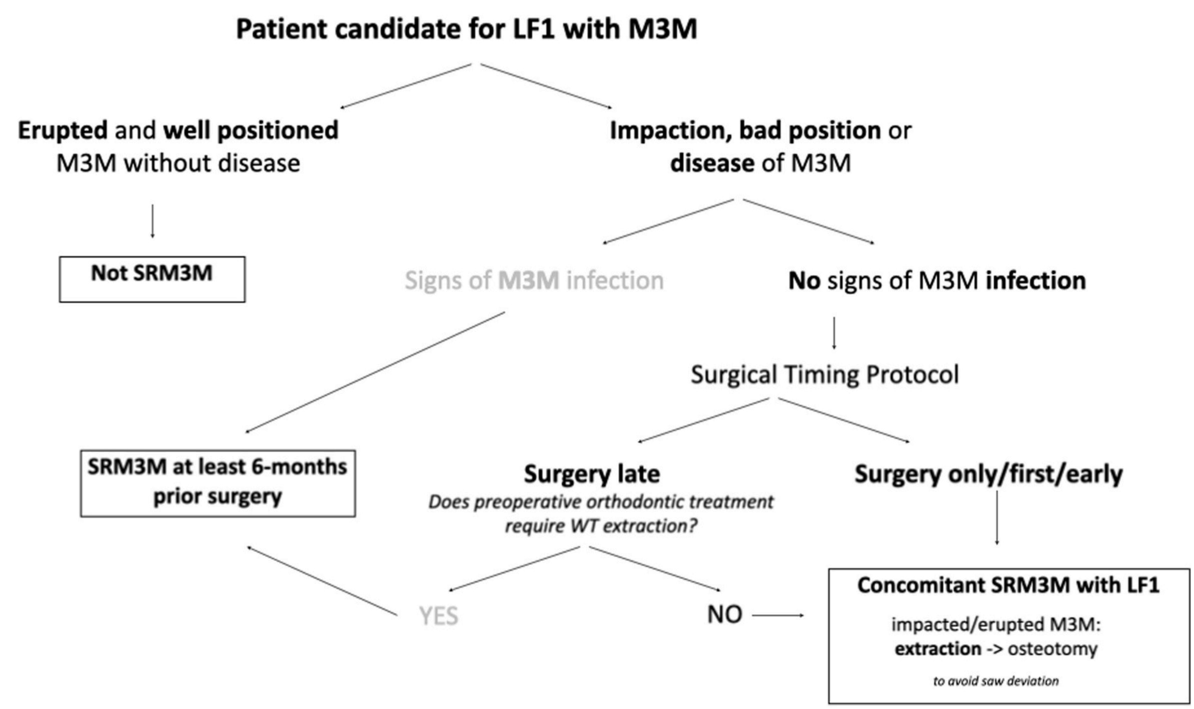

Fig. 7. Algorithm for concomitant removal of upper wisdom teeth with Le Fort I 'twist' osteotomy technique.

5. Conclusions

The results obtained demonstrated that removal of M3M in conjunction with LF1twist does not imply additional surgery time, differences regarding the level of PMJ separation, or an increase in perioperative complications. Furthermore, the concomitant procedure reduces the amount of maxillary and palatal bone in the disjunction area, which facilitates down-fracture and field clearing maneuvers for maxillary repositioning, while also avoiding a previous surgical procedure for M3M removal and its associated anesthetic and recovery intervals.

Financial support

None.

Conflicts of interest

None.

Ethical approval

Ethical approval was obtained from the Ethics Committee of Teknon Medical Center (Barcelona, Spain).

Patient consent

Written consent to access the CBCT database was obtained from all patients.

Declaration of competing interest

All the authors have seen and approved the manuscript.

Acknowledgements

The authors would like to thank all staff members at the Institute of Maxillofacial Surgery (Teknon Medical Center, Barcelona, Spain) for their administrative and clinical support.

References

Archer, W.H., 1966. Oral Surgery: a Step-by-step Atlas of Operative Techniques, fourth ed. W.B. Saunders Company, Philadelphia.
Balaji, S.M., 2011. Influence of third molars in Le Fort 1 osteotomy. Ann Maxillofac Surg 1 (2), 136–144.
Barbosa-Rebellato, N.L., Thomé, A.C., Costa-Maciel, C., Oliveira, J., Scariot, R., 2011. Factors associated with complications of removal of third molars: a transversal study. Med. Oral Patol. Oral Cir. Bucal 16 (3), e376–e380.
Cheung, L.K., Fung, S.C., Li, T., Samman, N., 1998. Posterior maxillary anatomy: implications for Le Fort I osteotomy. Int. J. Oral Maxillofac. Surg. 27 (5), 346–351.
Chiapasco, M., De Cicco, L., Marrone, G., 1993. Side effects and complications associated with third molar surgery. Oral Surg. Oral Med. Oral Pathol. 76 (4), 412–420.
Chin, Y.P., Leno, M.B., Dumrongwongsiri, S., Chung, K.H., Lin, H.H., Lo, L.J., 2017. The pterygomaxillary junction: an imaging study for surgical information of LeFort I osteotomy. Sci. Rep. 7 (1), 9953.
Eshghpour, M., Mianbandi, V., Samieirad, S., 2018. Intra- and postoperative complications of Le Fort I maxillary osteotomy. J. Craniofac. Surg. 29 (8), e797–e803.
Haas Junior, O.L., Guijarro-Martínez, R., Sousa Gil, A.P., Méndez-Manjón, I., Valls-Otañón, A., de Oliveira, R.B., et al., 2019. Cranial base superimposition of cone-beam computed tomography images: a voxel-based protocol validation. J. Craniofac. Surg.
Hernández-Alfaro, F., Guijarro-Martínez, R., 2013a. New protocol for three-dimensional surgical planning and CAD/CAM splint generation in orthognathic surgery: an in vitro and in vivo study. Int. J. Oral Maxillofac. Surg. 42 (12), 1547–1556.
Hernández-Alfaro, F., Guijarro-Martínez, R., 2013b. "Twist technique" for pterygomaxillary dysjunction in minimally invasive Le Fort I osteotomy. J. Oral Maxillofac. Surg. 71 (2), 389–392.
Hernández-Alfaro, F., Guijarro-Martínez, R., 2014. On a definition of the appropriate timing for surgical intervention in orthognathic surgery. Int. J. Oral Maxillofac. Surg. 43 (7), 846–855.
Iwata, E., Hasegawa, T., Kobayashi, M., Tachibana, A., Takata, N., Oko, T., et al., 2021. Can CT predict the development of oroantral fistula in patients undergoing maxillary third molar removal? Oral Maxillofac. Surg. 25 (1), 7–17.
Kramer, F.J., Baethge, C., Swennen, G., Teltzrow, T., Schulze, A., Berten, J., et al., 2004. Intra- and perioperative complications of the LeFort I osteotomy: a prospective evaluation of 1000 patients. J. Craniofac. Surg. 15 (6), 971–977. ; discussion 8–9.
Morton, L., Downie, I., 2017. Surgical and social implications of extraction of mandibular third molars as a separate procedure before bilateral sagittal split osteotomy. Br. J. Oral Maxillofac. Surg. 55 (9), 937–939.
Obwegeser, H.L., 1969. Surgical correction of small or retrodisplaced maxillae. The "dish-face" deformity. Plast. Reconstr. Surg. 43 (4), 351–365.
Politis, C., 2012. Life-threatening haemorrhage after 750 Le Fort I osteotomies and 376 SARPE procedures. Int. J. Oral Maxillofac. Surg. 41 (6), 702–708.

Ramanathan, M., Nathan, S., Kiruba, J.G.A., 2020. A rare presentation of an oro-antral communication after Trimble's modification of Lefort I osteotomy. Med. Leg. Update 20 (4), 2358–2360.

del Rey-Santamaría, M., Valmaseda Castellón, E., Berini Aytés, L., Gay Escoda, C., 2006. Incidence of oral sinus communications in 389 upper thirmolar extraction. Med. Oral Patol. Oral Cir. Bucal 11 (4), E334–E338.

Robinson, P.P., Hendy, C.W., 1986. Pterygoid plate fractures caused by the Le Fort I osteotomy. Br. J. Oral Maxillofac. Surg. 24 (3), 198–202.

Shoshani-Dror, D., Shilo, D., Ginini, J.G., Emodi, O., Rachmiel, A., 2018. Controversy regarding the need for prophylactic removal of impacted third molars: an overview. Quintessence Int. 49 (8), 653–662.

Steinbacher, D.M., Kontaxis, K.L., 2016. Does simultaneous third molar extraction increase intraoperative and perioperative complications in orthognathic surgery? J. Craniofac. Surg. 27 (4), 923–926.

Ueki, K., Nakagawa, K., Marukawa, K., Yamamoto, E., 2004. Le Fort I osteotomy using an ultrasonic bone curette to fracture the pterygoid plates. J. Cranio-Maxillo-Fac. Surg. 32 (6), 381–386.

Ueki, K., Hashiba, Y., Marukawa, K., Okabe, K., Alam, S., Nakagawa, K., et al., 2009. Assessment of pterygomaxillary separation in Le Fort I osteotomy in class III patients. J. Oral Maxillofac. Surg. 67 (4), 833–839.