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Original Article

Maxillary sinus recovery after LeFort I osteotomy: a prospective clinical and radiographic evaluation

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Abstract – Introduction: The purpose of this study was to obtain insight into the perioperative condition of the maxillary sinus in the LeFort I osteotomy by evaluating clinically and radiographically. **Materials and methods:** 25 patients who required conventional LeFort I procedures for orthognathic correction were included in the study. Damage to the maxillary sinus during the procedure and its recovery were prospectively analysed using validated questionnaires for sino-nasal complaints using RSOM-31 (RSOM – rhinosinusitis outcome measure), VAS score (VAS – visual analogue scale) and CT scan to compare and analyse changes in maxillary sinus prior to surgery and postoperatively 2 months after the surgery. The scores obtained from RSOM-31 questionnaire was analysed using Chi-square test, VAS questionnaire was interpreted using Wilcoxon sign rank test and CT scan findings were analysed using Fischer's exact test. **Results:** Mucosal thickening assessed using CT scan was the only consistent finding that was evident for all the patients who underwent LeFort I osteotomy which showed a statistically significant results of $P < 0.05$, whereas clinical correlation showed insignificant results of $P > 0.05$. **Conclusion:** In our attempt on extensive patient analysis we found that mucosal thickening was the prime alteration that was observed radiographically and no clinical changes were evident.

Introduction

Dentofacial deformities affect approximately 20% of the population who present with various degrees of functional and aesthetic compromise [1]. Correction of these deformities require orthognathic surgeries which involves mobilization, repositioning and fixation of the maxilla and mandible. LeFort I osteotomy is the most frequently performed orthognathic surgery to correct such dentofacial deformities. Performing this surgery had shown to have a direct effect on the morphology of nasal cavities as well as the maxillary sinus, Hypertrophic turbinates, deviated septum and other nasal conditions which may also obstruct the nasal passage [2].

A variety of complications following LeFort I osteotomies have been documented. These complications include devitalization of teeth, necrosis of entire dentoalveolar segments, skeletal relapse, infection, velopharyngeal incompetence, lack of tearing, nasal septal perforation and haemorrhage. But the most commonly reported complication following a LeFort I maxillary osteotomy is the development of a maxillary sinusitis [3]. However, healing after surgery is generally uneventful. In this study, the damage caused to the maxillary sinus during a Lefort I maxillary osteotomy and its recovery were prospectively analysed in 25 patients. We used an existing validated questionnaire which was distributed to the patients before surgery and also 2 months after the surgery to assess any sino-nasal related complaints. RSOM-31 (rhinosinusitis outcome measure) was used to assess complaints concerning sino-nasal pathology, VAS score (visual analogue scale to estimate the intensity of pain and CT scan was used to compare the changes in maxillary sinus prior to surgery and postoperatively after 2 months of surgery.

The aim of this current study was to evaluate the mucosal changes in maxillary sinus after LeFort I osteotomy and to assess the influence of LeFort I procedure on sino-nasal architecture.

Materials and methods

This study was carried out on 25 healthy adults between the age groups of 18–30 years who reported to the department of oral and maxillofacial surgery for aesthetic correction of jaws. The protocol of this study was reviewed and approved by the institutional review board of our institution (MADC/IRB/2014/008, Meenakshi Academy of Higher Education and Research Institute, India) and informed consent was obtained from individual participants included in the study.

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Indications for surgery

Functional reasons which includes:
- Anterior open bite
- Class II or a Class III malocclusion.

Inclusion criteria

- All patients undergoing conventional LeFort I osteotomy for orthognathic correction.

Exclusion criteria

- Patients with history of systemic diseases.
- Patients without consent for the study were excluded.

Description of the study

- In this study, the damage caused to the maxillary sinus during a Lefort I maxillary osteotomy and its recovery after the procedure was prospectively analysed in all patients included in the study.
- The following methods were used before and 2 months after surgery:
  - Validated questionnaires for sino-nasal complaints using RSOM-31(RSOM — rhinosinusitis outcome measure) and VAS score (VAS — visual analogue scale).
  - CT scan for postoperative changes of maxillary sinus

The questionnaires and CT scan were evaluated prior to the surgery and also 2 months after the surgery.

Methods of assessment

All the patients were evaluated by a single observer before the surgery and also at 2 months post-surgery.

The RSOM-31 questionnaire

The RSOM-31 is a 31-item rhinosinusitis-specific questionnaire that contains seven subscales: nasal, eye, sleep, ear, general, practical, and emotional [4]. Patients scored their symptoms on a six-item scale (0–5) (Tab. I). Preoperative and postoperative questionnaire scores were compared and analysed using SPSS software.

VAS questionnaire

VAS is a 19 item questionnaire specific to sinus related complaints with scores ranging from 0–10 with 0 being no pain, 5 being moderate pain, and 10 being the worst possible pain. Preoperative and postoperative questionnaire scores were compared and analysed using SPSS software [4] (Fig. 1).

Table I. RSOM-31 scoring (0–5).

0	not present/no problem;
1	very mild problem;
2	mild or slight problem;
3	moderate problem;
4	severe problem;
5	problem is as bad as it can be

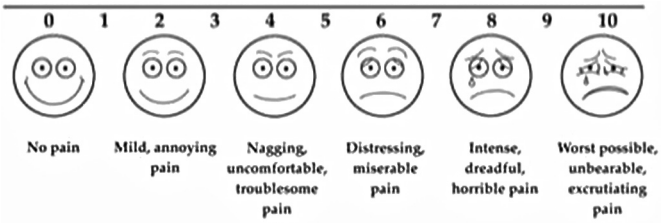

Fig. 1. Scoring of VAS (0–10 with 0 being no pain, 5 being moderate pain, and 10 being the worst possible pain).

CT imaging

A CT scan of the paranasal sinuses was done preoperatively and at 2 months after the surgery to evaluate the changes in sino-nasal anatomy and influence of LeFort I osteotomy in all maxillofacial sinuses. The following protocol was used — axial plane 0.9 mm and increment 0.45 mm, with 1.0 mm consecutive reconstructions in the axial, coronal, and sagittal planes. Preoperative and postoperative CT scan findings were compared and analysed using SPSS software.

Results

A total of 25 patients reported for aesthetic correction of jaws were subjected to conventional Lefort I osteotomy. Among 25 patients, 14 were male and 11 were female with a mean age of 23 years. 15 patients underwent a bimaxillary correction of jaws and 10 patients underwent only a LeFort I osteotomy procedure. All the 25 patients completed RSOM-31 and VAS questionnaire. The preoperative and postoperative scores for RSOM-31 and VAS questionnaire was compared and analysed with SPSS software using Chi-square test and Wilcoxon sign rank test with P value <0.05 was considered to be statistically significant.

The RSOM-31 and VAS questionnaire

On comparison, the preoperative and postoperative scores of RSOM-31 and VAS questionnaire showed a statistically insignificant results with $P > 0.05$ respectively (Tabs. II and III).

Table II. RSOM-31 questionnaire (chi-square test).

RSOM-31 item questionnaire	Preoperative scores						Postoperative scores						*P* value
	0	1	2	3	4	5	0	1	2	3	4	5	
Blockage/congestion of nose	25	0	0	0	0	0	21	3	0	0	1	0	0.1140
Rhinorrhea	25	0	0	0	0	0	25	0	0	0	0	0	–
Sneezing	24	1	0	0	0	0	24	0	0	0	1	0	0.368
Sense of taste/smell	25	0	0	0	0	0	24	1	0	0	0	0	1.000
Post nasal drip	24	1	0	0	0	0	23	1	0	0	1	0	0.600
Thick nasal discharge	25	0	0	0	0	0	25	0	0	0	0	0	–
Itchy eyes	25	0	0	0	0	0	24	1	0	0	0	0	1.000
Swollen eyes	25	0	0	0	0	0	25	0	0	0	0	0	–
Difficulty falling asleep	23	1	0	0	1	0	25	0	0	0	0	0	0.353
Waking up at night	24	0	0	1	0	0	25	0	0	0	0	0	1.000
Lack of good night's sleep	24	0	0	1	0	0	25	0	0	0	0	0	1.000
Waking up tired	24	0	0	0	1	0	22	2	1	0	0	0	0.252
Ear fullness	24	1	0	0	0	0	24	0	0	1	0	0	0.368
Ringing	25	0	0	0	0	0	23	0	2	0	0	0	0.490
Dizziness	25	0	0	0	0	0	25	0	0	0	0	0	–
Ear pain	25	0	0	0	0	0	24	0	0	1	0	0	1.000
Decreased hearing	25	0	0	0	0	0	22	2	1	0	0	0	0.203
Fatigue	24	0	0	1	0	0	24	0	0	1	0	0	1.00
Reduced productivity	23	1	0	1	0	0	25	0	0	0	0	0	0.353
Reduced concentration	25	0	0	0	0	0	25	0	0	0	0	0	–
Headache	20	4	1	0	0	0	24	1	0	0	0	0	0.206
Facial pain or pressure	23	2	0	0	0	0	17	5	1	2	0	0	0.159
Cough	25	0	0	0	0	0	24	1	0	0	0	0	1.00
Short of breath	24	1	0	0	0	0	25	0	0	0	0	0	1.00
Inconvenience of having to carry tissues	25	0	0	0	0	0	25	0	0	0	0	0	–
Need to rub nose or eyes	25	0	0	0	0	0	24	1	0	0	0	0	1.00
Need to blow nose	25	0	0	0	0	0	25	0	0	0	0	0	–
Bad breath	25	0	0	0	0	0	24	1	0	0	0	0	1.00
Frustrated	25	0	0	0	0	0	25	0	0	0	0	0	–
Sad	25	0	0	0	0	0	25	0	0	0	0	0	–
Embarrassed	20	3	2	0	0	0	24	0	0	0	1	0	0.095

CT scan findings

The pre-operative and post-operative sino-nasal conditions was evaluated using CT scan and the findings were analysed with SPSS software using Fischer's exact test with *P* value <0.05 was considered to be statistically significant (Tab. IV, Fig. 2).

- **Anatomy extra ostium:** An iatrogenic ostium was evident in the lateral nasal wall after the surgery in 4 patients while evaluating the post-operative CT scan (Fig. 3). These patients had a persistent patent opening in the lateral nasal wall on both sides at the level of the osteotomy, which was evident only through radiological examination which showed a statistically insignificant results of $P = 0.110$ respectively.
- **Anatomy septal deviation:** A pre-operative septal deviation was found in 25 patients, with or without a septal spine but the septal deviation was not influenced by the procedure, for which the results could not be determined statistically.
- **Mucosa sinusitis:** 1 patient showed signs of sinusitis that was clinically silent (Fig. 4) and the mucosa showed thickening which was treated with nasal glucocorticoids and antibiotics and was subsequently operated. The post-operative scan showed persistent sinusitis in this one patient (Fig. 5) with a statistically insignificant results of $P = 1.000$ respectively.
- **Reactive mucosa:** Thickened mucosal layer of maxillary sinus was seen in the pre-operative CT scans of 7 patients (Fig. 6). Post-operative CT scans of all 25 patients showed a thickened mucosal layer (Fig. 7). The thickening was primarily

Table III. VAS questionnaire (Wilcoxon sign rank test).

Questionnaire	Pre-operative scores (mean ± SD)	Pre-operative scores (mean ± SD)	*P* value
Headache	0.24 ± 0.60	0.16 ± 0.37	0.557
Nasal congestion	0.00 ± 0.00	0.160 ± 0.800	0.317
Nasal discharge	0.00 ± 0.00	0.00 ± 0.00	–
Pharyngeal mucosa	0.00 ± 0.00	0.00 ± 0.00	–
Feeling of full sinus	0.20 ± 0.58	0.28 ± 0.79	0.590
Decreased smell	0.00 ± 0.00	0.040 ± 0.20	–
Facial pain	0.320 ± 0.85	0.120 ± 0.44	0.339
Tooth pain	0.04 ± 0.20	0.00 ± 0.00	–
Tear flow	0.00 ± 0.00	0.00 ± 0.00	–
Coughing	0.00 ± 0.00	0.12 ± 0.43	–
Bleeding nose	0.00 ± 0.00	0.00 ± 0.00	–
Nasal crusting	0.00 ± 0.00	0.00 ± 0.00	–
Tiredness	0.28 ± 0.54	0.48 ± 1.0	0.448
Fever	0.00 ± 0.00	0.00 ± 0.00	–
Nausea	0.00 ± 0.00	0.00 ± 0.00	–
Vomitting	0.00 ± 0.00	0.00 ± 0.00	–
Diarrhoea	0.00 ± 0.00	0.00 ± 0.00	–

Table IV. CT scan findings (Fischer's exact test).

CT findings	Preoperative		Postoperative		*P* value
	Yes	No	Yes	No	
Anatomy – Extra Ostium	0	25	4	21	0.110
Anatomy – Septal deviation	25	0	25	0	–
Mucosa – Sinusitis	1	24	1	24	1.000
Mucosa – Reactive mucosa	7	18	25	0	0.0001
Mucosa – Sequesters	0	25	0	25	–
Bone in osteotomy	0	25	14	11	0.0001

identified at the level of the osteotomy and also around sequesters which showed a statistically significant results of $P = 0.0001$ respectively.

- **Sequesters:** None of the patients had a bony sequester in the maxillary sinus for which the results could not be determined statistically.
- **Bone in osteotomy:** A bony connection in the line of osteotomy was seen on the lateral wall of maxillary sinus in 14 patients whereas in the remaining 11 patients, there was no such bony connection identified in the same line of osteotomy assessed 8 weeks after surgery (Fig. 8) which showed a statistically significant results of $P = 0.0001$ respectively.

Discussion

LeFort I osteotomy had become a versatile procedure for correcting dentofacial deformities [2,3]. Apart from skeletal problems, Lefort I osteotomy was also useful in correcting obstructive sleep apnoea, nasopharyngeal tumours, nasal septal deformities, inferior turbinate enlargement, a tight nasal inlet (constricted piriform apertures) and an elevated nasal floor commonly co-exist with maxillary deformity [5–8]. Pre-operative assessment with CT scan was a helpful tool in identifying any abnormal sino-nasal changes preoperatively and aggravation of such changes after Lefort I osteotomy postoperatively especially when the maxilla was impacted [9,10].

In our study we have used CT scan of paranasal sinuses to identify any mucosal thickening in the maxillary sinus region by comparing the preoperative and postoperative CT scans to diagnose the presence of sinusitis as well as to assess any anatomic abnormalities if present. An iatrogenic ostium in the lateral nasal wall was seen after the surgery in the postoperative CT scan of 4 patients. These patients had a

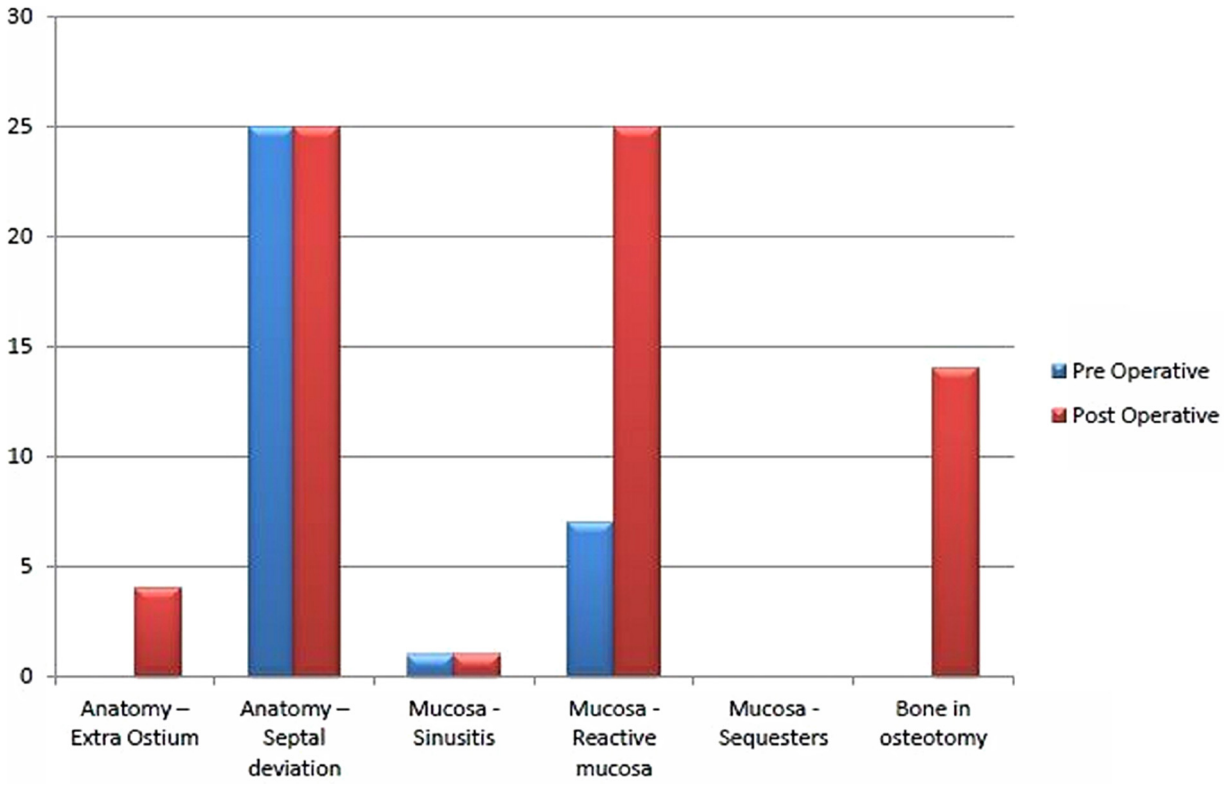

Fig. 2. Comparison of preoperative and postoperative CT scan (X axis represents the findings obtained from CT scan and Y axis represents the number of patients presented with such findings obtained from CT scan).

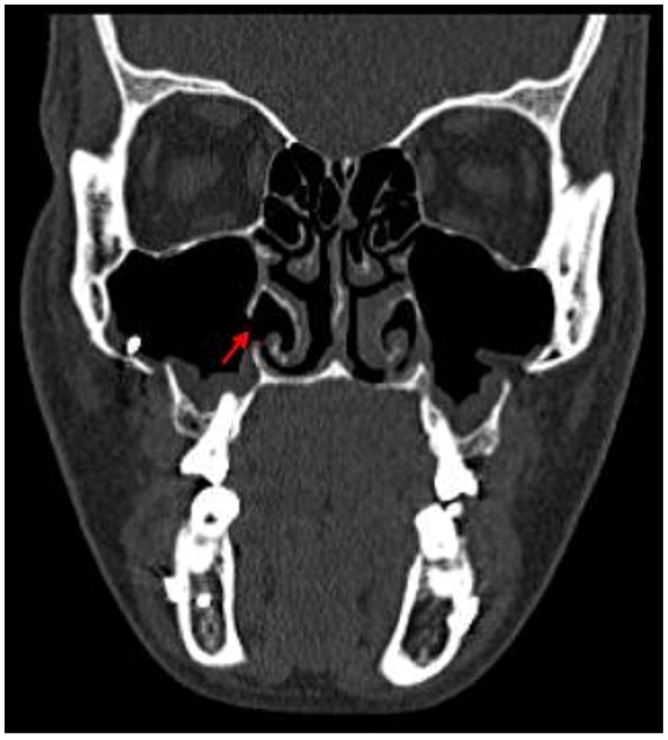

Fig. 3. Postoperative coronal CT image showing unilateral accessory maxillary ostium in the right side of the medial sinus wall (arrow).

Fig. 4. Preoperative coronal CT image showing unilateral sinusitis which was clinically silent on left side (arrow).

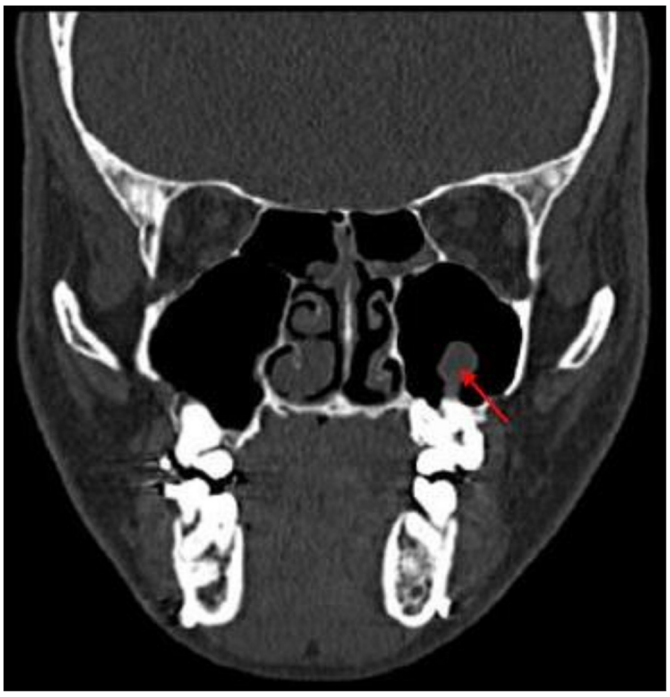

Fig. 5. Postoperative coronal CT image showing persistent unilateral maxillary sinusitis on left side (arrow).

Fig. 7. Postoperative coronal CT image showing bilateral mucosal thickening in the base of the maxillary sinus (arrows).

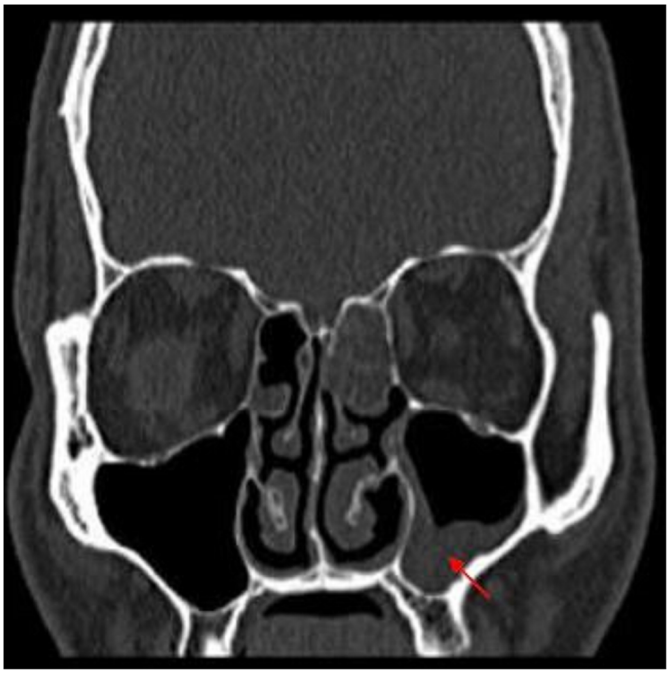

Fig. 6. Preoperative coronal CT image showing unilateral mucosal thickening in the base of the maxillary sinus on left side (arrow).

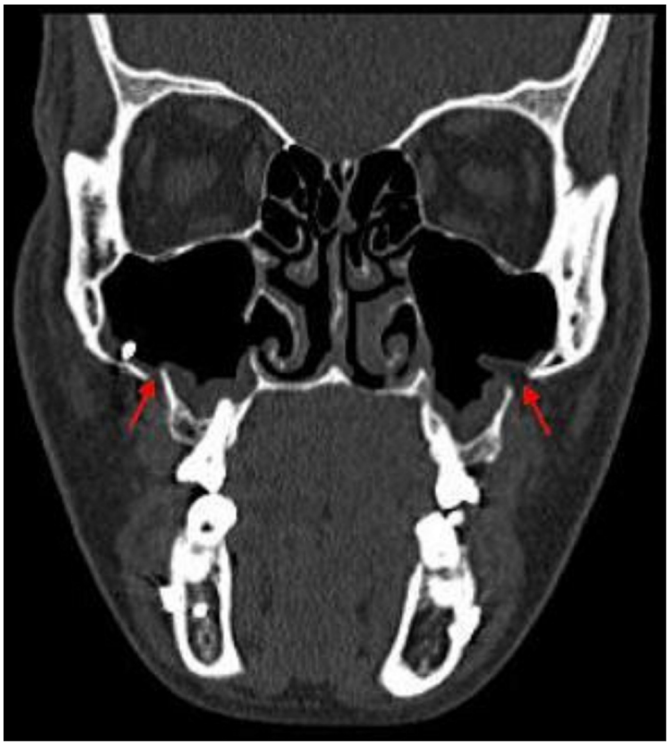

Fig. 8. Postoperative coronal CT image showing persistent bony dehiscence at the base of the maxillary sinus (arrows) with evidence of mucosal thickening in the bilateral maxillary sinus.

persistent patent opening in the lateral nasal wall on both sides at the level of the osteotomy, which was evident radiologically. This signifies an iatrogenic anatomic abnormality that had developed post-surgery.

Maxillary sinusitis, a possible complication that was encountered after Lefort I osteotomy was caused by impaired mucus clearance of the sinus. Generally, after Lefort I osteotomy the oedema of the mucosa causes increased mucosal

thickening which further limits the ciliary movements and in turn causes retention of the oedema that blocks the sinus osteomeatal complex causing a long standing sinusitis [11]. Valstar *et al.* [4] stated that incidence of sinusitis after a LeFort I osteotomy varies widely. This is due to several factors, most of which are attributable to the retrospective nature of the studies. Firstly, often there was an absence of systematically obtained data on the preoperative condition of the sinus, both subjective (validated questionnaire) and radiologically (CT scan). Secondly, only a limited number of radiological evaluations comparing the preoperative and postoperative panoramic as well as sinus view radiographs have been conducted instead of using the gold standard imaging modality which is CT scan. Also, there is a lack of uniformity in the time points of the follow-up [12–14].

Collin *et al.* [15] reported in his study that there were no signs of maxillary sinusitis before surgery but three months following the surgery 4 among 20 patients included in the study, presented with maxillary sinusitis. In our study we elicited maxillary sinusitis in 1 patient prior to surgery which was clinically silent and the mucosa showed thickening which was treated with nasal glucocorticoids and antibiotics and then operated subsequently. The post-operative scan of this patient showed sinusitis persisting even after the surgery. The pre-operative CT scans of 7 among 25 patients had a thickened mucosal layer while the postoperative CT scan of all 25 patients showed thickened mucosal layer with no such clinical correlation.

In our study, we evaluated maxillary sinus evaluation after a LeFort I osteotomy in a more comprehensive way with a validated questionnaire and CT imaging. One patient with a clinically unnoticed, but radiographically evident sinusitis was treated for the infection before the osteotomy. In this type of elective surgery, acquiring optimal information and meticulous clinical investigations before a surgery could probably prevent the exacerbation of pre-existing sinusitis. Consequently excessive bleeding, non-union of bone, and loosening of screws which could be influenced by sinusitis can also be prevented. From the questionnaires it was found that the pattern and frequency of complaints concerning sino-nasal abnormalaities were similar before and after surgery. In other words, the LeFort I osteotomy did not influence preoperatively existing physical or mental complaints in these 25 patients.

Pereira *et al.* [16] in his study showed 4.76% as the incidence of maxillary sinusitis after a Lefort I osteotomy and Moses *et al.* [17] reported 7 cases of maxillary sinusitis as a postoperative complication after LeFort I osteotomies which were treated by endoscopic surgery, and he also reported that the anatomic changes in the sinus drainage area occurred mainly in cases of maxillary intrusion and severe asymmetries. At the time of orthognathic procedures, the surgeon has an opportunity to further contribute to a patient's quality of life by simultaneously addressing long standing breathing difficulties and pathologies associated with maxillary sinus that may co-exist with the jaw deformity [18,19]. Even if the patient does not complain about these problems or is asymptomatic, pathologies related to maxillary sinus as well as any anatomical deformities that may lead to rhinosinusitis must be considered for correction during LeFort I osteotomy, as these problems might get aggravated or the patient may even become symptomatic after the surgery [20,21].

The above discussion projects that CT scan of paranasal sinuses is an important diagnostic tool for identifying any pre-existing sino-nasal or anyother anatomic deformities prior to Lefort I osteotomy. These abnormalities can be managed while correcting the dentofacial deformity. Manifestation of sinusitis after Lefort I was mostly seen in a month's time or it may vary postoperatively. In our study sinusitis was observed in one of the 25 cases when postoperative evaluation was done after 2 months. This limits our study as the duration was relatively short in order to report on the occurrence of maxillary sinusitis as a postoperative complication after Lefort I osteotomy within a period of 1-2 months.

Conclusion

All our findings were radiological and did not present as clinical complaints or symptoms.

- Mucosal thickening was the only consistent finding seen in all the patients who underwent Lefort I osteotomy.
- Bone in osteotomy was not completely ossified in 14 out of 25 patients. But, none of them had any presenting clinical symptoms nor did it affect the stability of the osteotomy.
- In our study, Lefort I osteotomy procedure did not have any clinically significant sino-nasal alteration.

Conflicts of interests: The authors declare that they have no conflicts of interest in relation to this article.

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