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# Survey on Complications of Orthognathic Surgery Among Oral and Maxillofacial Surgeons

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**Background:** Orthognathic surgery is performed to correct dentofacial and craniofacial deformities and improve facial aesthetics, occlusal relations, and the functionality of the stomatognathic apparatus. However, complications in orthognathic surgery may occur at any time during the course of treatment: in the preoperative judgment and planning, during perioperative orthodontic care, or intraoperatively. The aim of the current study was to survey oral and maxillofacial surgeons regarding the main complications of orthognathic surgery.
**Methods:** One hundred oral and maxillofacial surgeons with at least 5 years of experience in dentofacial management were interviewed during a Brazilian national oral and maxillofacial surgery meeting by 2 calibrated postgraduate students, using a questionnaire addressing complications of orthognathic surgery.
**Results:** No significant differences were found regarding educational background or postgraduate degrees among the oral and maxillofacial surgeons ($P > 0.05$). A total of 28.0% had no experience with vertical osteotomy of the mandibular ramus, 35.0% had no experience with subapical osteotomy of the mandible, and 4.0% had no experience with genioplasty. All participants had experience with sagittal osteotomy of the mandibular ramus. Among mandible procedures, the most common complication was nerve damage, followed by unfavorable osteotomy. The most common Le Fort I complication was also nerve damage (40%), followed by hemorrhage (29%). Regarding osteosynthesis fixation, fractures of the material were more frequent in the mandible (23%) and maxilla (10%).
**Conclusions:** Most oral and maxillofacial surgeons experienced similar orthognathic surgery complications to those reported in retrospective studies.

**Key Words:** Orthognathic surgery, craniofacial, complication

Orthognathic surgery is performed to correct dentofacial and craniofacial deformities and improve facial aesthetics, occlusal relations, and the functionality of the stomatognathic apparatus.[1] In some instances, orthognathic techniques can be used in tumor resections[2] and the treatment of obstructive sleep apnea syndrome.[3,4]

Corrected jaws lead to improved function and aesthetics, and the enhanced appearance also benefits the patient both psychologically and socially.[5] However, complications in orthognathic surgery may occur at any time during the course of treatment: in the preoperative judgment and planning, during perioperative orthodontic care, or intraoperatively.[6] Such complications include nerve damage,[6–27] unfavorable osteotomy,[22,28–34] temporomandibular joint problems,[23,35–47] hemorrhage,[5,6,21,34,48–57] malocclusion,[23,42,58,59] septum deviation,[52,60] infection,[13,61–73] maxillary sinusitis,[60,74,75] dental injuries,[51,76–78] bone necrosis,[13,53,79,80] periodontal disease,[81–83] ophthalmologic impairment,[11,25,84] failure of osteosynthesis material,[17,55,85–89] hearing problems,[90] hair loss,[91] dysphagia,[92] and neuropsychiatric problems.[93] Moreover, some complications can be fatal.[94,95] However, after investigating 2049 patients having undergone corrective jaw surgery, Van de Perre et al[96] reported that fatal complications are rare.

A number of factors affect the frequency and type of complication, such as surgery site, surgical approach, clinical nature of the surgery, surgery time, wound contamination, psychologic strength of the patient, postoperative care, and the surgeon's skill. When considering corrective jaw surgery, the surgeon must bear prevention in mind by considering the nature of complications and their causal factors. When a complication arises despite the precautions taken, the appropriate treatment should be instituted to ensure a good prognosis.[5]

Although the variety of possible complications is great, there are few reports addressing the actual incidence of complications in the entire range of orthognathic surgery.[5,6,14,19,52,56,76,78,97,98] To optimize the results while both minimizing complications and striving to carry out the procedures safely, it is prudent for the surgeon to perform a periodic assessment of his or her approach.[6]

The aim of the current study was to survey oral and maxillofacial surgeons regarding the main complications of orthognathic surgery. To the best of our knowledge, no similar surveys are found in the literature.

## METHODS

The current study received approval from the institutional ethics committee (CAAE/UPE 0117.0.097.000-09). All interviewees signed a statement of informed consent.

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Two postgraduate students in oral and maxillofacial surgery were trained and calibrated for use of the questionnaire and interviewed a random sample of 100 oral and maxillofacial surgeons attending a national meeting in Brazil. The inclusion criteria were at least 5 years of professional experience after concluding residency in oral and maxillofacial surgery and experience with the practice of dentofacial management; a lack of experience with sagittal and vertical osteotomies of the mandibular ramus (SOMR and VOMR), subapical osteotomy of the mandible, and genioplasty was acceptable. All surgeons selected had experience with orthognathic surgery complications. The participants were asked to not score associated complications in patients with orofacial clefts. A closed-end questionnaire with single answers to 3 topics (mandibular procedures, maxillary Le Fort I osteotomy, and bone fixation) was drafted for data acquisition on the types of intraoperative and postoperative complications.

The interviewees were specifically asked about dental necrosis, open bite, unplanned occlusion, periodontal defects, bad split, nerve damage, hemorrhage, condylar resorption, avascular necrosis of the bone segments, deficient aesthetic outcome, dehiscence of soft tissue flap and infection after SOMR, VOMR, subapical osteotomy of the mandible, and genioplasty. Regarding maxillary Le Fort I osteotomies, the participants were asked about dental necrosis, open bite, unplanned occlusion, periodontal defects, bad split, nerve damage, hemorrhage, condylar resorption, avascular necrosis of the bone segments, deficient aesthetic outcome, dehiscence of soft tissue flap, nasolacrimal injuries, ophthalmologic injuries, oronasal and oroantral fistulae, septum deviation, maxillary sinusitis, osseous nonunion or later osseous union, Eustachian tube dysfunction, velopharyngeal incompetence, arteriovenous fistulae, dysphagia, and infection. Regarding bone fixation, the interviewees were asked about material fracture, nerve damage, loss of material in deep tissue, and exposure of material.

Before the study began, a pretest of the questionnaire was performed with the participants of an oral and maxillofacial surgery continuing education course at the Pernambuco School of Dentistry, Universidade de Pernambuco (Brazil). The database file of survey answers was analyzed using the SPSS 11.0 program (SPSS Inc., Chicago, IL).

## RESULTS

One hundred individuals (88 men and 12 women aged 26–62 y; mean age [SD], 32.76 [6.32] y) were enrolled in the study. Forty-eight were specialists in oral and maxillofacial surgery alone, 30 had a master's degree (MSc), and 27 had a doctoral degree (PhD). Regarding the time elapsed since conclusion of oral and maxillofacial surgery residency, 59 had 5 years of professional experience, 31 had 6 to 10 years of experience, 12 had 11 to 20 years of experience, and 3 had more than 21 years of experience.

No significant differences were found regarding educational background or postgraduate degrees among the oral and maxillofacial surgeons ($P > 0.05$). Twenty-eight participants had no experience with VOMR, 35 had no experience with subapical osteotomy of the mandible, and 4 had no experience with genioplasty. All participants had experience with SOMR. Table 1 lists the mandible complications, Table 2 lists the Le Fort I complications, and Table 3 lists the bone fixation complications.

**TABLE 1.** Mandible Complications

| | Yes | | No | |
|---|---|---|---|---|
| **Variable** | **n** | **%*** | **n** | **%*** |
| Sagittal osteotomy | | | | |
| Bad split | 41 | 41.0 | 59 | 59.0 |
| Nerve damage | 92 | 92.0 | 8 | 8.0 |
| Hemorrhage | 14 | 14.0 | 86 | 86.0 |
| Anterior open bite | 13 | 13.0 | 87 | 87.0 |
| Condylar resorption | 21 | 21.0 | 79 | 79.0 |
| Condylar sag | 7 | 7.0 | 93 | 93.0 |
| Loss of vascularity | 3 | 3.0 | 97 | 97.0 |
| Deficient aesthetic outcome | — | — | 100 | 100.0 |
| Dehiscence of soft tissue flap | 1 | 1.0 | 99 | 99.0 |
| Infection | 19 | 19.0 | 81 | 80.0 |
| Vertical osteotomy of ramus | | | | |
| Bad split | 11 | 11.0 | 61 | 61.0 |
| Nerve damage | 4 | 4.0 | 68 | 68.0 |
| Hemorrhage | 6 | 6.0 | 66 | 66.0 |
| Anterior open bite | 8 | 8.0 | 64 | 64.0 |
| Condylar resorption | 2 | 2.0 | 70 | 70.0 |
| Condylar sag | 2 | 2.0 | 72 | 72.0 |
| Loss of vascularity | 1 | 1.0 | 71 | 71.0 |
| Deficient aesthetic outcome | 1 | 1.0 | 71 | 71.0 |
| Dehiscence of soft tissue flap | — | — | 72 | 72.0 |
| Infection | 5 | 5.0 | 67 | 67.0 |
| Subapical osteotomy | | | | |
| Bad split | 3 | 3.0 | 62 | 62.0 |
| Nerve damage | 4 | 4.0 | 61 | 61.0 |
| Hemorrhage | 3 | 3.0 | 62 | 62.0 |
| Anterior open bite | — | — | 65 | 65.0 |
| Condylar resorption | — | — | 65 | 65.0 |
| Condylar sag | — | — | 65 | 65.0 |
| Loss of vascularity | 3 | 3.0 | 62 | 62.0 |
| Deficient aesthetic outcome | — | — | 65 | 65.0 |
| Dehiscence of soft tissue flap | — | — | 65 | 65.0 |
| Infection | — | — | 65 | 65.0 |
| Genioplasty | | | | |
| Bad split | 15 | 15.0 | 81 | 81.0 |
| Nerve damage | 27 | 27.0 | 69 | 69.0 |
| Hemorrhage | 2 | 2.0 | 94 | 94.0 |
| Anterior open bite | — | — | 96 | 96.0 |
| Condylar resorption | — | — | 96 | 96.0 |
| Condylar sag | — | — | 96 | 96.0 |
| Loss of vascularity | 1 | 1.0 | 95 | 95.0 |
| Deficient aesthetic outcome | 13 | 13.0 | 83 | 83.0 |
| Dehiscence of soft tissue flap | 4 | 4.0 | 92 | 92.0 |
| Infection | 2 | 2.0 | 94 | 94.0 |

*Percentages obtained from total number of 100 oral and maxillofacial surgeons who performed the operation on patients with dentofacial deformities.

## DISCUSSION

Like any surgical procedure, orthognathic surgery carries the risk of accidents and complications. The diagnosis and understanding of these complications are the first steps toward the adoption of the appropriate treatment. Careful planning, with treatment simulations and model surgery, minimize the potential for intraoperative complications. In the current study, the inclusion criterion of at least 5 years of experience as a specialist was defined because of the learning curve in treating dentofacial deformities with orthognathic surgery, thereby diminishing the bias of the study.

Dimitroulis[97] classified preoperative complications in communication, diagnosis, laboratory work, and patient preparation. Intraoperative

**TABLE 2.** Le Fort I Complications

| Complications | Yes n | Yes %* | No n | No %* |
|---|---|---|---|---|
| Malocclusion | 28 | 28.0 | 72 | 72.0 |
| Hemorrhage | 29 | 29.0 | 71 | 71.0 |
| Vascularization deficiency | 2 | 2.0 | 98 | 98.0 |
| Periodontal defects | 9 | 9.0 | 91 | 91.0 |
| Tooth devitalization | 6 | 6.0 | 94 | 94.0 |
| Nerve damage | 40 | 40.0 | 60 | 60.0 |
| Ophthalmic injury | 1 | 1.0 | 99 | 99.0 |
| Oronasal and oroantral fistula | 4 | 4.0 | 96 | 96.0 |
| Nasal septum deviation | 36 | 36.0 | 64 | 64.0 |
| Maxillary sinusitis | 16 | 16.0 | 84 | 84.0 |
| Bad osseous union | 9 | 9.0 | 91 | 91.0 |
| Bad split | 11 | 11.0 | 89 | 89.0 |
| Eustachian tube dysfunction | — | — | 100 | 100.0 |
| Velopharyngeal incompetence | — | — | 100 | 100.0 |
| Arteriovenous fistula | — | — | 100 | 100.0 |
| Dysphagia | — | — | 100 | 100.0 |
| Condylar resorption | 1 | 1.0 | 99 | 99.0 |
| Condylar sag | — | — | 100 | 100.0 |
| Infection | 10 | 10.0 | 90 | 90.0 |

*Percentages obtained from total number of 100 oral and maxillofacial surgeons who performed the operation on patients with dentofacial deformities.

complications included hemorrhage, nerve damage, unfavorable osteotomy, and poor jaw positioning. Postoperative complications were separated into complications in the acute postoperative phase (<2 w) and chronic phase (>2 w). Wound dehiscence, hemorrhage, and infection were included in the acute phase, whereas relapse, nerve dysfunction, poor aesthetics, poor bone healing, poor fixation, and patient dissatisfaction were included in the chronic phase.

## Neurosensory Disturbance

The most common problem reported in the current survey was neurosensory disturbance of the inferior alveolar nerve (IAN), which 92% of the respondents reported in relation to SOMR, 4% reported in relation to subapical osteotomy, and 27% reported in relation to genioplasty. Previous retrospective studies also reported that IAN injury is the most common postoperative complication, with an incidence ranging from 9% to 100%.[8,10,16–19,23,24,27,54] Other neurologic deficits with SOMR have also been reported.[6] The lingual nerve may be affected by osteotomy of the inferior border, especially when an inferior border saw is used. Seventh nerve palsy is uncommon, but with the nearness of the nerve to the posterior border of the ramus, injury can occur, with the incidence reported to be between 0.4% and 1%.[17,24,54,61] Unlike with SOMR, the risk of nerve injury with intraoral vertical osteotomy is theoretically lower; however, long-term sensory deficit ranges from 2.3% to 14%.[20,22,48] The current study corroborates this finding because the frequency of the report of nerve damage with VOMR was 4%.

For Le Fort I osteotomy, 40% of the respondents reported experience with neurosensory disturbance. With the exception of the nasopalatine and superior alveolar nerves, which are inevitably transected with Le Fort I osteotomy, sensory loss in the infraorbital nerve distribution is temporary and recovery is nearly complete. This is because the infraorbital nerve is easily visualized and most osteotomies occur below the foramen.[9,21,75] Sensory deficit in the teeth, the palatal mucosa, and the buccal mucosa tends to resolve gradually for a period of 12 to 18 months. Other rare neurologic deficits of the second, third, fourth, fifth, sixth, tenth, and twelfth cranial nerves have been reported.[7,11,25,84,99] These are likely to occur as a result of unfavorable fractures ascending into the cranial base.[6]

Neurosensory disturbance was also the most common complication involving bone fixation (58% and 20% of the respondents reported this complication in mandible and maxilla fixations, respectively). The long-term incidence of sensory loss is approximately 1.5% to 2% and may occur as a result of extensive traction due to soft tissue retraction or due to compression at the time of plate fixation.[9,21,23,59,75] Whether the use of small monocortical plates reduces the incidence of IAN injury in comparison with bicortical position screws or bicortical lag screws is not clear[14] because previous studies report discrepant results with different fixation techniques.[23,27,59]

Although studies in the international literature reported nerve damage stemming from orthognathic surgery, the results of these investigations were obtained considering a large number of variables.[9,10,12,26,27,59,75] The use of objective tests for the detection of such injuries leads to a lower percentage of affected nerves, whereas the use of subjective tests leads to a higher rate of neurosensory disturbances,[8] thereby influencing the results. In any case, patients always should be informed of the relatively high risk of neurosensory disturbances[12] and that the occurrence of paresthesia may reduce the overall satisfaction with the outcome of treatment.[100]

## Unfavorable Osteotomy

Errors in model surgery performed with an articulator have also been reported as a possible cause for discrepancies in the postoperative period related to segment positioning.[101] However, variability in bone architecture and density can result in unanticipated fractures that hinder fixation and stabilization. This is more common in the mandibular ramus with bilateral sagittal split osteotomy and in pterygoid plates with Le Fort I osteotomy.[5]

In the current study, unfavorable fractures were the second most common complication in mandible osteotomies, with 41% of the respondents reporting this complication with SOMR, 11% with VOMR, 3% with subapical osteotomy, and 15% with genioplasty.

**TABLE 3.** Bone Fixation Complications

| Fixation of Bone Segments | Yes n | Yes %* | No n | No %* |
|---|---|---|---|---|
| Mandible | | | | |
| Fracture of material | 23 | 23.0 | 77 | 77.0 |
| Nerve damage | 58 | 58.0 | 42 | 42.0 |
| Loss of material | 11 | 11.0 | 89 | 89.0 |
| Exposure of plate | 32 | 32.0 | 68 | 68.0 |
| Maxilla | | | | |
| Fracture of material | 10 | 10.0 | 90 | 90.0 |
| Nerve damage | 20 | 20.0 | 80 | 80.0 |
| Loss of material | 7 | 7.0 | 93 | 93.0 |
| Exposure of plate | 13 | 13.0 | 87 | 87.0 |

*Percentages obtained from total number of 100 oral and maxillofacial surgeons who performed the operation on patients with dentofacial deformities.

The incidence of this complication with sagittal split osteotomies of the ramus ranges from 3% to 23%.[5,17,22,102–104] These include condylar neck, lingual plate, and buccal plate fractures. The "ideal" split may be technically difficult to achieve depending on anatomic variations (eg, variation in ramus width) and thereby hindering the ability to place and guide the osteotome.[17] Condylar neck fractures occur when the horizontal osteotomy is misdirected posteriorly and superiorly instead of horizontally to the occlusal plane. Buccal plate fractures typically occur when the vertical osteotomy at the inferior border is incomplete and a sagittal split is attempted using osteotome. Lingual plate fracture originating near the ascending ramus may occur when the mandibular third molars have not been previously extracted. Therefore, nonerupted third molars should be extracted 6 to 12 months before surgery to avoid uncontrolled fractures and facilitate internal fixation.[98] However, it remains unclear as to whether the presence of a third molar in the mandible actually increases the chances of an unfavorable split when attempting a SORM because a number of authors have found no difference in the incidence of this complication with or without third molars.[31,105]

With regard to Le Fort I, fewer respondents reported unfavorable osteotomy (11%) in comparison with other complications. However, it is difficult to compare this information with other studies because most investigations reported unfavorable osteotomy of the maxilla and mandible together. Moreover, there are more studies on bad splits in the mandible. Nevertheless, with unfavorable Le Fort I osteotomy, uncontrolled fracture extending into the cranial base may occur when the osteotomy is incomplete and downfracture is attempted or when the osteotome is improperly positioned during pterygopalatine disjunction. Such fractures may result in one of the rare yet well-described vascular, neurologic, or ophthalmic complications.[28,30,32,33]

## Condylar Resorption

Condylar resorption is a late complication that becomes evident within the first several years after surgery. Thus, follow-up beyond the first year is important.[6] Reported as a source of relapse (although not relapse per se), this process represents pathologic and destructive remodeling. It is known to occur in the general population (idiopathic condylar resorption) and in the orthodontic population without having undergone orthognathic surgery. It is not known whether it occurs more frequently in patients subjected to orthognathic surgery.[14] Several case series have been published,[36,40,42] and a small number of retrospective studies have reported a frequency of condylar resorption ranging from 2.3% to 26%.[35,37–39,45] The results of the current study regarding condylar resorption with orthognathic osteotomy corroborate this rate of frequency. All studies cited involved bilateral sagittal split osteotomy, although many concurrent procedures were performed, including Le Fort I osteotomy and genioplasty. The criteria used to diagnose condylar resorption vary between studies, which probably accounts for the large range reported. There is a predilection for young women with preoperative class 2 occlusion and a history of temporomandibular joint disorder.[39] This complication has also been reported in men, albeit less frequently.[36,37]

## Condylar Sag (Incorrect Condylar Position During Surgery)

The diagnosis of condylar "sag" (anterior–inferior displacement) can be confirmed by a lateral cephalometric radiograph.[56] Hall et al[106] found that a certain degree of condylar sag occurred in cases in which the condylar segment was left free and some cases required condylar segment repositioning and wiring. The authors also reported that open bite secondary to intraoral vertical subsigmoid osteotomy occurred approximately twice as often in patients without wire fixation of the condylar segments in comparison with those who received fixation. In the study cited, no open bites occurred after the adoption of the circumramus wiring technique after ramus osteotomy. To minimize postoperative condylar sag, limited stripping of the medial pterygoid muscle attachment was recommended because osteotomy too close to the posterior border of the vertical ramus would leave a small mass of muscle attached to the proximal segment, which may result in more sag.[106] On the contrary, in a national survey of intraoral vertical subsigmoid osteotomies, 73% of the respondents reported leaving the proximal segment unfixed and those who used fixation preferred transosseous to circumramus wire.[107] In another study in which no wiring of the proximal segments to the distal segments was performed after vertical subsigmoid segment osteotomy, only 4 patients exhibited radiographic evidence of lateral displacement and significant condylar sag.[76] Corroborating this, only 2% of the respondents in the current study reported condylar sag with SOMR.

## Hemorrhage

Hemorrhage occurring in the intraoperative period is rarely a problem, although bleeding from larger vessels may be difficult to control owing to difficulty with access.[5] Bleeding often occurs when the lateral mandibular vessels are severed or when a rotating bur is used.[51] A previous article found that 25% of surgeons reported excessive bleeding from the maxillary, inferior alveolar, and facial arteries. MacIntosh[17] reported problematic bleeding in 10.7% of cases with SOMR. The current study corroborates these findings because 14% of the surgeons reported experiencing hemorrhage with SOMR and 29% reported hemorrhage with Le Fort I osteotomy. On the contrary, these findings disagree with those described by Kim and Park,[5] who reported only 5 cases (2.0%) of vascular injury occurring with sagittal split ramus osteotomy and 1 case (1.5%) occurring during the Le Fort I procedure. The authors state that the maxillary artery was damaged in these cases because of careless dissection of the lateral soft tissues or the improper use of dissecting tools.

The use of local anesthesia with a vasoconstrictor and controlled hypotensive anesthesia significantly reduces generalized bleeding and the need for blood transfusion while greatly improving the visualization of the operative field.[108] One study demonstrated that controlled operative hypotension reduces blood loss by approximately 44%.[49] Significant hemorrhage is uncommon and is more likely to occur with maxillary osteotomy.[49,96] The vessels at risk in this procedure are the greater palatine vessels, maxillary artery, and pterygoid plexus.[21] Significant hemorrhage with mandibular osteotomy (bilateral sagittal split osteotomy or intraoral vertical osteotomy) is uncommon.[20,62] The vessels at risk are the inferior alveolar artery, maxillary artery, facial artery, retromandibular vein, and the pterygoid venous plexus.[48]

Management of intraoperative hemorrhage requires visualization of the problem area. This may involve rapid completion of an osteotomy to allow the application of direct pressure, vascular clips, or electrocautery. Deliberate, controlled hypotension can be temporarily useful but does not preclude the need for direct control of the bleeding.[5] When a serious complication arises, early recognition, rapid response, and effective resolution are essential.

## Malocclusion

Surgical malocclusion is uncommon but can occur and becomes readily apparent in the early postoperative period.[96] Early relapse tendencies can often be managed with class 3 or class 2 dental

 

elastics and/or orthopedic appliances, if minimal (edge-to-edge incisal relation). However, more significant recurrence of the initial preoperative occlusion requires a return to the operating room in most circumstances. Occlusal relapse can also occur long after the initial surgery and is a result of a complex etiology of functional dental and muscle forces reestablishing equilibrium and the remodeling of the facial skeleton. Long-term follow-up is important, and management is directed toward the cause.[6]

Anterior open bite is usually due to a failure of the screws and/or plates placed at the time of fixation or technical difficulties incurred at the time of the splitting of the segments, with resulting edema in the joints, which resolves over time. However, anterior open bite is much more commonly seen in patients after intraoral vertical ramus osteotomy upon the release of maxillomandibular fixation. Suggestions for the prevention of anterior open bite include the removal of the coronoid process, the placement of skeletal wires, or the use of modified cuts of the ramus and 8 weeks of maxillomandibular fixation. Postoperative elastics have been used for 2 to 6 weeks when anterior open bites is noted.[109] In the current study, 13% of the respondents reported experience with open bite with SOMR, 8% with VOMR, and 28% with Le Fort I osteotomy.

## Septum Deviation

Postoperative septum deviation and airway obstruction may result from Le Fort I osteotomy. A total of 36% of the surgeons surveyed in the current study reported this type of complication. Nasal asymmetry and preexisting septum deviation should be identified preoperatively. Intraoperatively, careful attention must be given to the position of the anterior nasal spine, septal cartilage, and vomer. Failure to shorten these structures during maxillary impaction will force them from the midline, causing buckling and nasal airway obstruction.[6]

## Maxillary Sinusitis

Maxillary sinusitis is a possible complication of Le Fort I osteotomy described in the literature. Sinusitis after maxillary osteotomy can be caused by a change in the clearance mechanism of the maxillary sinus. However, infections are rare, probably because of the use of postoperative antibiotics. The literature describes a relatively low incidence of this complication ranging from 0.24% to 20%. There are numerous potential causes of the development of sinusitis, such as the formation and retention of a large blood clot, previous sinusitis,[110] secondary dental infection due to iatrogenic apical trauma, tissue ischemia, a lack of vascularization, debris in the sinus, and sutures and plates or screws in the sinus cavity.[74] A recent study reported a 4.76% incidence of maxillary sinusitis as a postoperative complication. In the current study, 16% of the respondents reported experiencing this complication. Panula et al[55] reported an incidence of 6%.

## Infection

The incidence of infection in orthognathic surgery is difficult to evaluate because most studies combined all orthognathic procedures. The current study found low rates of infection. The highest figure occurred with SOMR, for which 19% of the respondents reported experience with infection, followed by Le Fort I (10%). None of the surgeons reported infection with subapical osteotomy. Numerous antibiotic regimens have been used without any standardization.[14,71] Nonetheless, postoperative infection after orthognathic surgery is uncommon.[6] Most studies reported an incidence of less than 1%,[61,64,96] ranging from 0% to 18% with either a perioperative antibiotic regimen[64,67,68,70] or a combined perioperative and postoperative antibiotic regimen.[62–66,68–70,72] Infection rates between 0% and 53% have been reported without antibiotics.[62,63,66,67] Although the use of antibiotics seems to reduce the incidence of infection, the evidence supporting the continued use of antibiotics after the perioperative period is marginal.[14]

## Dental and Soft Tissue Injuries

The risk of tooth injury is minimized with careful preoperative planning. However, tooth fracture or loss may occur when performing interdental osteotomy. Presurgical orthodontics should provide adequate spacing for anticipated osteotomies, which should be performed with microburs. Periapical film is a useful adjunct to determine the safe depth for an osteotomy. Postoperatively, teeth may be clinically followed up based on coloration. A compromised tooth is treated secondarily through endodontic intervention, which may include extraction and prosthetic replacement, sometimes with osseointegrated implants and bone grafts in cases of associated alveolar loss.[6] In the study carried out by Kim and Park,[5] dental injury occurred in 3 cases (1.0%) having undergone Le Fort I osteotomy and genioplasty combined with anterior segmental osteotomy. In the current study, 6% of the respondents reported experience with dental injury with this same osteotomy.

A total of 9.0% of the surgeons reported experience with periodontal soft tissue injury, which corroborates findings described by Kim and Park,[5] who reported a rate of 6%. Soft tissue injuries can occur during different stages of surgery. For example, prolonged traction of the lip or mucosa to secure the operative field and facilitate access when applying wire fixation to secure the jaw can cause injury or laceration when surgical instruments scrape against soft tissues. Excessive prolonged traction of the soft tissues should be avoided, and the upper and lower lips should be protected with a layer of petroleum jelly or antibacterial ointment before and after surgery to prevent soft tissue laceration and abrasion.[5]

## Failure of Osteosynthesis Material

The advent of rigid fixation has had a major influence on both patients undergoing orthognathic surgery and the surgeons performing this surgery. With the use of rigid fixation, patients recover more safely and comfortably and the treatment results are more stable.[89] This procedure is also less cumbersome for surgeons, who previously had to rely on suspension wires and maxilla–mandibular fixation. However, rigid fixation may fail. Fixation failure is usually evident within the first week after surgery, when a change in the occlusion is noticed. The following are typical occlusal changes associated with bilateral fixation failure: (1) development of anterior open bite, (2) the mandible moves forward with the molars into a class 3 relation, (3) the incisors develop anterior cross bite, and (4) early posterior dental contact followed by movement of the anterior mandible occurs when the patient occludes.[56]

In the current study, failure of the fixation material was attributed to the fracture of the material and was the third most present complication related to osteosynthesis material reported for both the mandible (23%) and the maxilla (10%). Panula et al[55] reported the removal of all or part of the osteosynthesis material from 48 patients, representing approximately 8% of those with rigid internal fixation in the study. However, the need for the removal of bone plates and screws is controversial.[86,88]

# CONCLUSIONS

The results of the current study reveal that most oral and maxillofacial surgeons experienced similar orthognathic surgery complications to

those reported in retrospective studies. Despite the wide variety of severe complications reported, the frequency of these complications seems to be extremely low, making orthognathic surgery a safe procedure.

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# Osteoconductive Properties of β-Tricalcium Phosphate Matrix, Polylactic and Polyglycolic Acid Gel, and Calcium Phosphate Cement in Bone Defects

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**Abstract:** Extensive bone defects in maxillofacial region can be corrected with autogenous grafts; otherwise, the disadvantages of the therapeutics modality take the research for new bone substitutes. The aim of the study was to evaluate and compare the osteoconductive properties of 3 commercial available biomaterials. A total of 30 calvarial defects (5-mm diameter) were randomly divided into 5 treatment groups, with a total of 6 defects per treatment group (n = 6). The treatment groups were as follows: 500 to 1000 μm β-tricalcium phosphate (β-TCP), polylactic and polyglycolic acid (PL/PG) gel, calcium phosphate cement, untreated control, and autograft control. The evaluations were based on histomorphometric analysis at 60 postoperative days. The results have shown that β-TCP and autograft control supported bone formation at 60 postoperative days. β-Tricalcium phosphate showed the highest amount of mineralized area per total area and statistically significant compared with PL/PG, calcium phosphate cement, and untreated control groups. The PL/PG gel does not have osteoconductive properties and performed similar to empty control. Calcium phosphate cement showed higher number of multinucleated giant cells around the sites of the biomaterial and showed newly formed bone only at the edges of the biomaterial, without bone formation within the biomaterial. The findings presented herein indicate that bone formation reached a maximum level when rat calvarial defects were filled with β-TCP at 60 postoperative days. Further studies should be conducted with β-TCP to understand the potential of this biomaterial in bone regeneration.

**Key Words:** Osteoconductive properties, β-tricalcium phosphate, polylactic and polyglycolic acid, calcium phosphate cement, rats, calvarial, bone, biomaterials

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