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Complications associated with orthognathic surgery: A retrospective study of 485 cases

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ABSTRACT

Purpose: To identify the most prevalent types of complications associated with orthognathic surgery and its possible risk factors.
Methods: This study was a retrospective investigation of records of 485 patients who underwent orthognathic surgery between 2008 and 2014 at the Oral and Maxillofacial Surgery Service at the Federal University of Paraná, Curitiba, Brazil. Types of complications were recorded. Independent variables such as sex, age, duration of surgery and hospitalization, number of surgeries, surgical site, and types of osteotomy performed were evaluated. Complications were also evaluated based on the treatment according to the Clavien–Dindo Classification. Data were submitted to statistical analysis with a significance level of 0.05.
Results: A total of 93 complications were reported (19.2%), including postoperative malocclusion, hemorrhage, inferior alveolar nerve injury, bad split, and infection. Complications were more common in men ($p = 0.029$). The number of complications was higher in surgeries that took more time to perform ($p < 0.05$) when the entire sample was taken into consideration. The prevalence of complications was related to a higher number of procedures per surgery ($p = 0.019$). Complications were more frequent in mandibular procedures ($p = 0.010$), particularly in bilateral sagittal split osteotomies ($p < 0.001$). Related to treatment, Clavien–Dindo grade I complications were the most frequent (72.04%). There was no association between sex, age, surgery duration, length of hospitalization, or surgical site with complication grades according to the Clavien–Dindo classification ($p \geq 0.05$).
Conclusion: Postoperative malocclusion, hemorrhage, inferior alveolar nerve injury, bad split and infection are the most prevalent complication in orthognathic surgery. They seem to be related to sex, duration of surgery, number of surgeries, surgical site, and the type of osteotomy performed. With these in mind, it is possible to explain to the patient the different levels of severity of complications related to the surgery.

1. Introduction

Orthognathic surgery is performed for the correction of dentofacial deformities and malocclusion. Its principle involves surgical manipulation of the facial skeleton bones, mainly the maxilla and mandible, in order to re-establish the anatomical relationship and function (Patel and Novia, 2007). Orthognathic surgery is indicated for patients with moderate or severe conditions that exceed the

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implication for orthodontic correction (Reid, 2007; Khechoyan, 2013). Important technical and scientific advances related to the methods of diagnosis, planning, surgical technique, and materials have made orthognathic surgery increasingly safe and accessible to the general population (Bailey et al., 2001). Functional issues, malocclusion, pain-related problems such as temporomandibular joint (TMJ) disorders, and cosmetic issues are the main reasons for seeking this type of procedure (Panula et al., 2001; Kriwalsky et al., 2008; Verweij et al., 2016).

Orthognathic surgery, similar to any other type of surgical procedure, has complication risks. The most commonly described complications in the literature are nerve injuries with altered sensitivity, temporomandibular joint disorders, hemorrhage, condylar resorption, postoperative malocclusion, infection, unwanted fracture or bad split, non-union of bone segments, relapse, nasal abnormalities, bone necrosis, soft tissue or periodontal injuries, dental injuries, unsatisfactory esthetic result, suture dehiscence, and fixation material failure (Panula et al., 2001; Patel et al., 2007; Chow et al., 2007; Morris et al., 2007; Kim and Park, 2007; D'Agostino et al., 2010; Ho et al., 2011; de Santana Santos et al., 2012; Williams et al., 2012; Iannetti et al., 2013; Jędrzejewski et al., 2015; Robl et al., 2014). Sex, age, presence or absence of third molars, surgery duration, surgeon experience, type of maxillomandibular deformity, and single jaw or bimaxillary orthognathic surgery are risk factors for complications (Mehra et al., 2001; Jędrzejewski et al., 2015; Tabrizi et al., 2015; Bacos et al., 2019; Kantar et al., 2019).

Another way to evaluate complications associated with surgical procedures is based on the manner in which the complication is treated. The Clavien–Dindo Classification (Clavien et al., 2009), which can be used for all medical areas, grades complications from I to V with increasing severity. To the best of our knowledge, there are no studies using this classification in orthognathic surgery.

The aim of the present study was to identify the most prevalent types of complications related to orthognathic surgery and the association with possible risk factors.

2. Material and methods

2.1. Study subjects

The study was approved by the local Research Ethics Committee at the Federal University of Paraná (Protocol number 27371914.1.0000.0102) in compliance with the Declaration of Helsinki.

This retrospective cross-sectional observational study included data from patients who underwent orthognathic surgery at the Hospital do Trabalhador, Curitiba, Paraná, Brazil, from 2008 to 2014. Exclusion criteria were incomplete or inconsistent records, records of individuals who underwent temporomandibular joint surgery concomitant to orthognathic surgery, and records of individuals who underwent complex craniofacial surgeries (such as Le Fort II or III osteotomies).

2.2. Variables

The dependent variable was the presence of complications. Complication occurrence was classified into intraoperative and postoperative. The following complications were considered:

- Nerve injuries: partial laceration or total nerve transection
- Intra- or postoperative hemorrhage. (1) Intraoperative hemorrhage was considered to be intense bleeding during surgery due to the rupture of large vessels that delayed or made it impossible to continue the surgery. Hemorrhage required measures to achieve homeostasis, such as blood pressure adjustments with hypotensive medication, adequate visualization and direct pressure, vessel clamping, surgical packing, topical homeostatic agents, or electro-cauterization. (2) Postoperative hemorrhage was considered to be bleeding that occurred within 48 h after surgery that required surgical packing or any revision surgery to find the source of bleeding and to perform homeostasis
- Bad split: undesired fracture of the mandible at the proximal or distal fragment when performing a sagittal split osteotomy (SSO)
- Infections: infection complications were considered for those individuals who required antibiotic therapy, and in some cases, surgical drainage. Post-operative sinusitis was also considered in Le Fort I osteotomies
- Dental injuries: trauma or sectioning of one or more teeth by surgical instruments such as drills, saws, and chisels, damage such as pulp necrosis, increased mobility, fracture, discoloration, or tooth loss
- Soft tissue or periodontal injuries: soft tissue or periodontal tissue laceration by instruments during the stages of osteotomy or chiseling
- Non-union of bone segments (pseudarthrosis): when the osteotomy line showed no radiographic evidence of the consolidation process progression, indicated by sclerosis at the osteotomy ends, presence of a gap, and persistence or widening of the osteotomy trace
- Postoperative malocclusion: immediate or mediate postoperative occlusion different from the planned occlusion when correction with the use of intermaxillary elastics or postoperative orthodontic treatment is impossible
- Skeletal relapse: the immediate postoperative bone repositioning result is lost during the follow-up period
- Failure of fixation screws and plates: breaking, loosening, or failure of bone segment fixation plates and screws requiring surgical re-intervention for correction
- Breakage or failure of surgical instruments: breakage of surgical instruments such as drills, saws, and chisels during the surgical procedure
- Temporomandibular joint disorders: pain, cracking, difficulty opening or closing the jaw, and TMJ disc displacements that did not exist before surgery
- Condylar resorption: nonexistent preoperative condylar resorption diagnosed in postoperative follow-up
- Nasal abnormalities: deviation of the nasal septum or nose widening secondary to maxillary repositioning associated with esthetic alterations
- Ophthalmic abnormalities: ophthalmological lesions were considered indirect lesions of neurovascular structures occurring during traction or compression; lesions caused by forces transmitted during surgery and fractures extending to the cranial base or the orbit associated with the maxillary downfracture
- Bone necrosis or osteomyelitis: bone necrosis in the osteotomy region requiring re-intervention and antibiotic medication
- Suture dehiscence: opening of the surgical wound with or without fixation exposure with no associated infection that was treated effectively with debridement and suture

Complications with frequencies fewer than four were classified as "other."

Independent variables such as sex, age, duration of surgery and hospitalization, region and number of surgical sites, and type of osteotomy performed were collected. The duration of surgery and hospitalization was measured in hours. Regions of surgical sites were divided into groups, taking into consideration the modality of surgery performed: (1) maxilla, (2) mandible, (3) maxilla and mandible, (4) maxilla, mandible, and chin, and (5) maxilla and chin, mandible and chin, or only chin. The number of surgical sites was classified according to (isolated surgeries of maxilla, mandible, or chin), two (combined maxillary and mandible, maxilla and chin, and mandible and chin surgeries), and three (combined maxilla, mandible, and chin surgeries). Types of osteotomies were classified as: bilateral sagittal split osteotomy (BSSO), Le Fort I osteotomy, surgically assisted rapid palatal expansion (SARPE), horizontal sliding osteotomy of the mandibular symphysis (HSOMS), and others (intraoral vertical ramus osteotomy, mandibular symphysial midline osteotomy, subapical mandibular osteotomy, and inverted-L osteotomy of the mandibular ramus). It is important to note that one patient could undergo more than one type of osteotomy.

The Clavien–Dindo Classification (Clavien et al., 2009), which is used for all medical areas, grades complications from I to V. Grade I refers to any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, or radiological interventions. The acceptable therapeutic regimens for grade I are drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside. Grade II complications require pharmacological treatment with drugs other than those allowed in grade I complications. Blood transfusions and total parenteral nutrition were also included. Grade III relates to those complications that require surgical, endoscopic or radiological interventions and is subdivided into grade III-a when intervention is not performed under general anesthesia and grade III-b when intervention is performed under general anesthesia. Grade IV deals with life-threatening complications (including central nervous system complications) that require intermediate care or intensive care unit management. It is subdivided into IV-a for single organ dysfunction (including dialysis) and IV-b for multi-organ dysfunction. Finally, grade V complications result in patient death. The Clavien–Dindo classification of complications (Clavien et al., 2009) was described by frequency of grades in the sample.

Data were submitted to statistical analyses. Univariate analyses were performed to verify the association of complications with risk factors. P values < 0.05 were considered statistically significant. Data were analyzed with the computer program IBM SPSS Statistics version 20.0.

3. Results

A total of 485 orthognathic surgeries were performed during the study period. Women represented 64.9% (n = 315) and men represented 35.1% (n = 170), which gave a ratio of 1.8:1. The mean age was 29.9 ± 8.5 years, with 46.8% of surgeries performed in patients aged 21–30 years. Surgeries in the maxilla only were the most frequently performed surgical modality, representing 38.8% of operated cases, followed by maxilla and mandible combined surgery, representing 33.2% of cases. A total of 769 osteotomies were performed. The most frequent was BSSO (35.9%), followed by Le Fort I osteotomies (34.5%).

Complications occurred in 19.2% of surgeries (n = 93). Twenty-eight complications occurred in the intraoperative phase and 65 in the postoperative phase. The most frequent complications were postoperative malocclusion (n = 12/12.9%), hemorrhage (n = 12/12.9%; with eight in the intraoperative phase, and four in the postoperative phase), inferior alveolar nerve injury (n = 9/9.6%), and bad split (n = 9/9.6%). There was no case of condylar resorption. Complication types are detailed in Table 1. Complications classified as other were skeletal relapse (four), patient dissatisfaction with facial esthetics (four), ophthalmic abnormalities (three), suture dehiscence (three), nasal abnormalities (two), temporomandibular joint disorder (two), dyspnea (two), inflammation associated with bone fixation plates and screws (two), tooth injury (one), displacement of oropharyngeal tamponade gauze to the gastrointestinal tract (one), non-union of bone segments (pseudarthrosis; one), and postoperative systemic commitment requiring intensive care (one).

Table 1
Type and frequency of complications.

Complications	n	%
Postoperative malocclusion (open bite or occlusion different from planned)	12	12.9
Hemorrhage	12	12.9
Inferior alveolar nerve injury	9	9.6
Bad split/inadequate osteotomy	9	9.6
Infection	8	8.6
Fixation device fracture/failure	7	7.5
Failure or break of surgical instrumental	5	5.3
Soft tissue and periodontal injuries	5	5.3
Others	26	27.9
Total	93 (19.2%)	

Men (24.7%) presented significantly more complications when compared to women (16.2%) [Fisher's exact test, $p = 0.029$/PR: 1.53 (95% CI: 1.06–2.19)]. There was no association between complications and patient age (Student's t-test, $p = 0.923$).

The duration of surgery and overall hospitalization time was statistically different when related to the surgical modalities performed (one-way analysis of variance [ANOVA] and Kruskal–Wallis test, $p < 0.001$), as shown in Fig. 1A, B. A significant correlation was found between the duration of surgery and length of hospitalization (Spearman's rank correlation coefficient 0.63, $p < 0.001$). A statistically significant relationship was found between the duration of surgery (Student's t-test, $p = 0.019$) and the length of hospitalization (Mann–Whitney test, $p = 0.001$), with the occurrence of complications when the entire sample was taken into consideration without dividing the regions of surgical site. Comparisons between complication presence or absence with surgery duration and length of hospitalization in accordance with the surgical site are shown in Table 2. An association was observed between the length of hospitalization and the presence of complications in two groups (isolated maxillary surgeries and combined maxilla/chin or mandible/chin surgeries; $p < 0.05$).

There was a significant association between the number of surgeries and surgical sites and the occurrence of complications (Chi-square test, $p = 0.019$). Complications in one-region surgeries (isolated surgeries of maxilla, mandible or chin) were 15.73% (n = 39/248); complications in two-region surgeries (combined maxilla and mandible, maxilla and chin, and mandible and chin surgeries) were 20.31% (n = 39/192) and in three-region surgeries (combined maxilla, mandible and chin surgeries) were 33.33% (n = 15/45). When groups were compared, the prevalence ratio and confidence interval were as follows: one-versus two-region surgeries [PR = 1.29 (CI95%: 0.87–1.93)]; one-versus three-region surgeries [PR = 2.12 (CI95%: 1.28–3.51)]; and two-versus three-region surgeries [PR = 1.64 (CI95%: 1.00–2.70)].

The complications prevalence was significantly higher in patients who underwent mandibular surgery [Fisher's exact test, $p = 0.010$/PR: 1.72 (95% CI: 1.14–2.59)]. A higher prevalence of complications was found in the BSSO and segmental Le Fort I (Chi-square test, $p < 0.001$) cases. Complications occurred in 14 of 115 (12.1%) SARPE cases, 31 of 265 (11.7%) Le Fort I osteotomies, four of 23 (17.4%) segmental Le Fort I osteotomies, 60 of 276 (21.7%) BSSO

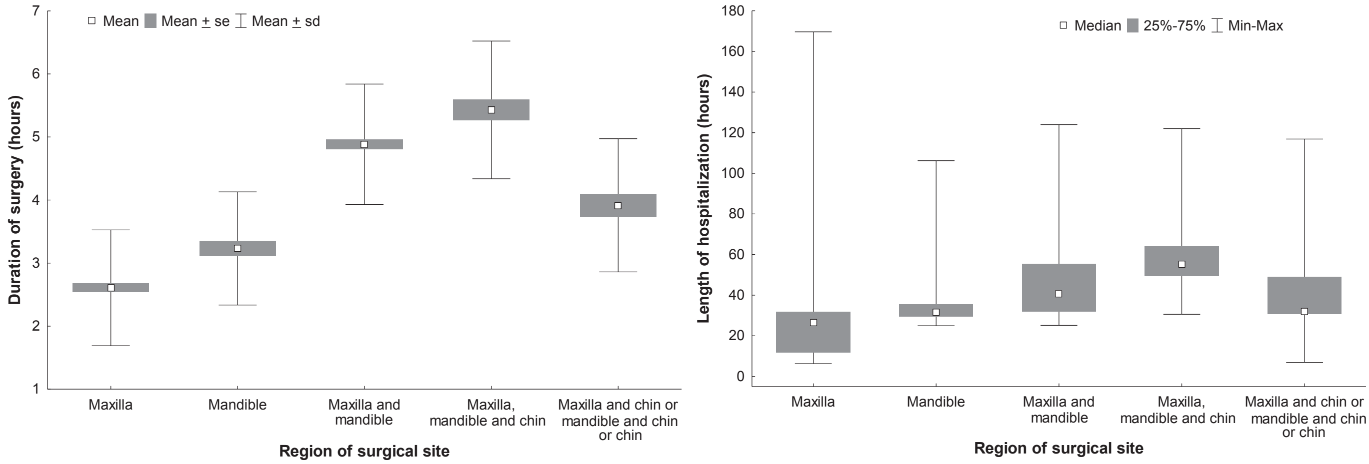

Fig. 1. (A) and (B) show a comparison of the surgical site and duration of surgery, and a comparison of the surgical site and length of hospital stay, respectively.

cases, two of 79 (2.5%) HSOMS cases and no complications occurred in "other" osteotomies.

The distribution, according to Clavien–Dindo classification for surgical complications, was 67 (72.04%) grade I, nine (9.68%) grade II, three (3.23%) grade III-a, 13 (13.98%) grade III-b, and one (1.07%) grade IV-a.; there were no grade IV-b or V complications. The sex distribution was 39 women and 28 men for grade I, five women and four men for grade II, three men for grade III-a, six women and seven men for grade III-b, and one woman for grade IV-a. There was no association between sex and complications according to the Clavien–Dindo classification (Fisher's exact test, $p = 0.056$). Likewise, no association was found between age and complications grades (Student's *t*-test, $p = 0.749$). There was no statistical difference between grades of Clavien–Dindo classification for the length of hospitalization (one-way ANOVA, $p = 0.234$), as well as for surgery duration (one-way ANOVA, $p = 0.169$). Finally, no association was found between the classification grades and surgical sites (Fisher's exact test, $p = 0.610$).

4. Discussion

A surgical complication is defined as any deviation from the normal intraoperative or postoperative course. The complications prevalence and definition may vary between research studies due to differences in methods and parameters. Previous studies showed complication rates of 9.7% in a sample of 1,294 patients (Chow et al., 2007), 12.4% of 1,000 patients (Robl et al., 2014), and 25.6% of 3,236 performed surgeries (Iannetti et al., 2013). Our research complication rate was 19.2%. One of the features of the service where the research was based is that all surgeries were performed by third-year residents in Oral and Maxillofacial Surgery and were always supervised by a senior surgeon. All patients had their medical history collected and pre-surgical laboratory tests requested. In addition, they underwent pre-anesthetic and cardiological evaluation. Other specific pre-surgical needs were referred to medical specialties. Surgical planning was performed by detailed preoperative clinical intra- and extraoral examination, dental plaster model evaluation, cephalometric radiographs with tracings examination, cephalometric predictive tracing, and model cast surgery for surgical guides creation (using articulator-mounted models). Therefore, we can infer that the service has an educational aspect, and the complication rate seems to be low.

Postoperative malocclusion occurs when the occlusion is different from the planned occlusion and when correction with the use of intermaxillary elastics or postoperative orthodontic treatment is impossible. There are a variety of possible causes of postoperative malocclusion: severity of dentofacial deformity, complexity of surgical procedure, fixation technique, surgeon experience, plates and screws fixation failures, patient noncompliance during postoperative care, inadequate mandibular condyles positioning during fixation, relapse of maxillary expansion, lack of intraoperative methods to maintain expansion, orthodontic relapse, condylar resorption, or additional growth (Wijbenga et al., 2009).

We found 12 cases of hemorrhage in the intraoperative (eight) and the postoperative phase (four). Intraoperative and

Table 2
Comparison between complication presence or absence and surgery duration and length of hospital stay.

Operated bone(s)	Complication	n (%)	Surgery duration (hours)	p^*	Length of hospital stay (hours)	p^{**}
			Mean ± SD		Median (Min.–Max.)	
Maxilla	No	161 (33.2)	2.6 ± 0.9		25.6 (6.3–169.6)	
	Yes	27 (5.5)	2.9 ± 0.8	0.148	30.4 (8.6–70.6)	**0.018**
Mandible	No	45 (9.3)	3.2 ± 1.0		31.7 (25.0–106.2)	
	Yes	12 (2.5)	3.3 ± 0.7	0.800	30.4 (25.7–80.0)	0.529
Maxilla and mandible	No	128 (26.4)	4.9 ± 1.0		39.8 (25.2–124.0)	
	Yes	33 (6.8)	5.0 ± 0.9	0.468	50.7 (25.2–102.4)	0.636
Maxilla, mandible, and chin	No	30 (6.2)	5.6 ± 1.2		55.2 (30.6–122.0)	
	Yes	15 (3.1)	5.2 ± 0.8	0.195	54.3 (31.3–86.3)	0.482
Maxilla and chin or Mandible and chin or only chin	No	28 (5.8)	3.8 ± 1.1		31.4 (6.9–84.6)	
	Yes	6 (1.2)	3.9 ± 0.6	0.826	55.6 (30.1–116.8)	**0.033**

*Student's *t*-test, $p < 0.05$.
**Mann–Whitney test, $p < 0.05$.
Bold values represent statistical significance.

postoperative bleeding was well controlled in most cases. However, bleeding was occasionally intense, and in one case, surgery had to be suspended. In another case of postoperative bleeding, the patient had to receive a blood transfusion. It is highly recommended that surgeons be prepared for heavier bleeding by reserving blood at a blood bank (Piñeiro-Aguilar et al., 2011). It is also recommended that for hypotensive general anesthesia, elevated head position and vasoconstrictors be used to prevent bleeding (Sousa and Turrini, 2012).

The conduction of BSSOs and HSOMS surgeries present a risk of neurosensory disorders due to the proximity of osteotomy sites with the inferior alveolar nerve and mental nerve, respectively. Inferior alveolar nerve damage can occur at various stages when performing a sagittal split ramus osteotomy (Al-Bishri et al., 2004), including during the medial dissection of the ascending ramus of the mandible, during bone cutting using burs or other instruments, during separation and movement of the distal and proximal bone fragments, or due to the compression or stretching of fragments after stabilization (Kriwalsky et al., 2008). Cranial nerve damage after Le Fort I osteotomies is not rare, and in most cases, it is related to unwanted fractures of the skull base and anatomical variations. Since the infraorbital nerve can be visualized and avoided in most procedures, the sensorial loss is usually temporary, and there is usually complete recovery (Patel et al., 2007) even if the branches are injured. Neurosensory disorders may be transient or permanent, depending on individual response, age, type, and damage intensity (Morris et al., 2007). Virtually all patients experience some neurosensory impairment after orthognathic surgery, particularly in mandibular surgeries (Patel et al., 2007; Kahnberg et al., 2005). In most cases, recovery is spontaneous (Wijbenga et al., 2009). The experience of the surgeon is relevant (Al-Nawas et al., 2014). The medical records used in the study did not demonstrate a compulsory registration for nerve damage occurrence and long-term follow-up of neurosensory disorders, which did not allow for evaluation of its frequency and whether symptoms were transient or permanent. For this reason, neurosensory disorders were not recorded as complications; only reported nerve injury at the intraoperative phase was considered.

In the present study, although there was a balanced distribution of procedures performed between men and women, complication occurrence was significantly higher among men. It can be inferred that surgery in men may be technically more demanding because they present a more robust bone structure and they may be less cooperative during the postoperative period. No correlation was found between surgical complications and age; however, some studies have shown a complication tendency in older patients undergoing orthognathic surgery (Panula et al., 2001; Sousa and Turrini, 2012; Phillips and Essick, 2011).

A statistical relationship was found between the duration of surgery and length of hospital stay for orthognathic surgery procedures when evaluated only for the presence or absence of complications. Likewise, there was a directly proportional relationship between the duration of surgery and complications occurrence. As expected, when complications occurred, postoperative hospitalization time was also directly affected. Limiting the duration of surgery and anesthesia is likely an effective way to reduce postoperative complications and length of postoperative hospitalization (Friscia et al., 2017).

The greater the number of surgeries performed, the greater the occurrence of complications. It is expected that some technique types, more extensive procedures, higher number of procedures per surgery, longer surgery duration, and frequency with which the procedure is performed increase the possibilities of complications (Chow et al., 2007). Large skeletal movements seem to have greater relapse potential, as well (Wijbenga et al., 2009).

In this study, complications occurred more frequently in surgeries performed in the mandible, which is in agreement with the literature (Patel et al., 2007; Kim and Park, 2007; de Santana Santos et al., 2012; Castro et al., 2013; Robl et al., 2014). Reasons likely pertain to the fact that the mandible is movable, articulated bone and has several masticatory muscles attached to it. Its anatomical characteristics, the impossibility of inferior alveolar neurovascular bundle visualization during osteotomies, inherent technique difficulties, professional experience, and type of fixation technique can directly influence complications occurrence. Conduction of segmental Le Fort I osteotomy was the second most common reason for complication occurrence in the present study. It seems reasonable to state that the more segmentations or osteotomies that are performed, the greater the technical difficulty; consequently, there is more chance of intra and postoperative complications (Friscia et al., 2017; Kahnberg et al., 2005). Studies have shown, however, that complications in this technique are relatively low, and it is being proved to be safe and stable (Ho et al., 2011). As segmentations of the maxilla are more complex surgeries, greater complication possibilities are noted. The majority of studies do not include this modality of surgery (Scariot et al., 2010; Chew, 2006).

Reporting complications requires a standardized and widely accepted grading system. Effective comparisons between research studies and improvement in surgical practice are advantages of grading surgical complications. A single attempt to group and to classify complications in orthognathic surgery has been performed (Dimitroulis, 1998). Clavien–Dindo classification has never been used in orthognathic surgery research, although its reliability and validity has already been discussed in head and neck surgery (Monteiro et al., 2014).

Regarding Clavien–Dindo classification, most of the sample ($n = 67/72.04\%$) were classified as grade I, showing that complications in orthognathic surgery tend to have mild repercussions and a low complexity of treatment. Statistical analysis showed no correlation between the Clavien–Dindo classification grades and variables of sex, age, duration of surgery, length of hospitalization, or surgical site.

Most of the common complications during and after orthognathic surgery are well known, and must be explained in detail to each patient at the preoperative phase. Unfortunately, it is usually impossible to predict which patient will experience a specific complication.

5. Conclusion

In this study, it is observed that postoperative malocclusion, hemorrhage, inferior alveolar nerve injury, bad split and infection are the most prevalent complication in orthognathic surgery. They seem to be related to sex, duration of surgery, number of surgeries, surgical site, and type of osteotomy performed. With this, it is possible to explain to the patient the different levels of severity of complications related to the surgery and the possible risk factors associated with them. Besides, for the surgical service, it is important to know these data with an intention to improve the procedure, both in the intraoperative and postoperative periods.

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