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Original Research

# A 27-year retrospective clinical analysis of 2640 orthognathic surgery cases in the Tokyo Dental College

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ABSTRACT

In this retrospective study, we aimed to analyze 2640 cases of orthognathic surgery performed in the Department of Oral and Maxillofacial Surgery, Tokyo Dental College, Suidobashi Hospital between April 1990 and March 2017. We also, analyzed the incidence of bad splits in bilateral sagittal split osteotomy (BSSRO) and massive blood loss exceeding 1000 g, between January 2012 and December 2016.The aim was to gain insight into the circumstances surrounding orthognathic surgery cases and to identify potential trends in jaw deformity treatment. The study included 952 males (35.9%) and 1688 females (64.1%). The majority of patients were 10–30 years old. Mandibular osteotomy was performed in 1820 and double-jaw surgery was performed in 787 cases, including the Le Fort I osteotomy and bilateral sagittal splitting ramus osteotomy (BSSRO). The annual number of orthognathic surgeries increased gradually, while the average operating time and blood loss decreased. Massive blood loss occurred in three cases, and bad splits following BSSRO were occurred in 13 cases between January 2012 and December 2016.There was a significant correlation between operating time and blood loss; operating times and blood loss improved over the 27-year study period.

## 1. Introduction

With the inclusion of surgical orthodontic treatment in Japan's National Health Insurance coverage in 1990, and its increased social recognition, orthognathic surgery is now performed in many Japanese institutions. In recent years especially, a rise in surgical cases has been seen with the improvement of techniques, procedures, and tools, and it is now an important field of oral surgery.

At the Department of Oral and Maxillofacial Surgery at the Tokyo Dental College, Suidobashi Hospital, surgical orthodontic treatment is performed in collaboration with orthodontists in- and outside the hospital. To date, various techniques has been devised to provide safer and more reliable surgical procedures; we aim to continue to improve the safety and quality of our medical care.

To gain insight into the circumstances surrounding orthognathic surgery cases performed in our department, we analyzed 2640 orthognathic surgeries performed between April 1990 and March 2017.

## 2. Methods

### 2.1. Cases

We retrospectively examined the records of 2640 patients diagnosed with jaw deformities who underwent orthognathic surgery in our hospital between April 1990 and March 2017. We included the records of patients who underwent surgery as an intervention for malocclusion, and excluded cases in which genioplasty or surgery was performed only to remove fixation devices.

### 2.2. Analyzed factors

Using patients' medical and operative records, we analyzed the

*Abbreviations:* (BSSRO), bilateral sagittal splitting ramus osteotomy; (IVRO), intraoral vertical ramus osteotomy; (LF-I), Le Fort I osteotomy; (SARPE), Surgical Assisted Rapid Palatal Expansion

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number of cases according to financial year, sex, age at time of surgery, clinical diagnosis, and procedure, as well as operating time and blood loss in relation to the surgical site. The survey period was divided into 13 years between April 1990 and March 2003 (Period I) and 14 years between April 2003 and March 2017 (Period II); a comparative review between periods was performed for all factors. Statistical analyses were performed using the chi-square test and Mann-Whitney U test. We also analyzed the incidence of 'bad split' complications in bilateral sagittal splitting ramus osteotomy (BSSRO) and massive blood loss of more than 1000 g, between January 2012 and December 2016.

## 3. Results

### 3.1. Number of cases by financial year (Fig. 1)

Between April 1990 and March 2017, an increasing trend was observed in the number of orthognathic surgeries, with the number exceeding 150 each year following 2014. More recently, these cases have constituted about 30% of the total number of inpatient surgery cases in our department. Compared to Period I, the annual average number of double-jaw cases and mandible-only cases in Period II increased 3.2 and 2.1 times, respectively. Approximately procedures performed in the financial year of 2010 were fewer than those in the average year by 20. This is believed to be due to the effects of the Tohoku Earthquake that occurred March 11th, 2011. All operations were postponed for two months due to this earthquake (Fig. 1).

### 3.2. Number of cases by sex (Fig. 1)

Compared to males, more females (male: n = 952, 35.9%; female: n = 1688, 64.1%) underwent orthognathic surgery (male-female ratio, 1:1.77). The proportion of females was also higher within each age group. While the male-female ratio in Period I was 1:1.95, the proportion of males increased in Period II (male-female ratio, 1:1.70).

### 3.3. Number of cases by age at the time of surgery (Fig. 2)

The youngest patient was 13 years old and oldest was 57 years old, with the average age being 25.5 years. The proportion of patients in their 20 s constituted more than half the total cases (1412 cases; 53.3%), followed by 584 (22.1%), 471 (17.8%), 147 (5.6%), and 26 (1.0%) cases with patients in their teens, 30 s, 40 s, and 50 s, respectively. The proportion of patients having undergone surgery by their 30 s was > 90%. The average ages in Periods I and II were 23.4 and 26.4 years, respectively. Compared to Period I, the number of cases and proportions of patients in their 40 s and 50 s increased in Period II. The youngest patient underwent double-jaw surgery (Fig. 2).

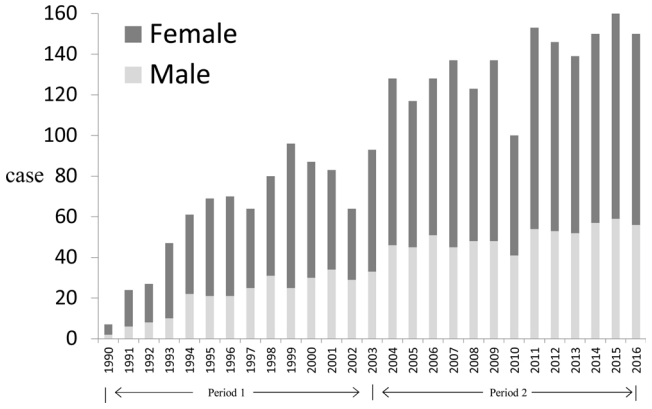


**Fig. 1.** Number of cases by financial year.

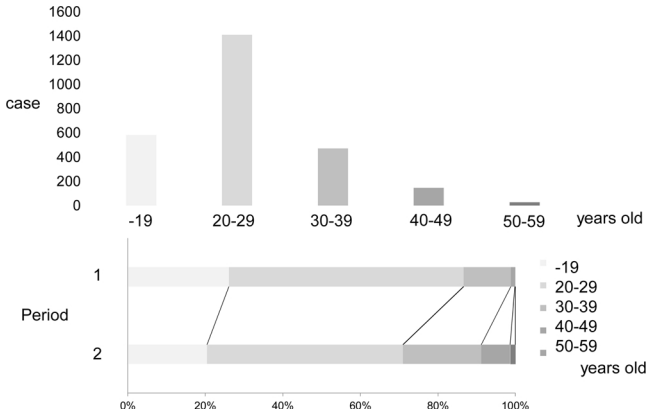


**Fig. 2.** Number of cases by at the time of surgery.

### 3.4. Number of cases by clinical diagnosis (Table 1)

Clinical diagnoses were made based on facial examination findings upon initial assessment, intraoral findings, and frontal and lateral cephalometric analyses. Cases of mandibular protrusion alone (i.e., without concurrent skeletal abnormalities) were most common (1237 cases; 46.9%). Mandibular protrusion with maxillomandibular asymmetry occurred in 344 cases (13.0%), mandibular protrusion with open bite occurred in 101 cases (3.8%), and 12 cases (0.5%) had mandibular protrusion with both maxillomandibular asymmetry and open bite. Mandibular retrusion alone was observed in 168 cases (6.4%), mandibular retrusion with maxillomandibular asymmetry was observed in 28 cases (1.1%), mandibular retrusion with open bite in 27 cases (1.0%), and mandibular retrusion with both maxillomandibular asymmetry and open bite was found in five cases (0.2%). Maxillomandibular asymmetry occurred in 151 cases (5.7%), open bite occurred in 44 cases (1.7%), and maxillomandibular asymmetry with open bite occurred in 12 cases (0.5%). Combined mandibular protrusion and maxillary retrusion occurred in 313 cases (11.9%), combined mandibular protrusion and maxillary retrusion with maxillomandibular asymmetry was observed in 62 cases (2.4%), combined mandibular retrusion and maxillary protrusion occurred in 60 cases (2.3%), and combined mandibular retrusion and maxillary protrusion with maxillomandibular asymmetry occurred in eight cases (0.3%). Jaw deformity of both the maxilla and mandible was observed in 1033 cases (39.1%). Mandibular protrusion was diagnosed most often in both Periods I and II (Figs. 3 and 4).

### 3.5. Number of cases by procedure (Table 2)

Procedures were classified into 22 categories. Assessment of the

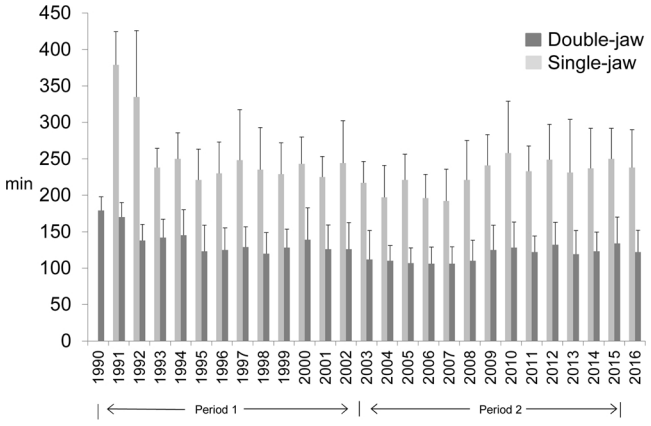


**Fig. 3.** Operating time.

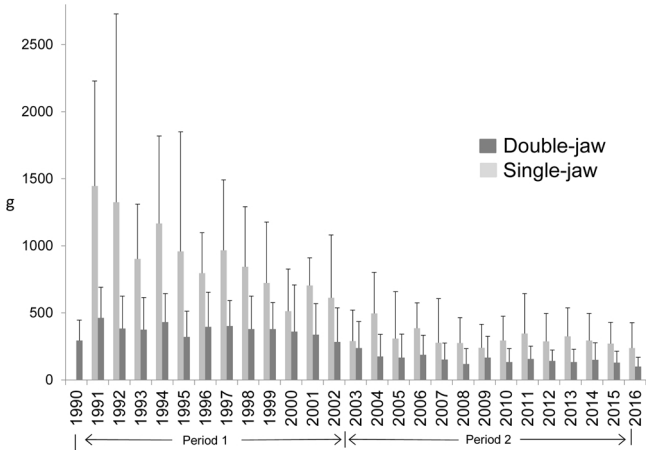


**Fig. 4.** Blood loss according to surgical site.

number of cases according to procedure revealed that BSSRO alone was performed in the highest number of cases (1806 cases; 68.4%). This was followed by 736 cases (27.9%) in which a Le Fort I osteotomy (LF-I) was performed in combination with BSSRO. Maxilla-only, mandible-single-jaw, and double-jaw surgeries were performed in 33 (1.3%), 1821 (69.0%), and 786 (29.8%) cases, respectively, with the proportion of mandible-single-jaw surgeries constituting approximately 70% of all orthognathic surgeries. From 2015 onward, the number of double-jaw surgeries exceeded the number of mandible-single-jaw surgeries. Furthermore, alveolar iliac bone grafts were performed in 30 cases (1.1%) (Tables 1 and 2).

### 3.6. Operating time and blood loss according to surgical site (Figs. 3 and 4)

The average operating time for mandible-single-jaw surgeries was 129 min in Period I (74–252 min), and 122 min in Period II (47–394 min). For double-jaw surgery, the average duration was 249 min in Period I (155–579 min), and 233 min in Period II (85–484 min). A slightly decreasing trend was observed in the average operating times for both single-jaw and double-jaw surgeries, and a statistically significant difference was noted.

Over the years, a decreasing trend was observed in the average blood loss that occurred during mandible-only surgeries. A similar decreasing trend was observed for maxillomandibular surgeries. The average blood loss during mandible-only surgeries was 368 g in Period I (least: a little, most:2229 g), and 160 g in Period II (least: a little, most: 1400 g). For maxillomandibular surgery, the average blood loss was 899 g in Period I (least: a little, most: 5666 g), and 302 g in Period II (least: a little, most: 2231 g). A decreasing trend in average blood loss was observed for both mandible-only and maxillomandibular surgeries, and a statistically significant difference was noted.

### 3.7. Massive blood losses (Table 3)

A total of 778 cases who underwent either BSSRO or combined BSSRO and Le Fort I osteotomy between January 2012 and December 2016 were included in this analysis. Massive blood loss exceeding 1000 g occurred in three cases of double-jaw surgery. In two cases, bleeding occurred from around the descending palatine artery of the maxilla. Patients in two cases had undergone previous double-jaw surgery, which caused bone ankyloses, and moving up the posterior nasal spine, and requiring the bone to be, scraped off (Table 3).

### 3.8. Bad splits in BSSRO (Table 4)

Bad splits occurred in 13 cases and 14 split sites in 778 cases between January 2012 and December 2016. The incidence rate is 0.96% per split site. Six cases (seven sites) had a proximal segment fracture, one case had a distal segment fracture, two cases had a coronoid process fracture, one case had a condylar neck fracture, one case had a proximal and segment fractures, and one case had a coronoid process and condylar neck fracture. All bad split cases had no further complications (Table 4).

**Table 1**
Number of cases by clinical diagnosis.

| A | | |
|---|---|---|
| Variables | Frequency | |
| | case | % |
| All of the orthognathic surgery patients reviewed (n = 2640) | | |
| Sex | | |
| Female | 1688 | 64.1 |
| Male | 952 | 35.9 |
| Skeletal classification | | |
| Class 1 malocclusion | 223 | 8.4 |
| Class 2 malocclusion | 324 | 12.3 |
| Class 3 malocclusion | 1433 | 79.3 |
| Part classification | | |
| Single-jaw | 1821 | 69.0 |
| Double-Jaw | 785 | 29.7 |
| Maxillary-jaw | 34 | 1.3 |

| B | | |
|---|---|---|
| Diagnosis | case | % |
| Mandibular protrusion | 1237 | 46.9 |
| Mandibular protrusion + Open bite | 101 | 3.8 |
| Mandibular protrusion + Maxillo-mandibular asymmetry | 344 | 13.0 |
| Mandibular protrusion + Maxillo-mandibular asymmetry + Open bite | 12 | 0.5 |
| Mandibular protrusion + Maxillo-mandibular asymmetry + Chin excess | 1 | 0.0 |
| Mandibular protrusion + Chin excess | 2 | 0.1 |
| Mandibular protrusion + Maxillary retrusion | 313 | 11.9 |
| Mandibular protrusion + Maxillary retrusion + Maxillo-mandibular asymmetry | 62 | 2.4 |
| Mandibular protrusion + Maxillary retrusion + Chin excess | 1 | 0.0 |
| Mandibular protrusion + Maxillary protrusion | 12 | 0.5 |
| Mandibular protrusion + Maxillary retrusion + Open bite | 5 | 0.2 |
| Mandibular protrusion + Maxillary protrusion + Open bite | 1 | 0.0 |
| Mandibular protrusion + Maxillary protrusion + Chin deficientry | 1 | 0.0 |
| Mandibular retrusion | 168 | 6.4 |
| Mandibular retrusion + Open bite | 25 | 0.9 |
| Mandibular retrusion + Maxillo-mandibular asymmetry | 28 | 1.1 |
| Mandibular retrusion + Maxillo-mandibular asymmetry + Open bite | 5 | 0.2 |
| Mandibular retrusion + Chin deficientry | 2 | 0.1 |
| Mandibular retrusion + Maxillary protrusion | 60 | 2.3 |
| Mandibular retrusion + Maxillary protrusion + Open bite | 6 | 0.2 |
| Mandibular retrusion + Maxillary protrusion + Maxillo-mandibular asymmetry | 8 | 0.3 |
| Mandibular retrusion + Maxillary protrusion + Chin deficientry | 3 | 0.1 |
| Mandibular retrusion + Maxillary retrusion | 1 | 0.0 |
| Mandibular retrusion + Maxillary retrusion + Maxillo-mandibular asymmetry | 2 | 0.1 |
| Maxillary protrusion | 12 | 0.5 |
| Maxillary protrusion + Open bite | 2 | 0.1 |
| Maxillary protrusion + Maxillo-mandibular asymmetry | 4 | 0.2 |
| Maxillary retrusion | 14 | 0.2 |
| Maxillary retrusion + Maxillo-mandibular asymmetry | 1 | 0.0 |
| Open bite | 44 | 1.7 |
| Maxillo-mandibular asymmetry | 151 | 5.7 |
| Open bite + Maxillo-mandibular asymmetry | 12 | 0.5 |

## 4. Discussion

With the increased social recognition of the surgical orthodontic treatment of jaw deformities in Japan, the number of patients undergoing such surgeries has increased. This report includes the largest

**Table 2**
Number of cases by procedure.

| Surgical procedure | case | % |
|---|---|---|
| LF-1 | 8 | 0.3 |
| Multiple-segment LF-1 | 1 | 0.0 |
| Anterior maxillary segmental osteotomy | 12 | 0.5 |
| Posterior maxillary segmental osteotomy | 1 | 0.0 |
| LF-1 + bone graft | 6 | 0.2 |
| LF-1 + Posterior maxillary segmental osteotomy | 1 | 0.0 |
| SARPE | 4 | 0.2 |
| BSSRO | 1806 | 68.4 |
| BSSRO + GEN | 8 | 0.3 |
| BSSRO + IVRO | 1 | 0.0 |
| BSSRO + bone graft | 2 | 0.1 |
| Mandibular distraction | 2 | 0.1 |
| Anterior mandibular segmental osteotomy | 2 | 0.1 |
| LF-1 + BSSRO | 736 | 27.9 |
| LF-1 + BSSRO + bone graft | 22 | 0.8 |
| LF-1 + Distraction(lower) | 3 | 0.1 |
| Distraction(upper) + BSSRO | 1 | 0.0 |
| LF-1 + SSRO + IVRO | 1 | 0.0 |
| LF-1 + BSSRO + GEN | 5 | 0.2 |
| Anterior maxillary&mandibular segmental osteotomy | 3 | 0.1 |
| Anterior maxillary segmental osteotomy + BSSRO | 14 | 0.5 |
| Posterior maxillary segmental osteotomy + BSSRO | 1 | 0.0 |

number of orthognathic cases in Japan. A nationwide survey conducted by Kobayashi et al. [1] and the Japanese Society of Jaw Deformities reported that 3000 patients underwent orthognathic surgery between April 2006 and March 2007 in Japan. In the past 27 years (1990–2017), orthognathic surgery was performed in 2640 cases in our hospital.

### 4.1. Number of cases by financial year

There were seven orthognathic surgery cases in 1990, but an increasing trend was observed after 2004 with more than100 cases per year, and more than 150 cases per year after 2015. This trend is likely due to the implementation of insurance coverage for surgical orthodontic treatment, which thereby reduced the financial burden on patients, as well as increased orthodontists' recognition of the usefulness of orthognathic surgery. Furthermore, the hospital has been providing "Tokyo Dental Clinic Orthodontic Treatment Seminars" for oral surgeons and orthodontists since 2009, which fostered good relationships with orthodontists not only in the Tokyo metropolitan area but also in many other states, cities, and prefectures. In a study by Lee et al. [2], an increasing trend in the number of patients undergoing orthognathic surgery in Korea was reported. However, reports from the United States [3,4] demonstrate a decreasing trend for the number of patients undergoing orthognathic surgery in recent years. It is believed that this is due to advances in orthodontic technology, such as implant anchorage, that have enabled the nonsurgical treatment of more cases [3].

### 4.2. Number of cases by sex

The ratio of males and-females who underwent orthognathic surgery in our study was 1:1.77; although the number of males was higher compared to ranges reported in other Japanese studies (1.77–3.9) [5–9], in all studies more females are undergoing surgery. Since orthognathic surgery not only improves functional impairment but also addresses many aspects of facial esthetics, this trend is believed to reflect female patients' desire for cosmetic improvement. Furthermore, compared to the male-female ratio of 1:1.95 in Period I, the proportion of males who underwent orthognathic surgery increased in Period II (male-female ratio, 1:1.70). This reflects the recent marked increase in cosmetic awareness and the narrowing difference between males and females. In a 2014 Brazilian report [9], the male-female ratio was approximately 1:1.5, whereas a study conducted in Singapore [10] reports almost equal numbers of males and females.

**Table 3**
Massive blood loses between January 2012 and 2016.

| Case | Gender | Age | Blood loss (g) | Transfusion (ml) | Operation Time (min) | Part of blood loss | Past operation | Distance of movement |
|---|---|---|---|---|---|---|---|---|
| 3–1 | Female | 27 | 1240 | Autologous Blood Transfusion 400 | 336 | descending palatine artery | LFI + BSSRO | PNS up |
| 3–2 | Female | 24 | 1057 | Autologous Blood Transfusion 400 | 268 | descending palatine artery | Nothing | PNS up |
| 3–3 | Female | 48 | 1015 | Autologous Blood Transfusion 800 | 484 | Inferior alveolar neurovascular bundle | LFI + BSSRO | PNS down |

**Table 4**
Bad splits in BSSRO between January 2012 and December 2016.

| Case | Gender | Age | Bad split site | Bad split pattern | Situation |
|---|---|---|---|---|---|
| 4–1 | Male | 27 | Right | proximal segment | splitting |
| 4–2 | Female | 18 | Left | proximal segment | splitting |
| 4–3 | Female | 36 | Right | proximal segment | osteotomy |
| 4–4 | Male | 36 | Right | proximal segment | osteotomy |
| 4–5 | Male | 19 | Left | proximal segment | splitting |
| 4–6 | Female | 19 | Both | proximal segment | splitting |
| 4–7 | Female | 42 | Right | proximal segment | splitting |
| 4–8 | Male | 22 | Left | proximal, distal segment | trimming |
| 4–9 | Male | 38 | Left | distal segment | extraction of wisdom teeth |
| 4–10 | Male | 22 | Right | coronoid process | splitting |
| 4–11 | Female | 20 | Right | coronoid process | splitting |
| 4–12 | Male | 18 | Left | condylar neck | splitting |
| 4–13 | Female | 37 | Right | coronoid process, condylar neck | splitting |

### *4.3. Number of cases by age*

The average age at the time of orthognathic surgery was 25.5 years. The proportion of patients in their 20 s was more than half (1412 cases; 53.5%). The proportion of patients having undergone surgery by their 30 s was greater than 90%; however, the number of patients undergoing orthognathic surgery in their 40 s and 50 s has increased in recent years. It is surmised that the major factors influencing this trend are the more widespread awareness of surgical orthodontic treatment generated by mass media, and the increasing number of patients requesting surgical orthodontic treatment for sleep apnea syndrome, occlusion improvement via implant-supported dental prostheses following tooth loss, etc. A further increase in the performance of orthognathic surgery for these types of patients is expected.

### *4.4. Number of cases by clinical diagnosis*

Complex cases involving mandibular protrusion represented the majority of diagnoses observed (2092 cases; 72.2%). These observations are similar to those of other reports [1,5–9,12,13]. In an American report [13], the number of mandibular protrusion cases constituted 30% of the total cases of jaw deformity, while they constituted 55% of the total cases in the Brazilian report [9], and 68% in the report from Singapore [10]. Mandibular protrusion is a common characteristic in the Japanese population [13], which is reflected in the large proportion of orthognathic surgeries performed to correct this abnormality. It has been suggested that most patients likely seek treatment because, compared to other jaw deformities, mandibular protrusion is more conspicuous [9].

Complex cases involving mandibular retrusion totaled 308 (11.7%). One of the factors responsible for the increasing number of mandibular retrusion surgeries being performed in recent years is greater recognition that orthognathic surgery can improve sleep apnea syndrome.

### *4.5. Number of cases by procedure*

The most frequently performed orthognathic procedure was BSSRO (1806 cases; 68.4%). Many studies from other Japanese institutions have reported that mandibular orthognathic surgeries are performed at high rates [1,5–9]. However, studies conducted by Mori et al. [14] indicate that the intraoral vertical ramus osteotomy (IVRO) is performed at high rates for the following reasons: compared to BSSRO, the procedure is simpler and there is less blood loss during surgery; there are few post-surgery occurrences of mental nerve paresthesia; and the procedure takes the temporomandibular joint into consideration. However, post-osteotmy fragment fixation is not performed during the IVRO procedure; therefore, BSSRO is more frequently performed in our hospital in consideration of the possibility of anterior dislocation of the temporomandibular joint, as well as in consideration of the patient's pain and the burden related to postsurgical intermaxillary fixation for fragment stabilization. Even in severe cases for which surgery was not conventionally considered in the past, surgical treatment has become more viable due to the development of more advanced instruments, such as piezosurgery devices. As such, the proportion of complex surgeries involving bone lengthening is thought to have increased.

Furthermore, the performance of alveolar bone grafting during orthognathic surgery for patients with an alveolar cleft has decreased in recent years. It is believed that this is due to the fact that alveolar bone grafting is now frequently performed during the early canine eruption stage, and is performed less often in combination with orthognathic surgery. The LF-I osteotomy was the most frequently performed maxilla-related procedure. This surgical procedure was introduced in Japan in 1975 by Takahashi [15]. The approach enables relatively simple maxillary bone grafting, has a wide range of applications, and is performed in many institutions. It is believed that the LF-I osteotomy is now performed more frequently because safer and more stable surgical options have become available, and there is increased demand from orthodontists for the improvement of occlusion and facial features, as well as postsurgical stability. Moreover, multiple-segment LF-I osteotomy of the maxilla has also been performed in recent years.

In this study, a change in the surgical methods performed was observed over time; the frequency of double-jaw surgery increased from 20% during Period I to 35% during Period II. Since 2015, double-jaw surgery has been performed more often than single-jaw surgery. Single-jaw surgery is less invasive and more predictable than double-jaw surgery, but is potentially inadequate at achieving a harmonious profile and occlusion in cases of mandibular protrusion, which is prevalent among Japanese patients. For that reason, double-jaw surgery and genioplasty are now commonly performed [2,17–19].

### *4.6. Operating time and blood loss according to surgical site*

Kobayashi et al. [1] reported that the average operating times in Japan were 163 min (69–337 min) for mandible-only cases and 285 min (98–560 min) for maxillomandibular cases; the average blood loss was 203 ml (50–512 ml) for mandible-only cases and 512 ml (20–1171 ml) for maxillomandibular cases. These operating times reported in the present study are short compared to those reported by other institutions: 155 min [8], and 157 min [14]. Furthermore, the average operating time and blood loss for maxillomandibular surgeries in which both LF-I osteotomy and BSSRO were performed were 237 min (132–464 min) and 385 g, respectively. The average operating time and blood loss observed in Period I were 249 min and 899 g, respectively, and those in Period II were 233 min and 302 g, respectively. These durations are short compared to those reported by other institutions: 281 min [14] and 290 min [8].

From an educational perspective, procedures in our department are performed by multiple practitioners with varying levels of experience, but a decreasing trend over time was observed for both operating time and blood loss, with a large reduction in blood loss especially. For both operating time and blood loss, temporary increases were observed due to the participation of new practitioners or the adoption of new approaches (such as the introduction of a new instrument), but operating times have recently stabilized. The number of cases with unexpectedly high levels of blood loss (exceeding 1000 g) and those with extended operating times have decreased over time. This is believed to have occurred due to the development of new anesthesia methods and improved anesthetics. Additionally, in relation to surgical methods and techniques, our department has long-used computed tomography data-based plaster jaw models (produced by a third party) to simulate procedures associated with jaw plastic surgery. However, in April 2014, Japan's first medical fabrication laboratory, the Fab Lab TDC, was

established at the university. This lab introduced inkjet 3D printers and surgical simulation software and promoted their clinical application to surgical treatment of maxillofacial disorders. We believe that this introduction influenced the reduction in operating times and blood loss observed during the study period. Moreover, these techniques have been relatively standardized and clinical pathways have also been introduced for operations such as orthognathic surgery, which are often performed in healthy patients without complications. Since the usage of clinical pathways was implemented, the objective has been one of standardized care; to that end, clinical pathway surveys have been conducted multiple times and variance management is in place. By continuing to conduct reviews and studies, and enhancing clinical pathways and sharing information, our goal is to provide safe medical care for complex cases, which we expect to increase in number. While continuing to perform orthognathic surgery for a variety of cases, we believe it is important to conduct further research, engage in further improvement of current techniques, and attempt to further alleviate the burden and pain experienced by patients.

### *4.7. Massive blood losses*

The part of massive blood of maxilla was almost around descending palatine artery. Patients in two cases had undergone double-jaw surgery in the past. The reason for massive blood loss in these cases was abnormal ankyloses of the bone and the scraping off of the bone around the descending palatine artery, which was required to move up the posterior nasal spine. No cases used an ultrasonic bone scalpel, which is necessary for scraping off the bone around the descending palatine artery and or suspected ankyloses caused by past operations. In the future studies, it will be important to investigate risk factors related to blood losses of the maxilla.

### *4.8. Bad splits in BSSRO*

The average reported incidence of bad splits in BSSRO is 2.3% per split site, ranging from 0.2% up to 11.4% per split site [19], which is less than the incidence rates reported in the current study. The cause of bad splits was inappropriate splitting or an unnecessary bone cut. In our hospital, we use three-dimensional images and three-dimensional models that are in mandibular bone form using CT. In future studies, we intend to investigate risk factors for bad splits.

## 5. Conclusion

The purpose of the present study was to analyze features related to orthognathic surgeries performed in our hospital. Improvements in this area can only be achieved through in-depth analysis of all procedures. Further studies should be carried out with the aim of determining the profile of orthognathic surgery cases in different countries and thus preparing orthognathic surgeons to achieve better results.

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## Conflict of interest

None declared.

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## Ethics

The present study was approved by the ethics committee of Tokyo Dental College (Tokyo, Japan; no. 672).

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