Trends in surgical-orthodontic management of Class III malocclusions in Western Australia

Webson Sibanda, Mithran Goonewardene, Christophe Duigou and Steven Naoum
UWA Dental School / Oral Health Centre of WA, Perth, Australia

Aim: The aim of this retrospective cohort study was to identify trends in the surgical-orthodontic management of skeletal Class III malocclusions in Western Australia between 1985 and 2016.

Methods: The records of 225 patients (132 females, 93 males) who received combined surgical-orthodontic correction of their Class III malocclusion between 1985 and 2016 were retrospectively assessed. The subjects were divided into three groups according to surgery type: Group (1) maxillary advancement only; Group (2) mandibular setback only; Group (3) two-jaw surgery.

Results: A trend towards two-jaw surgery for Class III correction was observed. Between 1985 and 2016, 123 patients (55%) were treated via two-jaw surgery; 97 patients (43%) were treated via maxillary advancement alone and five patients (2%) were treated via mandibular setback alone. Between 2011 and 2016, 61% were treated via two-jaw surgery; 37% were treated via maxillary advancement surgery; 2% were treated via mandibular setback surgery. Gender affected surgery type: two-jaw surgery (60% female); maxillary advancement (62% female); mandibular setback (17% female). A greater proportion of females received Class III surgical management in comparison with males (59:41).

Conclusion: Two-jaw surgery is the most common procedure for the surgical correction of skeletal Class III malocclusions in Western Australia. Of the single jaw procedures, isolated maxillary advancement surgery is more common than mandibular setback procedures.

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Webson Sibanda: swebson2000@yahoo.co.uk; Mithran Goonewardene: mithran.goonewardene@uwa.edu.au; Christophe Duigou: c.duigou@gmail.com; Steven Naoum: steven.naoum@uwa.edu.au

Introduction

The orthodontic management of Class III malocclusions presents a significant challenge. The multifactorial aetiology, growth unpredictability and the potential need for combined orthodontic-surgical treatment can cause the treatment of Class III patients to be complex. A skeletal Class III malocclusion can result from mandibular prognathism, maxillary retrognathism, vertical maxillary deficiency, or various combinations of maxillo-mandibular relationships. Epidemiological evidence indicates that 50–60% of Class III malocclusions are due to a combination of maxillary deficiency and mandibular prognathism, while maxillary deficiency or mandibular excess in isolation each contribute to approximately 20% of Class III cases.

In the first half of the twentieth century, the management of skeletal Class III malocclusions involved an osteotomy of the body to reduce and set back the mandible. During the 1950s, with subsequent development in surgical techniques, a procedure involving a sliding ramus osteotomy became frequent, along with the use of fixed orthodontic appliances for pre-surgical and postsurgical stabilisation. In the 1960s and 1970s, the bilateral sagittal split ramus osteotomy (BSSO) was developed following several technique modifications to enhance safety and predictability. The BSSO is illustrated in Figure 1.

However, in recent times the employment of mandibular setback surgery has been questioned as the results have been reported to be unstable even with
rigid fixation.\textsuperscript{8,12,13} ‘Condylar sag’ during mandibular surgery and post-surgical condylar remodelling are identified as causes of this instability.\textsuperscript{5,14} In addition, several undesirable side effects of mandibular setback surgery have been reported, including inferior alveolar nerve injury, dysphagia, and restriction of the pharyngeal airway space contributing to obstructive sleep apnoea.\textsuperscript{10,12,15}

Consequently, maxillary advancement surgery has become more common in the treatment of Class III malocclusions due to reported predictable post-surgical outcomes, stability, safety, improved aesthetics and sparing of the pharyngeal airway space.\textsuperscript{11,16} Since the mid 1930s, modifications of the Le Fort I osteotomy have been suggested (Figure 2), leading to the modern Le Fort I osteotomy procedure devised by Obwegeser in the 1960s and 1970s.\textsuperscript{6,7,17} The advent of rigid fixation in the 1990s, which led to improvements in stability and predictability of post-surgical outcomes, propelled the use of maxillary advancements for surgical correction of Class III malocclusion in isolation or combined with a mandibular setback.\textsuperscript{10,17}

A retrospective assessment of the surgical-orthodontic records of 333 Class III patients between 1978 and 1992 at the University of North Carolina indicated the trend. Within this cohort prior to 1985, only 15% of cases were treated using maxillary advancement. This is compared with the 50% treated by mandibular setback surgery and 35% treated via bimaxillary surgery. However, between 1985 and 1989, the proportion of patients treated via mandibular setback surgery dropped to 22%, while the number of maxillary advancement procedures increased to nearly 30%, bimaxillary surgery treatment rising to 50%. During the period from 1990–1992, the number of mandibular setback procedures declined to just 9% of Class III surgical treatment, which was far less than the number of maxillary advancement procedures (40%) and bimaxillary surgery procedures (50%).\textsuperscript{6} Supporting the findings of Bailey et al.,\textsuperscript{6} Proffit in 2007 reported a greater number of patients who received maxillary advancement surgery and fewer receiving mandibular setback surgery, both in isolation and in combination with maxillary advancement.\textsuperscript{14}

Importantly, while trends in the management of Class III patients requiring surgical-orthodontic management have been investigated within North America, no equivalent data have emerged from Australia. In addition, in 1985 when the present study began, the Le Fort 1 osteotomy was new in Australia.
Therefore, the aim of this retrospective cohort study was to identify trends in surgical-orthodontic management of skeletal Class III malocclusions in Western Australia between 1985 and 2016.

**Methods and materials**

The sample examined in this retrospective cohort study consisted of 225 subjects (132 females and 93 males). The included subjects demonstrated a skeletal Class III malocclusion surgically corrected between 1985 and 2016. The surgical procedures were performed at the clinics of three private oral maxillofacial surgeons (115 subjects) and at the publicly funded Oral Health Centre of Western Australia (OHCWA) (110 subjects). Approval for the study was received from the Human Research Ethics Committee of the University of Western Australia (Ethics Committee approval number: RA/4/1/4918). The age range of the cohort was 16–56 years old and the mean age of patients at the time of surgery was 24.4 years with a standard deviation of 9.5 years. The orthognathic surgical treatment was performed in all subjects using rigid fixation. All patients were treated using a consensus orthodontic sequence (no surgery-first cases were included) involving a period of pre-surgical alignment and decompensation with or without extraction using pre-adjusted 0.022 × 0.025 edgewise appliances. Pre-surgical records were evaluated by the surgeon and the orthodontist, followed by surgical planning and surgery. This was followed by a period of post-surgical orthodontic tooth detailing utilising inter-arch elastics and routine finishing procedures.

Patients with known craniofacial syndromes or cleft palates were excluded from the study.

The subjects were divided into three groups according to the type of surgical procedure performed, as shown in Table I.

- **Group 1**: Subjects treated via maxillary advancement only (Le Fort I maxillary osteotomy)
- **Group 2**: Subjects treated via mandibular setback only (Bilateral sagittal split osteotomy)
- **Group 3**: Subjects treated via two-jaw surgeries (combined maxillary advancement and mandibular setback surgeries)

Patient gender, age at the time of surgery, type of surgical procedure, and place of surgical procedure was recorded. Standardised pretreatment and post-treatment lateral cephalograms of each patient were calibrated and digitised by one investigator using OrthoTrac Software. The landmarks measured included Sella, Nasion, A point, B point, Menton, Gonion, Soft-Tissue Nasion, Labrale, Anterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), Porion, Orbital, Soft –Tissue, Gnathion and Pogonion.

**Results**

**Frequency of each surgical type**

Figure 1 displays the distribution of the surgical treatment completed for skeletal Class III patients requiring surgical-orthodontic management in Western Australia from 1985 to 2016. Two-jaw surgery was performed in 55%, maxillary advancement alone was performed in 43% and mandibular setback alone was performed in 2% of the study population.

**Change in frequency of each surgery type with time**

Figure 2 displays the absolute number of patients treated via each surgery type per year over the study period (1985–2016). From 1985 to 1999, an average of 0.6 patients per year were treated via two-jaw surgery. Over the same period, an average of 0.8 patients per year were treated via maxillary advancement alone. After 1999, a considerable increase was observed in the number of patients treated. After 1999, an increase in two-jaw surgery and isolated maxillary advancements was evident. The frequency of two-surgery was seven
patients per year and the frequency of maxillary advancement surgery was five patients per year.

**Percentage of each surgery type over time**

Figure 3 displays the percentage of cases completed within each calendar year of each surgery type between 2001 and 2016. An undulating trend was observed regarding two-jaw surgery and maxillary advancement procedures. Between 2001 and 2007, and subsequently between 2012 and 2016, a greater number of patients were managed via two-jaw surgery in comparison to maxillary advancement, with the exception of 2002. However, between 2008 and 2012 this trend was reversed, with the number of maxillary advancements over this period exceeding the number of two-jaw surgery procedures. Only a small number of mandibular setbacks alone were completed across the considered time frame.

**The effects of age and gender on surgery type**

The age range for the various surgery types in the study cohort comprised: two-jaw surgery: 16–48 years of age; maxillary advancement surgery: 16–53 years of age; and mandibular setback surgery: 17–56 years of age. When considering the effect of gender on surgery type, the proportion of females to males treated via each surgery type was: two-jaw surgery, 60:40; maxillary advancement, 62:38; and mandibular setback, 17:83. Additionally, it was found that the ratio of female to male patients within the study in total was 59:41, indicating that a higher proportion of females are likely to seek corrective Class III surgery in comparison with males.

**Pretreatment cephalometric parameters**

The pretreatment ANB angle and Wits value were calculated for each subject (Table II). A significant statistical relationship between ANB and Wits ($r = 0.49$, $p < 0.001$) was apparent and a clear linear relationship between the two variables was observed. For the entire cohort, the mean ANB value was -3.35º while the mean Wits value was -5.40 mm. A statistically significant difference between males and females for both ANB angle and Wits value ($p < 0.0004$, $p < 0.0036$) was also noted.

**Discussion**

Depending on the diagnosis, recent reports indicate that two-jaw surgery is now the preferred surgical approach for the correction of a skeletal Class III malocclusion.9,18 In the present study, two-jaw surgery was the most performed surgical procedure, accounting for 55% of the study population. This is consistent with findings from a North American population consisting of 333 Class III individuals requiring surgical correction, in which two-jaw surgery was performed in 50–60% (183 patients) of the study cohort.6
Several reasons have been suggested to explain why the prevalence of two-jaw surgery has increased in the treatment of severe skeletal Class III malocclusions. One suggested reason is the advances in technology that have increased the availability of three-dimensional imaging and CAD/CAM surgical planning. Lee et al. also suggested the ability of two-jaw surgery to improve clinician control of the post-surgical facial profile and occlusion, as well as the capacity to reduce the amount of mandibular setback required in comparison to mandibular-only corrections. This assertion is supported by a systematic review by Tan et al., who reported that two-jaw surgery should be considered for cases demonstrating severe mandibular prognathism in order to provide a more favourable post-surgical effect on the oropharyngeal airway space and reduce the risk of injury to the neurovascular bundle. Moreover, a reduction in the magnitude of a mandibular setback in Class III corrective surgery can increase the long-term skeletal and occlusal stability of Class III treatment, by reducing the risk of condylar sag and condylar resorption. The routine use of rigid internal fixation and improved clinician surgical skills have also been described as reasons for the increase in two-jaw surgical correction for Class III malocclusions.

In the present study, isolated maxillary advancement was performed in 43% of the study population. Bailey et al. reported a similar finding (40%) within their study cohort. Over the past three decades an increase in isolated maxillary advancement surgery has been reported. Greater post-surgical stability, with rigid fixation and improved facial aesthetics in Class III patients treated via maxillary advancement alone, has been widely reported as an explanation for this observation. Concurrently, over the same time period, there has been a significant reduction in the frequency of isolated mandibular setback surgery for Class III correction. This trend has been driven by clinical desire to reduce the incidence of side effects following mandibular setback surgery, including inferior alveolar nerve injury, dysphagia, post-surgical instability and restriction of pharyngeal airway space leading to obstructive sleep apnoea.

Within the present study, differences between the oral surgeons were identified, as shown in Table III. Of the three surgeons, KK performed 77 Class III corrective orthognathic surgeries, with isolated maxillary advancement surgery constituting 45.5% of these procedures; maxillary advancement combined with mandibular setback surgery comprising the remainder (54.5%). Surgeon AB performed a total of 15 Class III surgeries, 20% of these being isolated maxillary advancement surgery and 80% of these being maxillary advancement combined with mandibular setback surgery. Surgeon RB, who performed 23 Class III orthognathic surgical corrections, demonstrated a similar breakdown by surgery type, with 17.4% of performed surgeries recorded as isolated maxillary advancements and 82.6% being a bimaxillary combination. The preference for two-jaw surgery by the private oral surgeons depicted a trend that has been previously reported. Notably, differences in surgical procedure performed by surgeons in public and private environments were observed in the present study, with 57% of cases managed at OHCWA treated via maxillary advancement alone. In addition and with regard to mandibular surgery,
isolated mandibular setbacks were only performed at OHCWA. The present study did not explore the effect of surgeons’ age, experience, preferences and technical skills on surgery type. However, each oral surgeon utilised rigid fixation for all procedures.

Pretreatment cephalometric measures (ANB angle, Wits value) were used to determine the severity of each Class III malocclusion within the present study. For the study cohort, the pre-surgical mean values of ANB and Wits were -3.35° and -5.40 mm respectively (Table II). As the severity of Class III malocclusion increased, a slight trend towards two-jaw surgery was seen. When considering ANB, 40% of the patients with an ANB <-4° were treated via isolated maxillary advancements, while 37% of patients with an ANB <-6° had isolated maxillary advancements. Similarly, when considering Wits value, 35% of the patients demonstrating a Wits value <-7 mm were treated using maxillary advancement alone while 29% of patients with a Wits value <-8 mm were treated via an isolated maxillary advancement.

In the present study, there was a greater proportion of females to males (59:41) seeking surgical correction for their Class III malocclusion in Western Australia. This finding is consistent with Bailey et al., who reported a female to male ratio of 2 to 1 in a cohort of 333 skeletal Class III malocclusion cases. However, despite a greater proportion of females receiving treatment in the present study, the number of males seeking Class III surgical treatment increased with time. The trend of an increasing number of males presenting for Class III surgical correction in Western Australia has been similarly observed over the past decade in Korea, the United States of America and Singapore.

The limitations of the present study include the sample size and insufficient data to approximate trends. Larger sample sizes and longitudinal studies are recommended for further investigation. In addition, given that there were multiple maxillofacial surgeons who performed the procedures, confounding factors related to surgical methods, the perception of aesthetics and finishing standards were likely introduced.

Conclusions

Within the limitations of the present study, it may be concluded that two-jaw surgery is the most common procedure undertaken for the surgical correction of skeletal Class III malocclusions in Western Australia. Of the single jaw procedures, isolated maxillary advancement surgery is more common than mandibular setback procedures. A lack of large longitudinal studies in Australia assessing surgical-orthodontic management of Class III malocclusions suggests the need for further investigation in this area.

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