

# GONIAL ANGLE CHANGES AFTER BILATERAL SAGITTAL RAMUS OSTEOTOMY IN MANDIBULAR PROGNATHIC PATIENTS: A LITERATURE REVIEW

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## Abstract

The gonial angle plays an important role in insuring a harmonious facial profile. Changes in this angle after surgery may be an esthetic concern for both the patient and the surgeon. Bilateral sagittal ramus osteotomy and vertical ramus osteotomy are common techniques used for correction of the mandibular prognathism. Remodelling of the gonial angle might influence the post-operative stability of mandible. So, the aim of the current research was to determine factors that affect the Gonial angle after BSSRO in prognathic patients using PubMed and Medline database English literature by the terms "Gonial angle", "Bilateral sagittal", "Split ramus osteotomy".

**Key words:** Bilateral sagittal, Gonial angle, Split ramus osteotomy

## Introduction

Facial appearance is an important factor in interrelationships between humans, and it affects social and psychological development; therefore orthognathic surgery has the objective of correcting skeletal discrepancies, as well as altering facial balance, to achieve esthetic results in patients who have severe disharmony of the jaws.<sup>1</sup> Thus the treatment goals of orthodontics and orthognathic surgery have changed.<sup>2</sup> Orthognathic surgeries are performed in order to enhance the patients' function and esthetics. Different methods are developed for the improvement of mandibular deformities. Sagittal osteotomy is a technique preferred by oral and maxillofacial surgeons because of its benefits, such as its application for all types of mandibular movements.<sup>3</sup> The use of this method is accompanied by short- and long-term skeletal changes. Also, changes in the mandibular gonial angle occur in some patients play an important role in ensuring a harmonious facial profile from an esthetic point of view. The gonial angle is a representative of mandible morphology and its increase may cause the face to appear older. Gonial angle increase after mandibular setback has been reported.<sup>4</sup> Many different methods have been proposed for surgical correction of mandibular prognathism.<sup>5</sup> In a radiographic follow-up of mandibular prognathism cases operated by the sagittal osteotomy method, found resorptive processes occurring in the gonial angle region, which may have caused enlargement of the gonial angle.<sup>6</sup> An obtuse gonial angle is one characteristic feature of mandibular prognathism and it is desirable that the surgical treatment of the deformity also result in an improved gonial angle. Different surgical procedures may affect the gonial angle in different ways.<sup>7</sup> During the last two decades, many studies were undertaken to evaluate the short term changes, but in recent years the stability of orthognathic surgical procedures has been questioned on a long-term evaluation.<sup>4</sup> The main purpose of this study was to evaluate the gonial angle changes after bilateral sagittal split ramus osteotomy after mandibular setback.

## Material and Methods

The keywords used for the literature search for this review was peer-reviewed articles following key-words: Gonial

angle x Bilateral sagittal x Split ramus osteotomy. Among them, the papers were fit the criteria selected and available full-text articles read. Related articles were also scrutinized. Hand search was also driven. The search was carried out using Biological Abstracts, Chemical Abstracts, and the data bank of the PubMed and Medline database updated to 2017. The references found in the search were then studied in detail.

## Gonial angle

The present generation usually recognizes irregular teeth or obvious jaw deformities and seeks treatment from an orthodontist, for improving teeth alignment, function, and facial esthetics. Among these, once growth is ceased some patients neither growth modification nor the camouflage would be a possible solution; surgery is the only way to correct, a jaw discrepancy.<sup>8</sup> Development of the BSSO is introduced in past decades, revolutionized the correction of mandibular defects. Gonial angle is the angle between a tangential line along the posterior border of the mandibular ramus and another along the lower border of the mandibular corpus. The osteotomy of IVRO is nearer the gonial region than the SSRO. Remodelling of the gonial angle might influence the postoperative stability of mandible. The gonial angle is the most critical part in the profile, especially in curved osteotomy, since patients with an initially large gonial angle may show an even larger angle and thus an abnormal and unnatural contour after the procedure.<sup>9</sup> The gonial region is coincided with harmonious face and masticatory function.<sup>10</sup> Proffit *et al.*<sup>11</sup> attributed their lower percentage of relapse for the wire osteosynthesis group to the ability of the ramus to adjust itself post-surgically via movement at the osteotomy site. They reported a mean increase in the gonial angle at surgery of 3.7 degrees, with relapse 1 year later of 4.2 degrees. Relapse in ramus inclination thus represented 113% of the rotation at surgery. The gonial angle plays an important role in ensuring a harmonious facial profile. Changes in this angle especially after surgery may be an aesthetic concern for both the patient and the surgeon.<sup>3</sup> The gonial angle is a representative of mandible morphology and its increase may cause the face to appear older.<sup>3</sup>

### Sagittal Split Ramus Osteotomy

The most common osteotomy of the mandible for the correction of dentofacial deformities is the SSRO. It is developed a technique for performing an SSRO that involved extensive soft tissue dissection and a horizontal corticotomy on the medial and lateral aspects in the vertical ramus to the posterior border. They found that this technique provided good contact of wide cancellous bone surfaces that resulted in quick bony union. However, there are complications inherent in this technique, including excessive swelling and bleeding, intraoperative trauma to the temporomandibular joint (TMJ), damage to the inferior alveolar nerve and unfavourable fractures of the proximal and/or distal segments of the mandible. Unfavourable fractures can result in infection, sequestration of fragments, delayed union, malunion, or fibrous union of the osteotomy sites.<sup>12</sup> There have been numerous modifications to this technique, all attempting to optimize a variety of factors to aid in proper healing of the osteotomy and decrease the associated complications with this procedure.<sup>13</sup> Dal Pont<sup>14</sup> modified the technique by moving the lateral osteotomy to the distal area of the second molar thereby increasing the amount of cancellous bone contact. Hunsuck<sup>15</sup> modified the technique by decreasing the extent of the osteotomy of the cortical bone on the medial surface of the ramus immediately posterior to the mandibular foramen, which resulted in less soft tissue trauma. Epker<sup>16</sup> further modified the SSRO to eliminate the lateral dissection of the masseter and leaving major portions of the medial pterygoid and temporalis muscle attached to the proximal segment. He found that this modification decreased the incidence of excessive swelling and bleeding. In addition, he assumed there would be a lower incidence of avascular necrosis or infection of the proximal segment because of the increased vascularity provided by the attached musculature, as shown by Bell and Schendel.<sup>17</sup> Marquez and Stella<sup>18</sup> modified the SSRO of Hunsuck to reduce the potential for unfavourable fractures when an impacted third molar was located in the path of the osteotomy.

The risk of injury to the inferior alveolar nerve is a significant consideration when performing BSSO. The incidence of transection is reported between 2 to 3.5% and the incidence of some form of long-term neurologic deficit is reported in 10 to 30% of patients, whether symptomatic or not.<sup>19</sup> When the sagittal split osteotomy is performed with an osseous genioplasty, nearly 70% of patients have some degree of neurosensory deficit at 1 year.<sup>20</sup> Fixation of the segments without proper seating of the condyles can result in condylar malposition, which can lead to rotation of the proximal segment and ultimate relapse, malocclusion, worsening of TMJ symptoms, and remodelling of the condylar head. Malocclusion in the form of an open bite is often the result of inadequate original fixation or hardware failure.<sup>21</sup> When noted intraoperatively, the fixation should be revised; when noted in the postoperative course films should be obtained to assess for hardware function. Small postoperative posterior open bites can often be managed orthodontically. All orthognathic patients should be seen on

a weekly basis following surgery if any signs of malocclusion develop and elastics adjusted appropriately to ensure healing in the proper occlusion.<sup>22</sup> Decreased mobility after a BSSO is not an uncommon postoperative problem. It is most frequently attributable to prolonged immobility that results in fibrosis and atrophy of the muscle and connective tissue of the masticatory system. The incidence of hypomobility after BSSO has declined with the use of rigid fixation, as prolonged periods of maxillomandibular fixation are not necessary.<sup>21</sup> With the institution of a program of active rehabilitation, most patients return to preoperative interincisal opening within 3 months. Intraoperative serious haemorrhage is a rare complication during a BSSO. Maintaining the surgical dissection subperiosteally and adequate retraction of soft tissue prevent minor intraoperative oozing and most cases of major haemorrhage. Minor haemorrhage from tearing of the periosteum can be controlled with electrocautery, pressure, or additional vasoconstrictive agents.<sup>21</sup>

### Reports

In a recent study, Tabrizi *et al.*<sup>23</sup> compared the effects of sagittal split osteotomy (SSO) and intraoral vertical ramus osteotomy (IVRO) on the gonial angle. The age, sex, the change in occlusal plane (OP) and mandibular plane (MP) angles, and the amount of mandibular setback were considered as variable factors, while the type of surgery (SSO or IVRO) was considered the predictive factor. Fifty-six subjects were studied: 26 in SSO group and 30 in IVRO group. The change in gonial angle was  $6.07 \pm 4.468$  in SSO group and  $7.33 \pm 5.738$  in IVRO group; assessment of the data did not demonstrate a significant difference between the groups studied. Author's revealed mandibular osteotomy (SSO or IVRO) may change the gonial angle, but no significant difference observed between SSO and IVRO. Yazdani *et al.*<sup>24</sup> studied changes in the gonial angle following bilateral sagittal split osteotomy and VRO for mandibular excess using BSSO and VRO techniques. In the first group, mandibular setback was performed using the Obwegeser technique and wire osteosynthesis with 4 weeks' fixation (IMF) and in the second group, mandibular setback via VRO without wire osteosynthesis and 4 weeks' IMF was carried out. Lateral cephalograms were obtained for all the patients before surgery (T0) and 1 year after surgery (T1). Gonial angle and occlusal plane-SN in T0 and T1 were evaluated. Based on their report, the gonial angle had decreased in all patients. Decrease in the gonial angle in the VRO group was greater than the BSSO group. The average decrease in the gonial angle was significantly more in the VRO group ( $7^\circ$ ) than in the BSSO group ( $2^\circ$ ). They concluded Gonial angle decrease was observed in the present study following mandibular setback by the VRO and BSSO techniques. Choi *et al.*<sup>25</sup> studied long-term changes in mandibular and facial widths after mandibular setback surgery using intraoral VRO. Based on their report, the mandibular width increased immediately after surgery but decreased continuously thereafter. The ramus angulation showed negligible change within the first month and decreased thereafter up to approximately 36 months.

The amounts of mandibular setback and posterior impaction and the length of time postoperative influenced these changes. The lower facial width changed, although inconsistently, within 3 mm over time. In conclusion, the mandibular width increased after IVRO but seemed to normalize within approximately 3 years. The lower facial width did not reflect underlying skeletal changes. Therefore, long-term transverse changes after IVRO can be considered clinically irrelevant. In 2010, Bayat *et al.*<sup>3</sup> studied correlation between gonial angle and different variables after bilateral sagittal split ramus osteotomy. In this study, all subjects underwent surgery for mandibular setback with the BSSRO technique and IMF for 8 weeks. Lateral cephalograms were taken before surgery, immediately postoperatively and 2-4 years after surgery. Mean gonial angle was 135.05° (6.41) before and 128.73° (5.43) after surgery. The mean reduction of the gonial angle was 6.32° (4.08) immediately after surgery while it showed 4.89° (3.44) decrease after 2 years follow-up at the final examination. The mean of setback was 6.27 (2.28) mm which decreased to 5.82 (1.82) mm after follow-up. A significant correlation was observed between the amount of setback and reduction of the gonial angle but no correlation was found between sex and gonial angle changes or mandibular setback relapse. These researchers concluded surgical correction of mandibular prognathism using BSSRO and IMF can cause a decrease in the gonial angle. This increase in the setback, may reduce the gonial angle and have correlation to the amount of relapse. In a recent study on correlation between the change of gonial region and skeletal relapse after intraoral VRO for correction of mandibular prognathism, Lee *et al.*<sup>10</sup> 21 patients with mandibular prognathism were corrected by IVRO. Three cephalometric radiographs were collected from preoperative orthodontic treatment, immediately after surgery, and at 2-year postoperative follow-up. Relapse was defined as forward movement of menton (Me) after the 2-year follow-up. Three angular (SN-Go angle, mandibular plane angle, and gonial angle) and 2 linear (horizontal-Me and vertical-Me) measurements were compared after immediate operation and at the 2-year follow-up. Spearman rank correlation and Student t tests were used for statistical analysis. The mean setback of the Me was 12.7 mm, and the mean relapse was 1.5 mm. The magnitude of setback was not significant for relapse. There were weak correlations between relapse and factors concerned with the gonial region (SN-Go angle, mandibular plane angle, and gonial angle). Based on the findings, surgical correction of mandibular prognathism using IVRO can lead to an increase in the angle changes of gonial region but not correlate to skeletal relapse in long-term follow-up. In 2005, Jafarian *et al.*<sup>26</sup> assessed gonial angle changes after BSSO to treat mandibular prognathism in two groups of the patients first group (24 cases) underwent BSSO with wire osteosynthesis and IMF and second group (6 cases) underwent BSSO with rigid fixation (2 position screws). Gonial angle decreased in all patient with a mean of 7° (SD=4.2°). This reduction was 10.30° (SD=5.3) in rigid fixation group and 5.2° (SD=3.5) in nonrigid group. In

severe setbacks (more than 10 mm), the mean reduction was 5.40° (SD=3.8). They concluded there is a decrease in gonial angle after setback osteotomies using BSSRO, but no significant relation exists between the amount of setback and gonial angle changes. In another study, Kwon *et al.*<sup>27</sup> studied clinical analysis of gonial angle change after orthognathic surgery in patients with the mandibular prognathism. 35 patients were selected retrospectively. Lateral cephalometric radiographs were taken in just pre-operative time, post-operative 1-day, post-operative 1 year. They were analysed and gonial angles were measured. The results were as follows: 1. Gonial angle at post-operative 1 day was decreased about 9.3° than pre-operative and gonial angle at post-operative 1 year was increased about 4.0 degrees than post-operative 1 day. So gonial angle at post-operative 1 year was decreased about 5.3 degrees than pre-operative gonial angle. Mean pre-operative gonial angle was 129.4 degrees, showing significantly high value than normal and mean gonial angle at post-operative 1 year was 124.1°, showing value near to normal. Mean gonial angle change between pre-operative and post-operative 1 year was decreased about 5.4° in female and 5.3° male. There was no statistically significant difference between male and female. Principal factor influencing on decreased gonial angle in gonial angle change between pre-operative and post-operative 1 year was amount of mandibular setback. Principal factor influencing on increased gonial angle in gonial angle change between post-operative 1 day and post-operative 1 year was % horizontal relapse, and it was thought that resorption and bone remodelling on posterior area in mandibular distal segment also were related to increased gonial angle. It is thought that sagittal split ramus osteotomy in mandibular prognathic patients with high value of gonial angle is effective to improvement of gonial angle. Jonsson *et al.*<sup>28</sup> studied mandibular rami osteotomies and their effect on the gonial angle an increase in gonial angle was seen after mandibular setback with the BSSRO technique and decrease in gonial angle was seen after subcondylar osteotomy. As a result, they proposed the use of the IVRO method for mandibular setback. Additionally, Guglielmi *et al.*<sup>29</sup> on orthognathic surgery for correction of patients with mandibular excess reported Patients with a preoperative GA smaller than 125° have a greater risk of relapse after receiving bilateral sagittal split ramus osteotomy setback and Le Fort I advancement for the treatment of mandibular excess. Patients with a preoperative GA larger than 125° appear to have a more predictable procedure. Claudio *et al.*<sup>30</sup> in a study, analyzed the values of the mandibular angle in relation to variations of the vertical and sagittal positions of the jaw. The study was carried out on a sample of 42 patients who underwent surgery for maxillary-mandibular repositioning, advancing or raising the jaw, after a Le Fort I osteotomy and bilateral sagittal osteotomy of the jaw according to the technique described by Obwegeser-Dal Pont. In all patients, the maxillary bone was raised with a discrepancy of at least 3 mm between the anterior and posterior portions (favouring the latter) as a result of (clockwise) rotation of the bi-spinal plane. The data, obtained by means of cephalometric

analysis according to the method of Ricketts, showed how changes in the gonial angle differed between patients who require correction of an open-bite and those who do not. In particular, in patients without an open-bite, advancement of the maxilla limited the opening of the angle. Similarly, in patients with an open-bite, the tendency to form an open gonial angle can usually be corrected by the association of advancement of the maxilla whenever possible. Also, Kang<sup>31</sup> in 1998 investigate the changes in gonial angle after orthognathic surgery. For this study 30 patients were randomly selected. All patients with mandibular prognathism were operated upon with bilateral sagittal split ramus osteotomy and mandibular setback. The patients were cephalometric lateral radiographs for 1 year. Lateral cephalometric radiographs taken preoperatively, over 6-months and 1 year follow up were traced and analysed. The following conclusions were reached. During following up period for 1 year, the change of gonial angle after orthognathic surgery was decreased, except 3 cases. The mean gonial angle change was decreased from 128.6° (+/-4.83) to 123.4 ° (+/-5.52) in female. During follow up period for 1 year, the mean gonial angle was decreased after orthognathic surgery from 129.7 ° (+/-6.47) to 123.3 ° (+/-7.52), in all male patients. The mean gonial angle changes after orthognathic surgery was about 5.2 degrees in female and 5.4 degrees in male. There was less statistical significance between male and female. The ratio of mandibular setback amount from 6mm to 15mm was 83.3%, and from 1mm to 5mm was 10%.

### Discussion

From an esthetic point of view, gonial angel plays an important role in ensuring a harmonious facial profile.<sup>30</sup> (Claudio *et al.* 2005). An obtuse gonial angle is a characteristic feature in individuals with mandibular prognathism, and it is desirable that treatment of this deformity also improves the gonial angle. Both BSSO and IVRO are useful in gonial angle reduction in mandibular prognathic patients.<sup>3,23,24</sup> (Bayat *et al.* 2006; Yazdani *et al.* 2010; Tabrizi *et al.* 2016). There are reports on correlation between the amount of mandibular setback and gonial angle reduction.<sup>27</sup> (Kwon *et al.* 2000). Weak correlation reported between relapse and factors concerned with gonial region.<sup>10</sup> (Lee *et al.* 2011). However, a clear difference of opinion remains on the stability of 2 jaw-surgery compared with Lefort 1 maxillary advancement or mandibular ramus osteotomy alone.<sup>29</sup> (Guglielmi *et al.* 2013). The gonial angle value before surgery may affect the risk of relapse after mandibular setback.<sup>29</sup> (Guglielmi *et al.* 2013). In patients with an open bite, the tendency to form an open gonial angle can usually be corrected by the association of advancement of the maxilla whenever possible.<sup>30</sup> (Claudio *et al.* 2005). In patients who have normal range of gonial angle and are required with excessive mandibular setback, short lingual cut method, additional resection of posterior margin of distal segment, Obwegeser II method will be considered. More prudent operation and careful post-operative management will be responsible for maintenance of post-operative stable gonial angle.<sup>27</sup> (Kwon *et al.* 2000). Also,

one or two jaw surgery, fixation method, post-operative management might be responsible for differences between studies.

### Conclusion

The gonial region is important in facial harmony and aesthetics. An obtuse gonial angle is a characteristic feature in individuals with mandibular prognathism, and it is desirable that treatment of this deformity also improves the gonial angle. The bilateral sagittal split osteotomy, or BSSO for short, has evolved into an effective and preferred surgical procedure for mandibular advancement or setbacks and is effective in reducing obtuse gonial angel in mandibular prognathic patients. This research is part of our recent study on gonial angle changes after bilateral sagittal split ramus osteotomy and in the following researches we will focus on it.

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