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Lower face reduction with full-thickness marginal ostectomy of mandibular corpus-angle followed by corticectomy

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Summary *Background:* In Asian countries, many patients with a prominent mandibular angle desire its correction, because they consider it to be an unappealing feature. Reduction mandibuloplasty has been frequently performed through the intraoral approach, but an invisible mandibular angle forces the surgeon to perform blind ostectomy. In addition, the limited mobility of the oscillating saw leads to semi-vertical ostectomy, and leaves unnatural mandibular contours, such as loss of the mandibular angle.
Methods: To overcome the drawbacks of conventional procedures, we performed *en bloc* mandibular corpus-angle ostectomy using a contra-angle handpiece and subsequent corticectomy in 519 patients with prominent mandibular angles. A retractor with an endoscope was supportively used in 190 patients. A pre- and postoperative cephalogram was taken in 86 patients, and the gonial angle (GA) and the mandibular plane angle to the Frankfort horizontal plane (MPA) were measured.
Results: The majority of patients were satisfied with the aesthetic results. GA and MPA were increased by approximately 10°. GA was successfully improved to within the pre-set desired range in 84.5% and 60.0% of the female and male patients, respectively. The overall complication rate was 4.0%; all of these were minor complications, and no major complication such as malfracture or facial nerve injury was seen.
Conclusions: Our new technique allows surgeons to perform accurate, safe and reproducible ostectomies and to reshape prominent angles to more natural-looking ones with smooth ostectomised borders.

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A prominent mandibular angle is considered to be an unappealing feature in Asian populations, and mandibular angle ostectomy has been popular since Baek et al. introduced it in 1989.[1] Mandibular angle ostectomy with an oscillating saw through the intraoral approach has been a standard procedure for prominent mandibular angles, although a number of modifications and improvements in operative techniques have been reported in the last two decades.[2–7] Although the procedure provides relatively satisfactory results, several issues remain to be resolved.[8] The narrow operative field frequently hampers the surgeon from observing the ostectomy line; thus, it may be difficult to perform an accurate ostectomy as planned. In addition, surgeons may not be able to control the direction of ostectomy as they intended, because of the limited range of motion of the oscillating saw. Therefore, the ostectomy

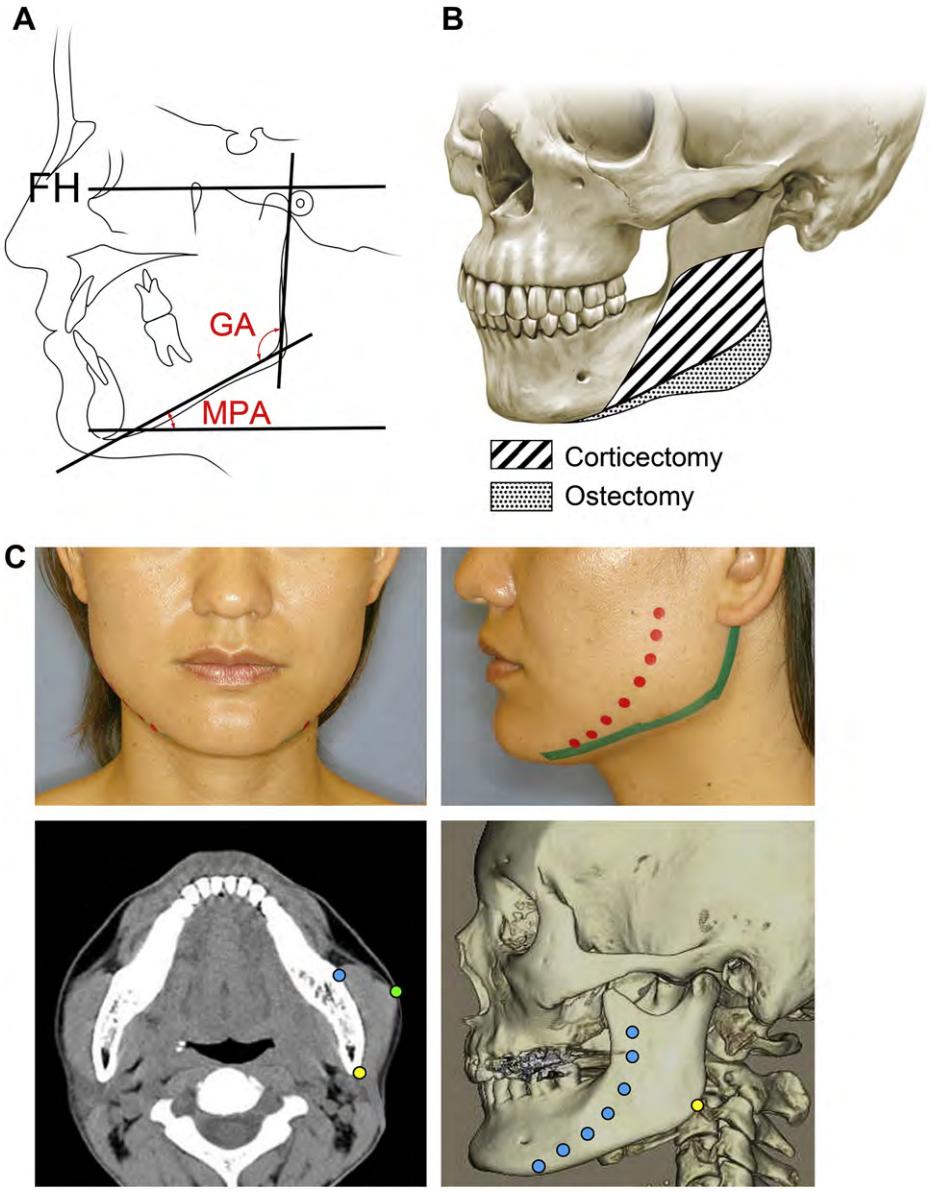

Figure 1 Preoperative evaluation and planning for mandibular angle reshaping. (A) The gonial angle (GA) and the mandibular plane angle to the Frankfort horizontal plane (MPA) were measured in cephalogram. FH: Frankfort horizontal plane, (B) Operative designs for ostectomy and corticectomy. The strategy we employ is a combination of en-bloc mandibular corpus-angle ostectomy (*dotted)* to correct lateral appearance and corticectomy (*striped*) to correct frontal appearance. (C) Relationship between the frontal view and the mandible bone. (*Above, left and right*) Facial contour in the frontal view is plotted with red dots (nearly invisible in the frontal view). Note that the red dotted line is different from the jaw line (green line) in the lateral view. A red triangle indicates the facial angle in the frontal view, while a yellow triangle indicates the facial angle in the lateral view. It is apparent that the tissue volume at the red dotted line must be corrected to reduce the width of the lower face. (*Below, left and right*) In horizontal and three-dimensional CT images, blue dots are plotted on the bone, corresponding to the red dotted line (facial contour in the frontal view) in the lateral view. A yellow dot indicates the angle of the bone. It is apparent that the bone at the blue dotted line must be shaved to reduce the lower face.

line at the posterior border of the mandibular ramus is frequently too vertical and is directed towards the condyle. As a result, the postoperative gonial angle tends to be abnormally large, and the mandibular angle looks small in comparison.[9] Thus, mandibular angle ostectomy with an oscillating saw tends to result not in reduction angleplasty, but in anglectomy.

To overcome these two major drawbacks of conventional procedures—blind and vertical ostectomy—we have developed a new combined procedure of ostectomy and corticectomy, comprising an *en bloc* full-thickness ostectomy of a marginal part of the mandibular body-angle region using a contra-angle handpiece followed by a corticectomy of the remaining mandible. In addition, in patients in whom the posterior border of the mandibular ramus and angle cannot be visualised through the intraoral approach, we used a retractor with an endoscope to expand the operative field, leading to a more accurate ostectomy. Instead of an oscillating saw, we used a contra-angle drill and several chisels to avoid a vertical-like ostectomy. With this method, the prominent mandibular angle was reshaped into a natural appearance by correcting the gonial angle (GA) and the mandibular plane angle to the Frankfort horizontal plane (MPA) within the desired ranges at satisfactory rates.

Patients and methods

Patients

A total of 519 patients (56 males and 463 females: 26.5 years old, on average (range: 19—59 years)) underwent our combination reshaping surgery between March of 2000 and June of 2007. Of these patients, 36 were revisional and two were unilateral. In 190 of 519 patients, the posterior border of the mandibular ramus and angle could not be visualised through the intraoral approach; thus, an endoscope was used supportively. A cephalogram was taken both before and 6 months after surgery in 86 patients, who were followed-up for more than 6 months and who accepted cephalometric evaluations; GA and MPA were measured and postoperative changes were analysed (Figure 1A).

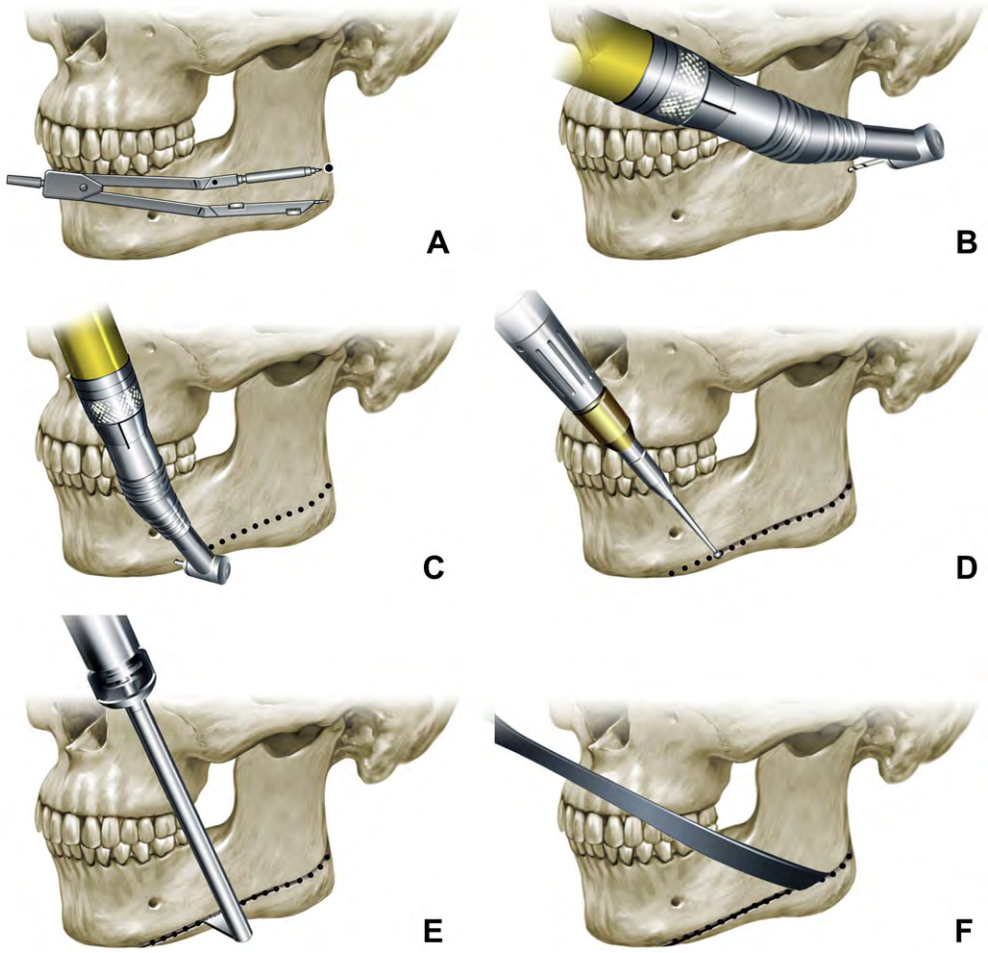

Figure 2 Operative procedures for en-bloc mandibular corpus-angle ostectomy (MCAO) with a contra-angle handpiece. (A) Initially, a pair of compasses are introduced at the posterior border of the mandibular ramus and a mark is made under endoscopic visualization to precisely determine the vertical height. (B) A contra-angle drill is then used to drill a hole exactly at the mark. (C) The drilling continues at 2-mm intervals toward the metal tubercle along the full length of the planned ostectomy line. (D) A round burr is used to groove to connect the drill holes along its full length. (E) An oscillating saw is used anteriorly. (F) Curved chisels are used posteriorly. See also Supplemental Video 1.

Preoperative plan

Most patients desired a three-dimensional contouring of the mandibular angle. It is important to separately discuss the plans for correcting the lateral and frontal appearances of the lower face, because the two types of targets require different surgical techniques, full-thickness ostectomy of the mandibular corpus-angle region and corticectomy of the remaining mandible, respectively.

For the lateral appearance, the direction and extent of protrusion of the mandibular angle and the relative position of the angle should be evaluated preoperatively. We analysed the distance between the earlobe and angle and cephalometric parameters such as GA and MPA. These values were used to determine the size and shape of the bone fragments to be resected and to design the ostectomy line (Figure 1B). We determined the targeted (cosmetically ideal) GA and MPA for Japanese patients by using data from Japanese people reported previously.[10] Targeted values were considered to fall between the average and the average +1 standard deviation (SD). Thus, the targeted GA was 123—130° for Japanese females and 121—128° for males, while the targeted MPA was 27—33° for Japanese females and 26—32° for males.

The principal desire in the majority of patients was to convert the square and broad appearance of their face in the frontal view to one as oval and slender as possible. Because the greatest width of the lower face is usually located around the oblique line, the mandibular corpus should be targeted to reduce the width of the lower face (Figure 1C). The corticectomy area was designed as shown in Figure 1B: the upper boundary was the horizontal line on the mandibular ramus extending from the occlusal plane, while the anterior boundary approximated the oblique line on the corpus extending from the anterior margin of the ramus. However, the line was modified depending on the width and shape of the mandibular corpus.

To achieve optimal results, the operative design was individualised by taking into account the patients' anatomy and their personal desires.

Surgical techniques

The operation was performed under general anaesthesia with nasotracheal intubation. Initially, local anaesthetic solution mixed with epinephrine was injected and a few minutes later, an incision was made in the mucosal membrane on the labial side of the buccal sulcus. The

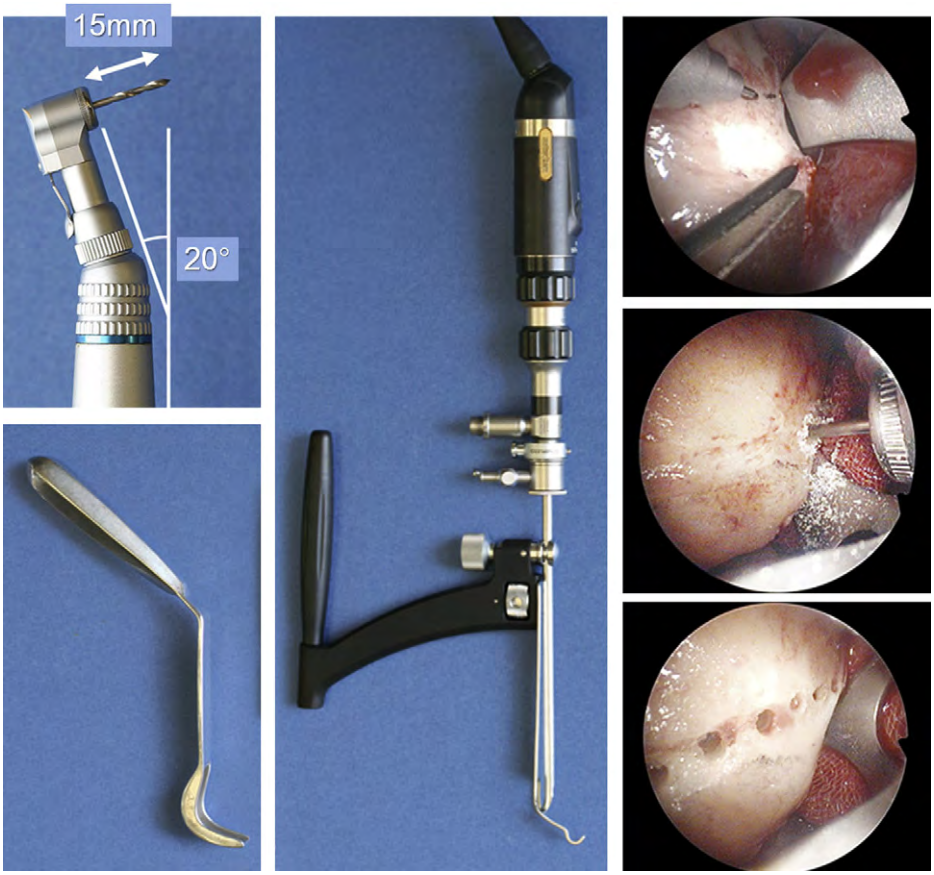

Figure 3 Operative devices and endoscopic views (*Left, top*) Contra-angle handpiece. The standard setting of the contra-angle handpiece is with a 15 mm-long drill with a diameter of 1.5 mm at a direction of 20°. (*Left, bottom*) A spoon-shaped retractor. (*Center*) A retractor with an endoscope; this is useful for performing a precise ostectomy at the posterior border of the mandibular ramus. (*Right*) Endoscopic views during en-bloc mandibular corpus-angle ostectomy. (*Top, right)* A mark is made using a pair of compasses. (*Middle, right)* A hole is exactly drilled with ease at the mark using a contra-angle drill. (*Bottom, right)* Holes at 2-mm intervals anteriorly.

lateral surface of the mandibular corpus and angle was widely exposed by subperiosteal dissection; following which, the operative field was extended using two types of retractors described below. The ostectomy of the marginal part of the mandibular corpus-angle was performed first, followed by corticectomy after evaluating the thickness of the resected bone fragment. Operative procedures were summarised in a 1-min video (Supplemental Video 1).

Correction procedure for lateral appearance: mandibular corpus-angle ostectomy with contra-angle handpiece

To correct the lateral appearance, we performed *en bloc* a mandibular corpus-angle ostectomy (MCAO). The ostectomy was conducted from the mandibular ramus to below the mental foramen and, in some cases, even to the mental tubercle. The ostectomy line was designed with a pencil, and a pair of compasses were used to measure the length between the angle and the ostectomy line on the ramus (Figure 2A). For *en bloc* ostectomy, we used a contra-angle handpiece to drill holes along the ostectomy line (Figure 2B and C). The angle and position of the contra-angle drill were freely adjustable without limitations (Figure 3) (Note that it is difficult to drill holes as planned with tools other than the contra-angle handpiece). Then, the drill holes were connected using a round burr to prevent unexpected malfracture (Figure 2D). Finally, we performed the anterior half of the ostectomy with an oscillating saw (Figure 2E), and the posterior half with curved chisels (Figure 2F).

Two types of retractors were used to perform the ostectomy safely and precisely (Figure 3). A spoon-shaped retractor was used to protect the surrounding tissue; it was inserted into the cavity on the reverse side of the mandible to avoid severe complications such as massive bleeding and facial nerve injuries. The other was a retractor (Optical retractor handle and 17-mm retractor blade, SYNTHES Maxillofacial, Paoli, PA, USA) with an endoscope (4 mm diameter, 30° angle scope; Olympus Corporation, Tokyo, Japan), which was particularly useful in patients with a severely protruded mandibular body or with the mandibular angle protruded inward (Figure 3). In such cases, the posterior border of the mandibular ramus was mostly invisible. Mastering the use of an endoscope is necessary to perform the most accurate osteotomy in any case.

Correcting procedure for frontal appearance: corticectomy or shaving of the mandibular body

We performed mandibular corticectomy to improve the frontal appearance. After designing the ostectomy line with a pencil, a groove was hollowed out on the lateral cortex using a round burr. Great care was taken to stop grooving once cancellous bone was exposed, to avoid any injury to the inferior alveolar nerve. Then, we performed corticectomy using a sagittal saw, which was kept in contact with the reverse side of the outer cortex. In patients with a thin mandible with little cancellous bone, which could be verified by checking the ostectomised bone after MCAO, we used a round burr for cortical shaving to avoid the risk of over-resection and irreparable deformity.

Results

The average operative time was 95 min (range: 76—164 min) for both MCAO and corticectomy. The majority of the patients were satisfied with the aesthetic results. Mandibular contouring was three-dimensionally refined; the width of the lower face was reduced in the frontal view and the mandibular angle appeared natural and inconspicuous in the lateral view. GA and MPA data are summarised in Table 1. GA and MPA values were significantly improved (by approximately

Table 1 Summarized cephalometric data.

Number of cases		Total 86					
		Female ($n = 71$)			Male ($n = 15$)		
Age		29.7 ± 8.9 [years]			31.5 ± 7.8 [years]		
GA	Before surgery	115.5 ± 7.3 [degrees]			115.8 ± 7.5 [degrees]		
	After surgery	125.6 ± 4.9 [degrees]			126.0 ± 5.5 [degrees]		
	Improvement by surgery	10.1 ± 6.0 [degrees]			10.2 ± 4.5 [degrees]		
	(Normal Japanese data)	(123.2 ± 6.6) [degrees]			(120.7 ± 7.0) [degrees]		
	Patient distribution	<Ave	Ave <, <Ave + SD	Ave + SD <	<Ave	Ave<, <Ave + SD	Ave + SD <
		4 (5.6%)	60 (84.5%)	7 (9.9%)	3 (20.0%)	9 (60.0%)	3 (20.0%)
MPA	Before surgery	20.0 ± 5.5 [degrees]			18.6 ± 5.9 [degrees]		
	After surgery	27.6 ± 4.1 [degrees]			27.1 ± 3.6 [degrees]		
	Improvement by surgery	7.6 ± 4.5 [degrees]			8.5 ± 4.7 [degrees]		
	(Normal Japanese data)	(26.8 ± 5.6) [degrees]			(26.0 ± 5.5) [degrees]		
	Patient distribution	<Ave	Ave<, <Ave + SD	Ave + SD <	<Ave	Ave<, <Ave + SD	Ave + SD <
		14 (19.7%)	51 (71.8%)	6 (8.5%)	3 (20.0%)	11 (73.3%)	1 (6.7%)

Cephalograms were taken both before and 6 mo after surgery in 86 patients (71 females and 15 males), and the gonial angle (GA) and the mandibular plane angle to the Frankfort horizontal plane (MPA) were measured. Data are shown as the average ± standard deviation (SD). Normal Japanese data were obtained from Yamanouchi et al.[10] Ranges of the average Japanese GA and MPA to the average plus one SD were chosen as the targeted ranges for each cephalometric value. The postoperative values of each patient were classified into three groups, and the number of patients in each group was counted: (1) below average Japanese data (< Ave), (2) within the targeted range (Ave <, <Ave + SD), and (3) above average plus one SD (Ave + SD <).

10° for GA and 8° for MPA). GA was changed to within the desired range, which was set to the average GA of the Japanese people to the average +1 SD, in 60 of 71 female patients (84.5%) and nine of 15 males (60.0%) (Table 1).

The overall complication rate was 4.0%. All of the complications were minor, and included infection in six cases, persistent numbness of the lower lip in eight cases, burns to the upper lip in two cases and immediate post-operative haematoma in five cases. All of the minor complications resolved within 6 months without specific treatments. Infection of the wound was usually indicated by observation of pus discharge 1–2 weeks after surgery and was treated with drainage, irrigation of the operative cavity and antibiotic medication. Infection can occur during surgery using an intraoral approach if coagula pooling occurs or a haematoma is left in the operative cavity. The use of bone wax may reduce the rate of haematoma, but could increase the risk of infection. Numbness of the lower lip resulted from the stretching of the mental nerve during the surgery. The burns to the upper lip were induced by accidental contact with a heated handpiece, which was avoided by covering the upper lip with a plastic sheet in later cases. There were no major complications such as malfracture, facial nerve injury or massive bleeding. Malfracture can be prevented by using a contra-angle handpiece to drill holes and using a round burr for connecting the holes before osteotomy with an oscillating saw. Facial palsy and massive bleeding, which result from injuries to the facial nerve and facial artery, respectively, can be prevented by using a spoon-shaped retractor, which has been shown to provide powerful protection from these kinds of injury. A small minority complained about aesthetic complications including asymmetry, irregularities and under- and over-correction. Two patients required re-operation for under-correction and one patient for asymmetry.

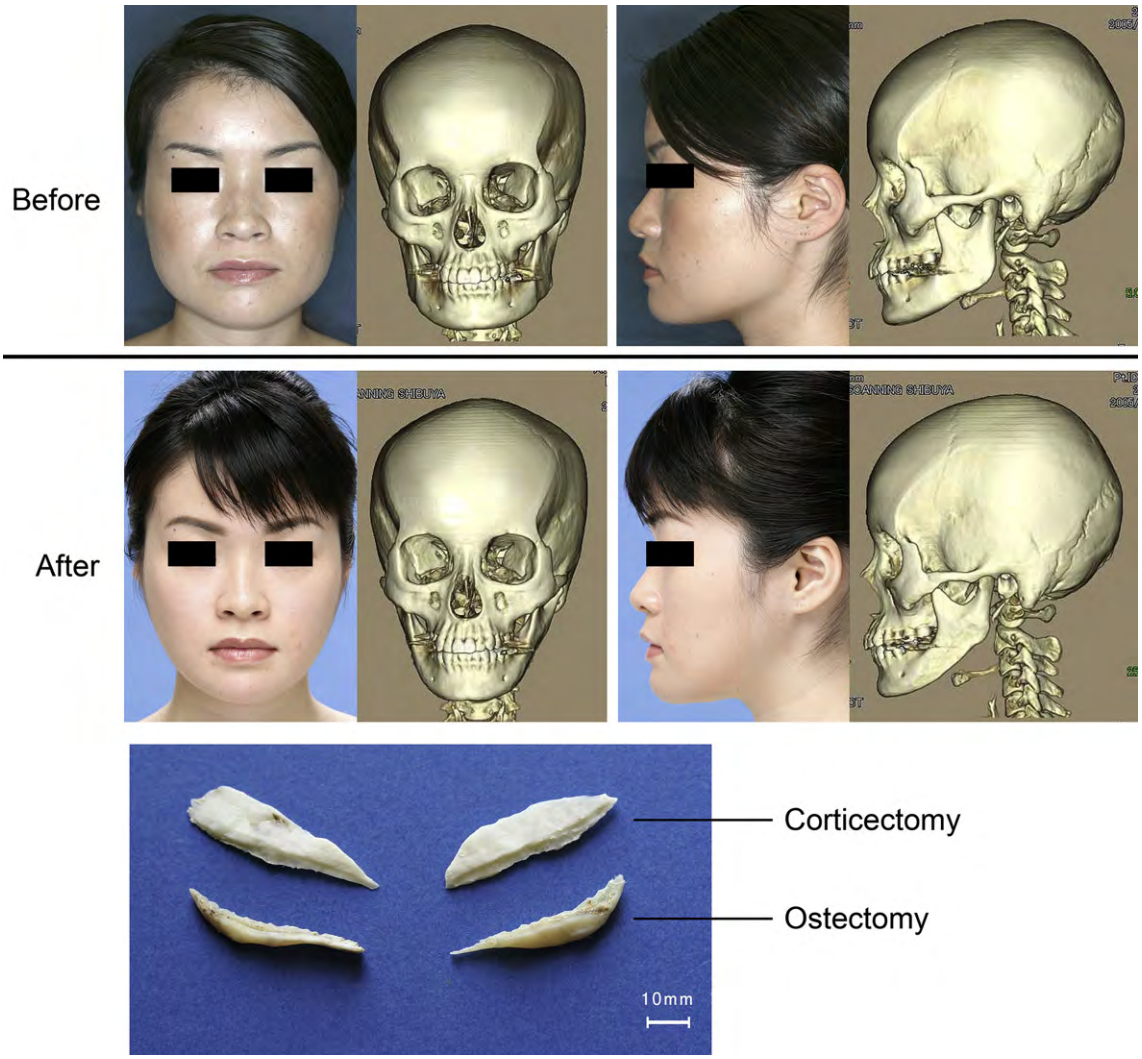

Figure 4 Case 1: A 24-year-old woman wanted her quadrangular facial shape to be more ovoid and underwent mandibular corpus-angle ostectomy and corticectomy. (*Above*) Frontal and lateral views and three-dimensional CT before and 6 mo after surgery. Her mandibular contours became nearly ovoid in the frontal view, the vertical height of the mandibular ramus was shortened, and the GA and MPA were enlarged to within targeted ranges in the lateral view. (*Below*) Bone fragments resected by ostectomy and corticectomy.

Patient reports

Representative cases are presented in Figures 4–6 and Supplemental Figure 1.

Discussion

En bloc MCAO with a contra-angle handpiece for correcting lateral appearance

The objective of mandibular angle reshaping is to make a prominent mandibular angle (with smaller-than-average GA and MPA values) less conspicuous, which does not mean eliminating the angle; rather, a new angle with larger GA and MPA values is constructed. Although preoperative planning of the exact size and shape of the mandibular bone fragments to be resected is required, a standard ostectomy line for the mandibular angle has not been established. One reason may be that surgeons cannot perform angle ostectomies as planned due to the blind nature of the surgery and the limited range of motion of bone saws.

We developed MCAO to overcome the problems listed above, and it has allowed us to perform accurate and reproducible ostectomies and to reshape a prominent angle to a natural-looking one with a smooth ostectomised border. Our preoperative planning for MCAO was based on the analysis of cephalometric values (GA and MPA) as well as the relative location of the angle, in terms of absolute distances of the angle from the mentum and the ear lobe. Preoperative cephalometric radiographs and/or three-dimensional computer tomography were helpful in designing the ostectomised area, which ranges from the mental tubercle to the angle.

One-stage ostectomies are more advantageous compared with multistaged ones.[11] Some previous procedures performed multistage (three to four stages) curved ostectomy with an oscillating saw[2,3,6]; favourable results were reported by experienced surgeons in the technique, but it was time consuming, difficult to resect the bone fragments as planned and could leave stepped deformities. On the other hand, using the one-stage MCAO with a contra-angle handpiece, we achieved *en bloc* resection from the symphysis to the angle within a relatively short time, and there were no bony irregularities. The direction and angle of the contra-angle

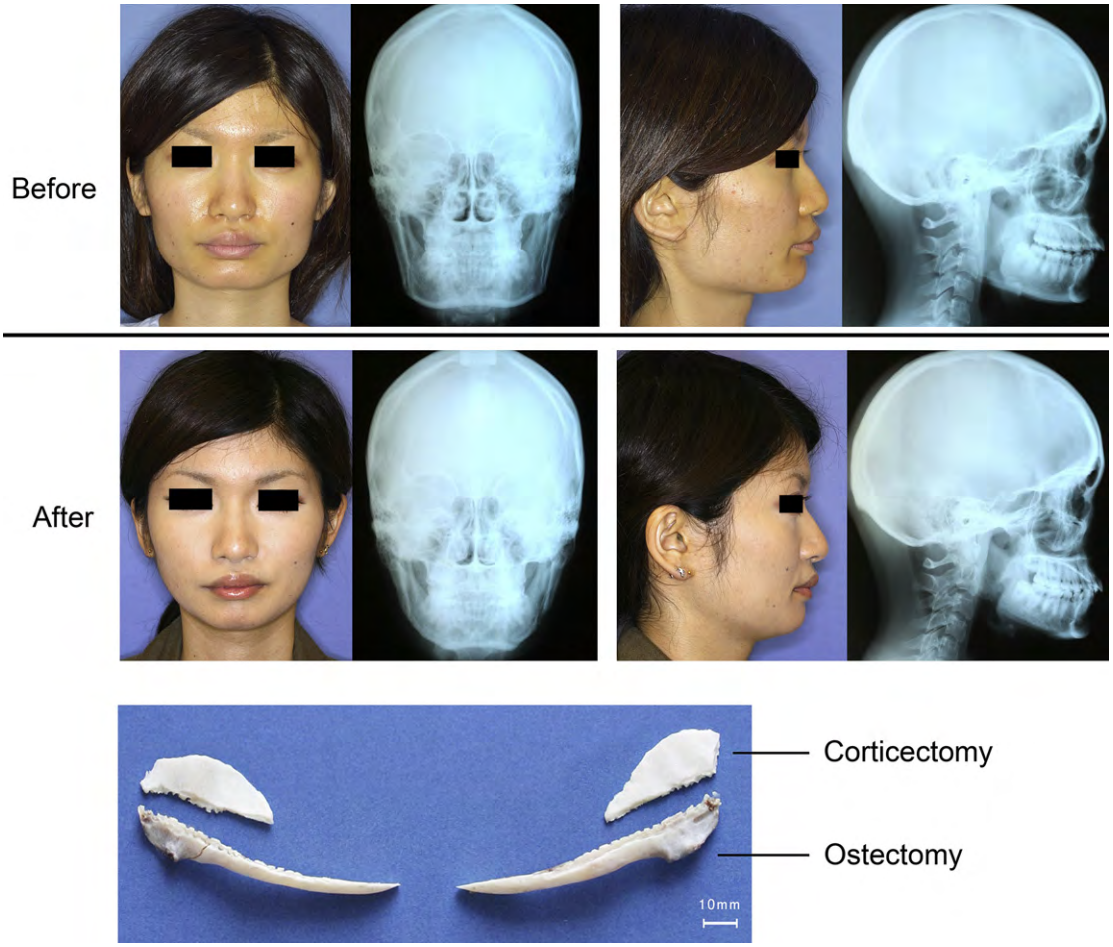

Figure 5 Case 2. A 21-year-old woman wanted her prominent mandibular angles and wide mentum to be corrected and underwent mandibular corpus-angle ostectomy from the angle to the mental tubercle on both sides and subsequent corticectomy. (*Above*) Frontal and lateral views and cephalograms before and 6 mo after surgery. Her mandibular contours became slender and ovoid in the frontal view. Her wide mentum was refined to a narrower one by en-bloc ostectomy. (Below) Bone fragments resected by ostectomy and corticectomy.

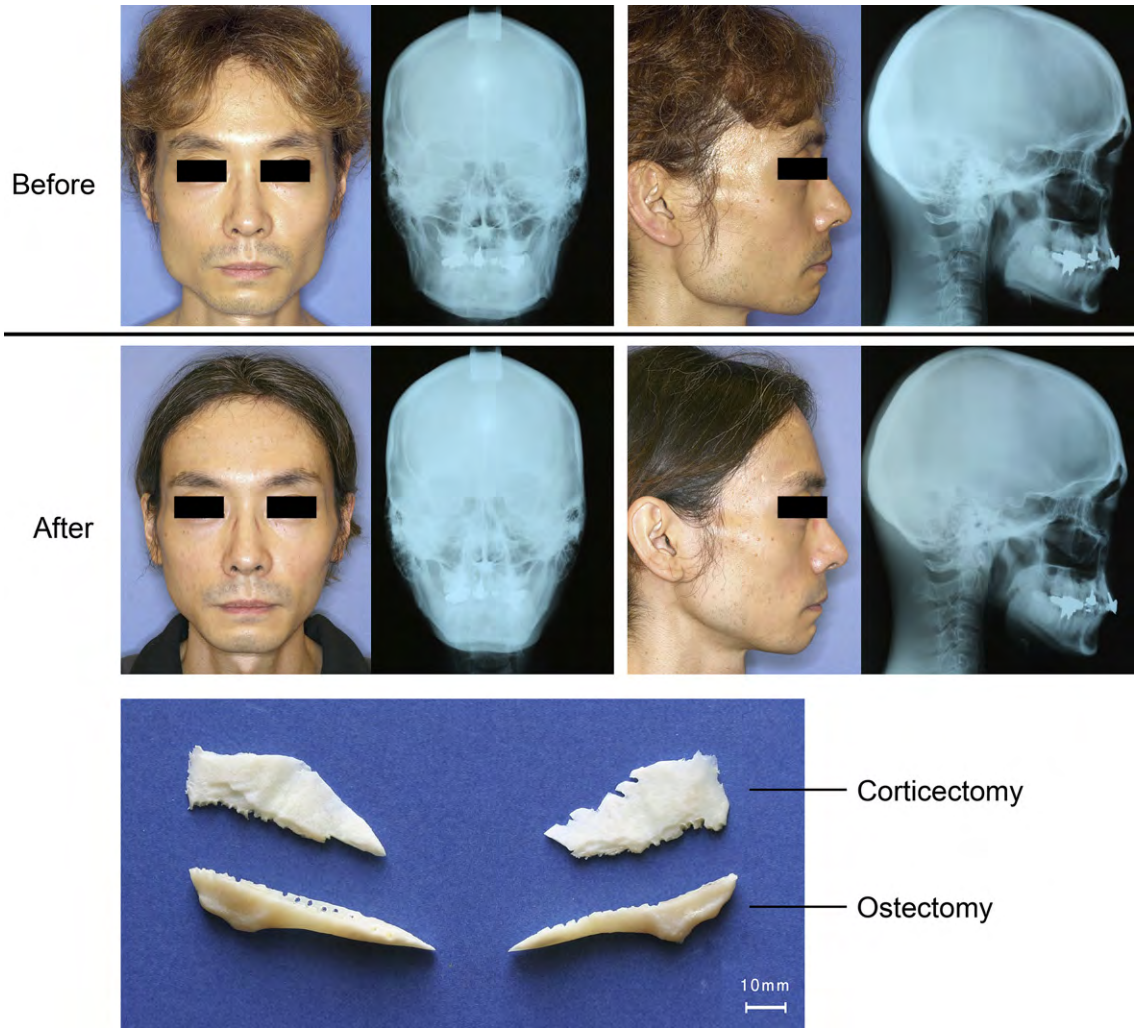

Figure 6 Case 3. A 35-year-old man with a muscular and square face desired mandibular reshaping and underwent mandibular corpus-angle ostectomy and corticectomy. (*Above*) Frontal and lateral views and cephalograms before and 6 mo after surgery. The postoperative frontal view shows that the width of his lower face was greatly reduced by ostectomy and corticectomy. In cephalometric photographs, GA and MPA were increased from 111° to 126° and from 23° to 32°, respectively. (*Below*) Bone fragments resected by ostectomy and corticectomy.

handpiece can be adjusted with a wide range, and ostectomy could be accurately performed as planned even without proficiency in the manoeuvre.

The mobility and direction of the oscillating saw, which is commonly used in conventional methods, is restricted at the commissure of the mouth. Consequently, the direction of ostectomy is forced to be vertical against the surgeon's intentions at the posterior border of the mandibular ramus. Serious complications in conventional procedures, such as condylar fracture caused by the blade directed towards the condyle, have been reported.[2,5,8] In addition, in conventional procedures, resected bone fragments are frequently isosceles triangle-shaped, and the GA deviates extensively from the normal range, resulting in the loss of the angle or anterior malposition of the angle.[8,9] We believe that MCAO with a semi-horizontal ostectomy line is a good means of avoiding these unfavourable aesthetic results. Kim et al. introduced mandibular angle ostectomy using a reciprocating saw through the external approach because it was an easier procedure with fewer complications,[12] but simple straight cutting of the mandibular angle frequently leaves an unnatural line[2,3] and carries a risk of facial nerve injury and scarring.[8]

Endoscopically assisted ostectomy

Frequently, the posterior border of the mandibular ramus and angle cannot be visualised through the intraoral approach. Consequently, surgeons may not be able to perform an accurate ostectomy, which can lead to unexpected and unfavourable results or possible complications.[8] In addition, blind ostectomies cannot correct asymmetric mandibles, for which a precise resection of different sizes of bone fragments from each side is required. Since the 1990s, a number of endoscopically assisted surgeries have been reported in the field of maxillofacial surgery.[7,13] We used a retractor with an endoscope to extend the operative field and a pair of compasses to design ostectomised fragments to the exact millimeter, resulting in an accurate ostectomy in which an angle is constructed with the targeted GA value.

Corticectomy for correcting frontal appearance

As previously described in the literature, to reduce the lower facial width in the frontal view, it is necessary to perform corticectomy of the mandibular body, including the oblique line.[4,9,14–18] A reciprocating saw is used in most of the conventional methods, but it is very hard to perform corticectomy with a reciprocating saw in patients with a concave type of the mandibular body. Furthermore, in patients with a thin mandible, where there is little cancellous bone between the outer and inner cortexes, it is almost impossible to resect the outer cortex alone with a reciprocating saw and chisels. In addition, there is some risk such as injury to the inferior alveolar nerve[9] and over-resection leaving an irretrievable deformity. To avoid these major complications, we performed MCAO, in which the inferior edge of the mandibular body was resected and the thickness of the cancellous bone was accurately evaluated prior to corticectomy. Although we prefer using a sagittal saw for corticectomy, due to its controllability, rather than a reciprocating saw, the sagittal saw was used only when a sufficient thickness of cancellous bone was verified by MCAO. In cases with little cancellous bone, cortical shaving was performed with a round burr instead.

There are problems with conventional procedures for correcting a prominent mandibular angle: an invisible mandibular angle through the intraoral approach frequently forces surgeons to perform blind surgery using an ostectomy device with a limited range of motion. This can result in an inaccurate ostectomy and unfavourable results. To overcome these problems, we described herein a new method that combines *en bloc* and full-thickness ostectomy of the mandibular corpus-angle using a contra-angle handpiece, sometimes assisted by an endoscope retractor, with a corticectomy of the remaining mandible. This procedure allows surgeons to perform a more accurate ostectomy according to their plans, which helps to avoid complications and leaves a natural-looking reshaped angle within the desired GA range and a smooth ostectomised border.

Financial disclosure and products

The authors declare that they have no competing financial interests.

Appendix. Supplementary data

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.bjps.2009.07.025.

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