ELSEVIER SAUNDERS

FACIAL PLASTIC SURGERY CLINICS OF NORTH AMERICA

Facial Plast Surg Clin N Am 14 (2006) 45–50

Endoscopic Approach for Mandibular Orthognathic Surgery

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The field of minimally invasive surgery (MIS) is defined as the combination of surgical innovation with modern technology [1]. It is the discipline of surgery that aims to minimize morbidity and complications usually associated with traditional procedures. MIS focuses on reducing tissue trauma and the resultant bleeding, edema, and injury to maximize the rate and quality of healing. This results in a faster recovery for the patient [2].

Until the mid 1800s, infection and the inability to effectively control hemorrhage, shock, and pain, limited the practice of surgery to the treatment of life-threatening conditions [3]. The use of aseptic technique, the discovery and widespread use of anesthesia, and improvements in perioperative patient management created an environment in which the art and science of surgery could flourish. The introduction of antibiotics after World War II allowed surgeons to carry out a greater variety of elective procedures to improve quality of life. During the last decade, craniomaxillofacial surgeons have begun to develop endoscopic techniques to treat soft tissue and skeletal defects [4] with decreased morbidity.

The first orthognathic surgical procedure was reported by Simon Hullihen in 1849, in the American Journal of Dental Science. The procedure described was a mandibular body ostectomy for correcting retrognathism and an anterior open bite resulting from a burn scar contracture of the neck. Hullihen realized that the constricting scar had to be released to facilitate the corrective jaw movement and to improve the long-term stability of the procedure. A collaborative effort between the orthodontist Edward Angle and the surgeon V. P. Blair led to the development of the St. Louis procedure. This technique involved bilateral ramus osteotomies for treating mandibular prognathism [5]. Schuchardt, in the German literature, was the first to describe a mandibular osteotomy resembling the current sagittal split. This approach to mandibular surgery first was discussed in the English literature by Trauner and Obwegeser in 1955. The technique proved to be quite versatile. It was used to treat various deformities including prognathism, retrognathism, asymmetries, and open bite. Another significant advantage of the sagittal split osteotomy was that a bone graft was not needed in cases where advancement of the mandible was required. The bilateral split osteotomy (BSSO) has been modified and improved over the years [6,7] to minimize morbidity and improve stability. The procedure, however, continues to be associated with significant swelling and potential injury to the inferior alveolar nerve.

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1064-7406/06/$ – see front matter
doi:10.1016/j.fsc.2005.11.003
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Minimizing morbidity associated with mandibular surgery continues to be a central issue in craniomaxillofacial surgery. The development of rigid internal fixation has improved short- and long-term skeletal stability and has eliminated the need for prolonged periods of maxillomandibular fixation. Controlled hypotensive anesthesia has decreased blood loss, thus minimizing the risk of transfusion [8,9]. Administration of perioperative corticosteroids has contributed to a decrease in perioperative edema and discomfort [10]. The combination of improvements in all of these areas has decreased the length of stay associated with mandibular orthognathic surgery [11]. Recent advances in imaging, instrumentation, and fiberoptic technology have allowed surgeons to develop and refine minimally invasive access for orthognathic surgical procedures. These techniques eventually may replace traditional open procedures and further decrease morbidity. The endoscopic approach to the mandibular ramus/condyle unit (RCU) is a minimally invasive access technique. It is used to perform osteotomies and reconstructive procedures such as vertical ramus osteotomies with rigid fixation, condylectomy and costochondral grafts, and placement of miniature distraction devices. A combination of endoscopic access, rigid fixation, and in cases requiring skeletal expansion, distraction osteogenesis, will decrease the morbidity associated with orthognathic and reconstructive procedures. In the future, these procedures may be performed predominantly in an outpatient setting. Ultimately, this will have profound impacts on cost, availability, morbidity, and patient acceptance.

Overview of endoscopic procedures

The benefits of endoscopy include small and remotely placed incisions, inconspicuous scars, and direct visualization of a magnified and illuminated operative field for the surgeon. Tissue dissection and manipulation are minimized, resulting in less pain, edema, and overall morbidity [2,7,12]. Length of hospital stay is shortened, and there is a quicker return to normal activity [2,4,12,19–21].

Endoscopic access can be used for orthognathic surgical correction of three types of mandibular deformities. In cases of mandibular prognathism or asymmetry, the endoscopic vertical ramus osteotomy is a minimally invasive alternative to the traditional vertical ramus osteotomy or sagittal split osteotomy. It also can be used for congenital or acquired temporomandibular joint conditions requiring either condylectomy and costochondral grafting or RCU construction. In cases of mandibular retrognathia, the endoscopic approach, when combined with a miniature distraction device, will be the minimally invasive alternative to the sagittal split osteotomy.

Endoscopic vertical ramus osteotomy

Background

For patients with mandibular prognathism (with or without asymmetry), the standard treatment options are the intraoral vertical ramus osteotomy (IVRO) or BSSO. IVRO offers the advantage of a lower incidence of inferior alveolar neurosensory disturbance when compared with BSSO. The osteotomy, however, generally is performed with poor visibility. It is not possible to use rigid fixation; therefore, the jaw must be immobilized by maxillomandibular fixation. The complication of condylar sag may result in postoperative open bite in a small percentage of patients.

The BSSO is a more complicated osteotomy than the IVRO and requires more soft tissue dissection (medial and lateral ramus). The distinct advantage of the BSSO is that it can be used with rigid internal fixation. There is, however, a significant risk of inferior alveolar nerve (IAN) damage [13,14].

The endoscopic vertical ramus osteotomy (EVRO) is a minimally invasive alternative to the IVRO and BSSO. It can be accomplished with minimal risk to the IAN, and it allows the use of rigid internal fixation. The EVRO is indicated for those patients with mandibular prognathism or asymmetry who refuse maxillomandibular fixation and who are not willing to accept the risks of inferior alveolar nerve injury. This procedure also allows for mandibular setback without the need for extraction of well-developed mandibular third molars, which are associated intimately with the IAN [12] [Fig 1].

The surgical technique for the EVRO begins with careful marking of the zygoma, temporomandibular joint, ramus, angle, anterior border, and condyle on the skin. Then, a 1.5 cm incision is made one finger-breadth below the inferior border of the mandible, parallel to existing neck creases. The dissection is carried bluntly to the masseter muscle, which is incised with a needlepoint electrocautery. The bone is exposed and the dissection completed, in the subperiosteal plane, using endoscopic elevators with a suction port. This dissection creates an optical cavity that allows for excellent visualization of the operative field. A 30° endoscope is placed into the wound and oriented parallel to the posterior border. This dissection provides direct access to the entire RCU [4,12].

With the endoscope the next step is to identify the anatomic landmarks of the RCU: posterior border, sigmoid notch, coronoid process, anterior border, and posterior mandibular body. An osteotomy is created, under direct endoscopic visualization,

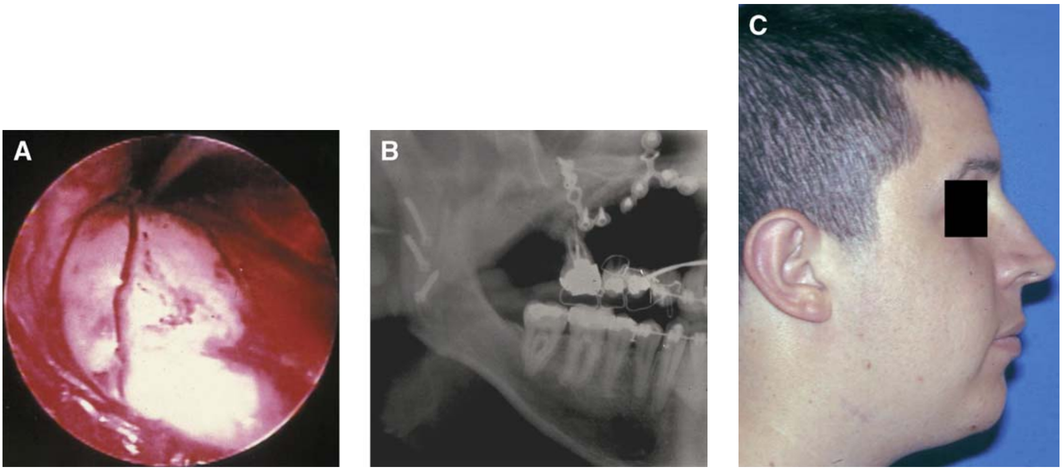

Fig. 1. Vertical ramus osteotomy. (*A*) Endoscopic view of right lateral ramus with completed osteotomy, extending from sigmoid notch to angle. (*B*) Close-up panoramic view showing vertical ramus osteotomy with setback and rigid fixation. (*C*) Lateral facial photograph of patient. Note healed incision.

from the sigmoid notch to the mandibular angle using a long-shaft reciprocating blade. The medial pterygoid muscle is stripped partially to allow for overlap of the proximal and distal segments. The patient is placed into maxillomandibular fixation in the preplanned occlusion. Rigid fixation is achieved with three 12 to 14 mm long, 2.0 mm diameter screws. The screw holes are drilled and the screws placed through the incision or with the aid of a percutaneous trocar. If there is minimal overlap of the proximal and distal segments, plate fixation may be used as an alternative [12]. Troulis and Kaban reported a retrospective study of 14 patients treated with EVRO [12]. The mean operating time was 37 minutes per side. A single patient suffered transient weakness of the marginal mandibular nerve, and this lasted less than 1 week. No patients required maxillomandibular fixation. One patient with concurrent medical problems had a hospital stay of 2 days. All other patients were discharged within 23 hours. The stability of bone positioning was documented at a mean of 1.7 years postoperatively with lateral cephalograms.

Condylectomy

Idiopathic condylar resorption

For those patients with mandibular retrognathism and open bite secondary to idiopathic condylar resorption or degenerative joint disease, endoscopic condylectomy and costochondral graft reconstruction are minimally invasive alternatives to the standard open-access approaches. The standard technique for condylectomy and costochondral graft RCU reconstruction involves preauricular and submandibular incisions [15,16] with potential risk for facial nerve paresis. The standard open approach also is associated with considerable bleeding and edema. Alternatively, condylectomy and RCU reconstruction can be achieved through the same 1.5 cm incision and dissection used for the EVRO. This approach results in a single, small and well-concealed facial scar. It also significantly decreases the risk to the facial nerve and the amount of bleeding and swelling.

The incision, dissection, creation of the optical cavity, and landmark identification are the same as described for the EVRO. However, dissection of the condylar head and neck, however, is extended into the lower compartment of the temporomandibular joint until the bone is skeletonized. The condyle then can be atraumatically removed and the undersurface of the articular disc visualized [4,20]. The patient is placed in maxillomandibular fixation, with a splint, producing a 2 3 mm posterior open bite on the sides to be reconstructed. This compensates for the loss of vertical height of the costochondral graft during healing [15].

Costochondral grafts are harvested in the standard fashion through an inframammary incision. Then, using the endoscope, the disc is identified, and the graft is placed into the glenoid fossa. The graft is fixed into position using a 2.0 mm titanium miniplate (as a washer) with multiple screws.

A retrospective evaluation of 10 patients revealed a mean operating time of 57 minutes per side exclusive of the rib harvesting procedure. Average hospital stay was 2.5 days [20]. There were no long-term neurologic changes associated with the IAN or lingual or facial nerves. All patients demonstrated a good range of motion, with maximal incisal opening returning to preoperative values by 1 year. In all patients, the desired occlusion

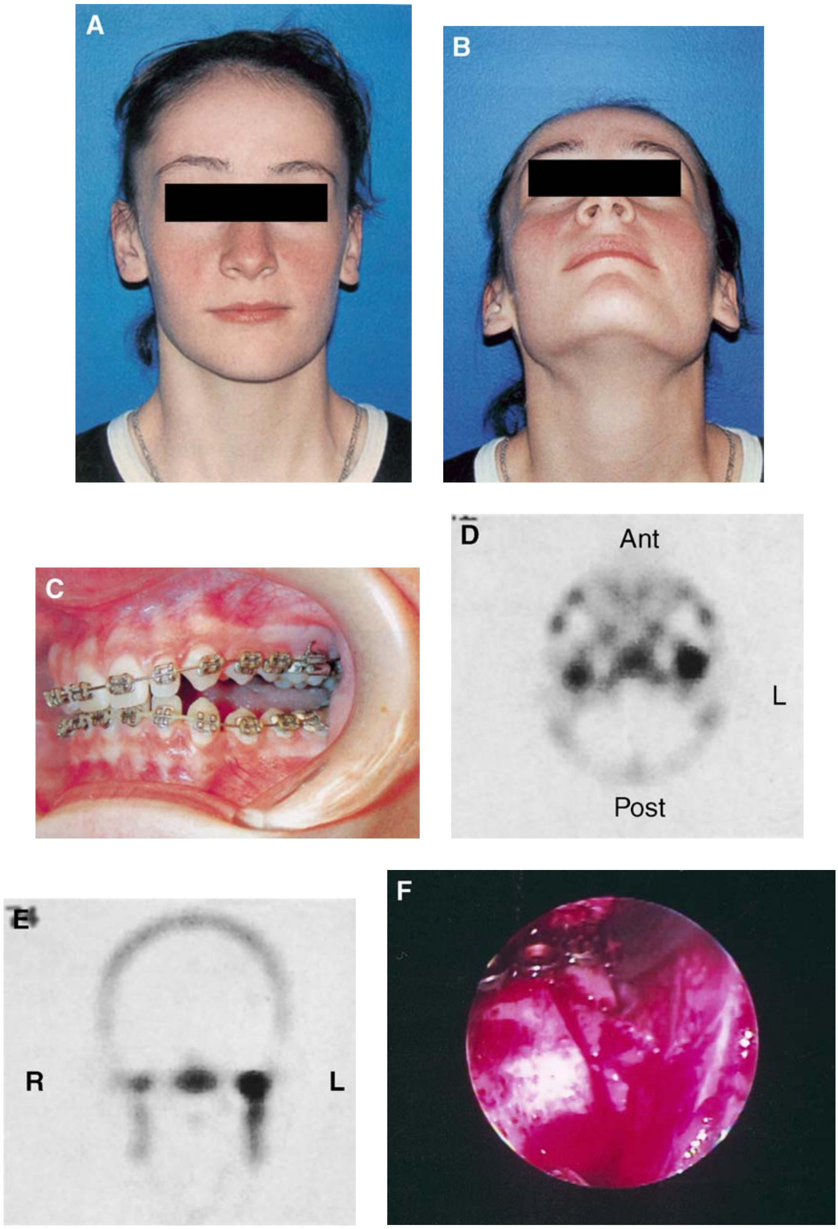

Fig. 2. Uncompensated left condylar hyperplasia, vertical pattern. Frontal (*A*) and submental (*B*) views of a 15-year-old patient with elongated left mandibular ramus indicative of condylar hyperplasia. (*C*) Intraoral view shows the left posterior open bite before the development of dental compensations, (*D*) SPECT scan showing the increased uptake of the left condyle. (*E*) Similarly, the left condyle is hyperactive. (*F*) Patient underwent endoscopic high condylectomy and vertical ramus osteotomy with rigid fixation. (*G*, *H*) Postoperative patients symmetry and left open bite have been corrected. (*From* Kaban LB, Troulis MJ. Pediatric oral and maxillofacial surgery. Philadelphia, PA: W.B. Saunders; 2004;343; with permission.)

was maintained at the latest follow up (longer than 1 year).

Condylar hyperplasia

For patients with mandibular asymmetry secondary to condylar hyperplasia, the previously described approach to the RCU also can be used to perform a growth-arresting procedure or high condylectomy. After exposing the condylar head and neck, the hyperplastic segment is marked, osteotomized, and removed. Then the normal condylar stump is smoothed and contoured. This procedure is performed best early in the disease cycle, before the development of dental compensations, to avoid

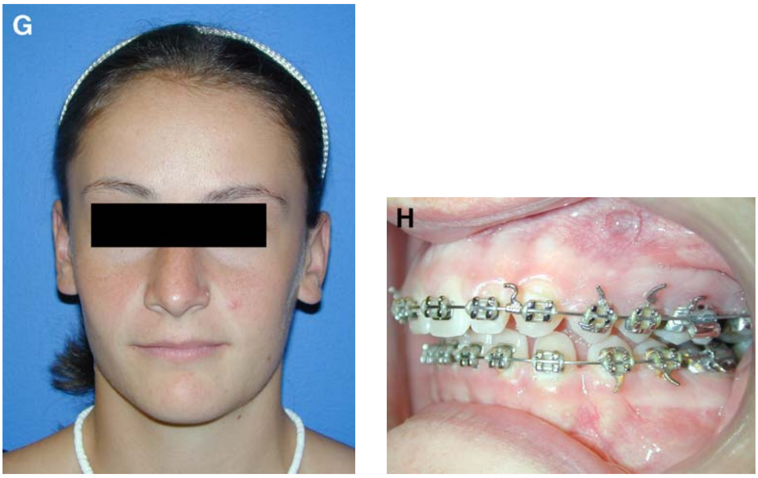

Fig. 2 ***(continued).***

the need for mandibular or bimaxillary orthognathic surgery. Patients who suffer from active condylar hyperplasia with secondary deformities of the maxilla and mandible are treated best by a combination of high condylectomy and bimaxillary orthognathic surgery. In patients who are clinically stable, orthodontic decompensation and standard orthognathic surgery are the treatment of choice [Fig. 2] [22].

Mandibular retrognathism

Patients with mandibular retrognathism account for approximately one third of all orthognathic surgical cases. The standard operation for the correction of this deformity is BSSO. Considerable research has been performed to minimize the morbidity and complications associated with this procedure. Despite these efforts, there are limitations associated with the sagittal split osteotomy. Sensory disturbance of the inferior alveolar nerve occurs in a high percentage of patients. This is mostly a result of the anatomy of the mandible and nerve canal rather than a specific surgical complication. IAN parethesia may occur because of stretch, when the jaw is advanced, trauma from retraction of the nerve on the medial side of the ramus, and compression or direct injury by bicortical screws used for rigid internal fixation. Sensory disturbance may range from paresthesia to anesthesia but is often transient and exhibits spontaneous resolution within 2 to 6 months in most cases. Up to 25% of the affected patients, however, have some persistent nerve deficit. The rate of this complication is even higher among patients over 40 years of age [13,14]. Another potential limitation is skeletal relapse, especially with advancements greater than 8 mm [6,7].

Distraction osteogenesis (DO) is a surgical technique that makes use of the body's healing potential to form new bone in response to tension forces placed across an osteotomy. A corticotomy is made, and a device is placed across the cut. The device is activated gradually to produce the desired amount of bone lengthening. Gradual expansion of bone and associated soft tissues allows for correction of the deformity. Skeletal expansion is tolerated better than soft tissue, risk to the inferior alveolar nerve and risk of relapse potentially are diminished as compared to acute movements [17]. In a recent retrospective evaluation of 20 consecutive patients with mandibular retrognathism, treated with either BSSO (n = 10) or DO (n = 10), 36% of the BSSO versus 21% of the DO patients had dense paresthesia postoperatively. This difference suggests that paresthesia is less frequent in DO, but further studies are needed to confirm this. Subjectively, the DO patients also recovered normal sensation in greater numbers and more quickly [18]. Currently, the placement of distraction devices for mandibular advancement is achieved with an incision and dissection similar to that for BSSO, but with significantly less dissection. The third molar is removed, if present, and a corticotomy is made through the third molar tooth region. The distracter is fixed across the gap between proximal and distal segments. The wound is closed, leaving the activation mechanism exposed transmucosally. After a latency period ranging from 2 to 4 days, distraction begins at a rate of 1 mm a day to the desired amount [23].

The development and refinement of endoscopic techniques for access to the maxillofacial skeleton will allow surgeons in the near future to perform complex osteotomies and place distraction devices, creating additional minimally invasive options for correcting skeletal deformities. In particular, a miniaturized DO device, totally buried, remotely activated and capable of three-dimensional movements is desirable. This device also could be placed endoscopically in either the maxilla or the mandible, thus combining the benefits of both techniques.

The combination of endoscopic techniques with a CT-based, three-dimensional navigation system will allow for more accurate execution of complex skeletal treatment plans. It is possible that with the minimally invasive techniques described in this article, treatment of skeletal defects will be performed in the future in an outpatient setting with local anesthesia and intravenous sedation. This would impact cost, patient morbidity, and availability of treatment significantly.

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