

Fig 3 A 17-year-old boy presented with old, multiple maxillofacial fractures. (A) Occlusion before surgery. An edge-to-edge bite was obvious, and mastication with the molars was impossible. (B) Simulation of the osteotomy using a preoperatively prepared occlusion model. (C) The teeth were fixed using polyethylene ribbon. (D) Occlusion 6 months after surgery. The patient received additional dental treatments, including orthodontic retention for aesthetic purposes. Good mastication with the molars was achieved.

dental field.⁹⁻¹² Before coagulation with resin or dental cement, the ribbon is soft and thin (approximately 0.4 mm thick), and it can be fitted easily to the surface of teeth and the dental arch. After resin or dental cement is applied, the thickness is still 1 or 2 mm. The ribbon surface can be smoothed, and there is almost no risk of pain or stomatitis of the labial mucosa. The color is either white or yellowish white, and it is not obvious visually even when the ribbon appears on the anterior segment of the teeth. Its adhesion to the tooth surface prevents pain and secondary carious teeth.⁹⁻¹² We conclude that plasma-treated lenowoven polyethylene ribbon is quite useful for firm fixation of bone segments in ASDO, which is performed mainly for aesthetic improvement.

REFERENCES

1. Wilhelm W. The surgical treatment of prognathism of the maxilla. *Bol Odontol* 1974;20:146-152

2. Converse JM, Horowitz SL. The surgical-orthodontic approach to the treatment of dentofacial deformities. *Am J Orthod* 1969;55:217-221
3. Johnson JV, Hinds EC. Evaluation of teeth vitality after subapical osteotomy. *J Oral Surg* 1969;27:256-271
4. Barton PR. Segmental surgery. *Br J Oral Surg* 1973;10:265-269
5. Kau K, Rudo DN. A technique for fabricating a reinforced composite splint. *Trends Techniques* 1992;11:31-33
6. Miller TE. A new material for periodontal splinting and orthodontic retention. *Compend Contin Educ Dent* 1993;14(6):800-812
7. Miller TE, Barrick JA. Pediatric trauma and polyethylene reinforced composite fixed partial denture replacements: a new method. *J Can Dent Assoc* 1993;59(3):252-526
8. Miller MB, Mabrito CA, Castellanos I. Ribbond. *Reality Now* 1993;42:1-2
9. Strassler HE, Bauman G. Current concepts in polishing composite resins. *Practic Peridon Aesthetics* 1993;(Suppl.):12-17
10. Dickerson WG. The concept bridge. *Dent Econ* 1994;6(1):67-68
11. Nash R, Kau K. Reinforcing composite resin: a restorative alternative. *Compend Contin Educ Dent* 1994;14(6):554-560
12. Strassler HE, LoPresti J, Scherer W, et al. Clinical evaluation of a woven polyethylene ribbon used for splinting. *Esthetic Dentistry Update* 1995;6:80-84

Plasma-Treated Lenowoven Polyethylene Ribbon for Bone Fixation at Dentoalveolar Osteotomy

Kensuke Kiyokawa, MD*
 Munekatsu Kiyokawa, DDS†
 Yasushi Hariya, DDS†
 Yoshiaki Tai, MD*
 Shinsuke Tanaka, MD*
 Yojiro Inoue, MD*
 Hiroko Yanaga, MD*

Fukuoka, Japan

Plasma-treated lenowoven polyethylene ribbon was used for splinting between teeth around osteotomy lines in anterior segmental dentoalveolar osteotomy. This fixation was continued for 2 to 3 months, during which there was no damage or fall of the ribbon. In addition, the patients were able to eat their usual food, had much less pain in the teeth and oral mucosa, did not feel uncomfortable in the mouth, had no tooth damage or carious teeth, and had a good aesthetic appearance. In all eight jaws (five patients), accurate and strong bone fixation was achieved based on the planned occlusion. Patient complaints and pain were obviously less with this method than other methods. Polyethylene ribbon is quite useful for bone fixation in anterior segmental dentoalveolar osteotomy.

Key Words: Rigid fixation, anterior segmental dentoalveolar osteotomy, aesthetic, polyethylene ribbon

Anterior segmental dentoalveolar osteotomy (ASDO) is performed to correct deformation of the anterior tooth segment. It is a quite useful technique for some patients because its surgical invasion is much less than Le Fort osteotomy and sagittal split mandibular osteotomy, and it does not require intermaxillary fixation.

From the *Department of Plastic and Reconstructive Surgery, Kurume University School of Medicine; and the †Kiyokawa Dental and Oral Surgical Clinic, Fukuoka, Japan.

Address correspondence to Dr Kiyokawa, Department of Plastic and Reconstructive Surgery, Kurume University School of Medicine, 67 Asahi-machi, Kurume, Fukuoka 830-0011, Japan.

tion.¹⁻⁴ However, in ASDO, roots are located close to both sides of the osteotomy line. Therefore, drilling into the bone and firm bone fixation using wire and plate become difficult. In usual cases, additional fixation of teeth using metal arch bars or wire is required. With long-term fixation, this could induce tooth damage or secondary carious teeth, and patient dissatisfaction would escalate.

Plasma-treated lenowoven polyethylene ribbon (Ribbond; Ribbond Inc., Seattle, WA) was developed by Kau and colleagues⁵ in 1992, and Miller and associates⁶⁻⁸ in 1993. It has been used for the fixation of artificial teeth or frail teeth in dental treatments, but has not yet been used for fixation in maxillotomy. We applied this polyethylene ribbon for bone fixation after ASDO, and were able to solve problems associated with fixation using metal arch bars and wire.

PROCEDURES

In ASDO, one side of the mucosa remained intact (i.e., mucosa on the lip side of the maxilla and on the lingual side of the submaxilla) to maintain blood flow to the bone segments. When necessary, the no. 4 teeth on the both sides were extracted. Before surgery, a model of the planned postoperative occlusion was designed and prepared. This model was applied to the mouth during surgery, and primary intermaxillary fixation was performed not only on the anterior segment but also on the posterior (molar) segment by using brackets attached to the teeth.

During the next step—bone fixation—drilling occurred above (for the maxilla) or below (for the mandible) the root in the bone. One place each, on the right and left sides, was fixed with titanium plate or wire. The plasma-treated lenowoven polyethylene ribbon was cut into the appropriate length, either

dental cement or resin was applied thinly to the surface, and the ribbon was then fixed to two or three teeth across the osteotomy line. The ribbon solidified when coated with either the dental cement or the resin. Time to solidification was approximately 15 minutes for dental cement and 30 minutes for resin. In this way, a strong splint was produced between the teeth and across the osteotomy line. The bones were fixed accurately in the position of the planned occlusion (Fig 1).

After removing the primary intermaxillary fixation, the gum and mucosa were sutured to complete the treatment. Bone fixation using the ribbon was continued for 2 to 3 months after surgery.

RESULTS

During ASDO, all five patients (eight jaws) demonstrated firm, accurate fixation of the planned occlusion. Ribbon fixation was continued for 2 to 3 months after surgery, during which time there was no damage to or fall of the ribbon, and the occlusion set at surgery was maintained. In addition, during this fixation period, except for one patient whose in-

termaxillary fixation was maintained after surgery, all patients were able to eat their usual foods 3 or 4 days after surgery. Tooth and gum pain were not reported, the feel of the ribbon was not uncomfortable, and no tooth damage or secondary carious teeth were reported. The aesthetic appearance of the anterior teeth was much better than with a metal arch bar. Overall, the ribbon fixation was easier for patients to endure. After its removal, there were no incidences of frail bones or position shift, and all patients demonstrated good bony adhesion.

CASE REPORTS

We applied this technique to eight jaws in five patients. There were three patients with maxillary and/or submaxillary protrusion, one patient with depressed deformation of the anterior segment of the maxilla, and one patient with old maxillofacial fractures.

Patient 1

Patient 1 was a 34-year-old woman with depressed deformation of the anterior segment of the maxilla

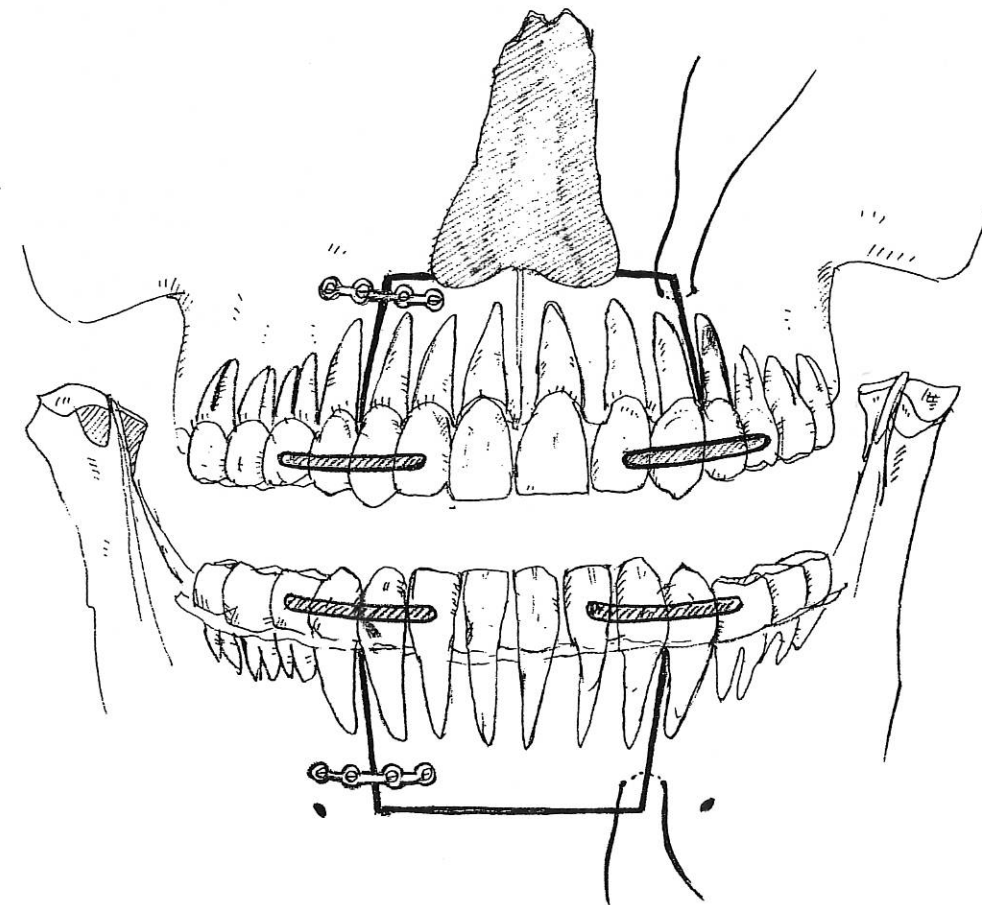


Fig 1 Bone fixation method using plasma-treated lenowoven polyethylene ribbon (Ribbond) for anterior segmental dentoalveolar osteotomy.

and with mandibular protrusion. During childhood, depressive deformation and mandibular protrusion were detected but the patient did not receive any treatment. Near puberty the deformation became noticeable. The patient consulted an orthodontist, but she did not undergo treatment because she was told that several years of treatment were necessary. When she first visited our office, reversed occlusion and crossbite were obvious (Fig 2A), and the mandible protruded and was malpositioned to the left. The maxillary arch was in a trapezoidal shape because of the malposition of the anterior segment toward the inside of the mouth (Fig 2B). ASDO was performed by dividing the anterior segment into two portions. Centered on the median line, the two segments were moved forward to form the arch shape (Fig 2C). For the bone defects produced by this movement, iliac bone was grafted. The submaxilla was segmented sagittally, rotated to the right, and moved to the inside. While the preoperatively prepared model was applied, intermandibular fixation was performed. The osteotomy line was then fixed with a wire, and the teeth were fixed with the polyethylene ribbon (Fig 2D). Intermandibular fixation was removed 1 month after surgery, and the ribbon fixation was removed 2.5 months after surgery. After that, dental treatments were conducted for 6 months, and good occlusion and maxillofacial arch were obtained (Figs 2E and 2F).

Patient 2

Patient 2 was a 17-year-old boy with old, multiple maxillofacial fractures. He underwent treatment at another institution, and was referred to our office for dysmasia resulting from occlusal disharmony. During his first visit an edge-to-edge bite was obvious, and mastication with the molars was difficult (Fig 3A). To treat this patient, the anterior segment of the maxilla was rotated counterclockwise by approximately 10 deg, which caused the nose to bend to the left. Our dentist determined that if the edge-to-edge bite on the anterior portion improved, occlusion of the molars could be improved with dental treatment. Therefore, ASDO was applied to the anterior segment of the maxilla and mandible. For the maxilla, an osteotomy was performed between teeth 3 and 4 on both sides, and the bones were rotated counterclockwise by approximately 10 deg. For the mandible, the no. 4 tooth on both the right and left sides was extracted, osteotomy was performed at these positions, and the bones were moved to the inside (Fig 3B). While the preoperatively prepared model was applied, primary intermandibular fixation was performed. The maxillary bones were fixed

with a miniplate and the mandibular bones were fixed with wire at the level above and below the root respectively. Primary intermaxillary fixation was removed after application of ribbon fixation between the teeth (Fig 3C). After ASDO, the molars were treated dentally, occlusion improved, and the patient was able to eat his usual food. Ribbon fixation continued for 3 months to prevent relapse of the bone segments. The patient has undergone additional dental treatments, including orthodontic retention for aesthetic purposes, 7 months after surgery (Fig 3D).

DISCUSSION

ASDO can adjust the deformation of the anterior segment of the teeth less invasively compared with Le Fort osteotomy and sagittal split mandibular osteotomy, and it is quite useful in some patients.¹⁻⁴ However, in ASDO, drilling of the bone has a risk of tooth damage because the teeth are located adjacent to the osteotomy line. This makes firm fixation of the bones using plate and wire difficult. In addition, touching area between the anterior bone segment and the posterior bone is narrower than in other osteotomy techniques, and it becomes very narrow if patients receive concomitant bone grafting, as did Patient 1 (see Fig 2D). Therefore, fixation using teeth becomes essential to strengthen bone stability and to achieve good bony adhesion. Fixation should continue for 2 to 3 months, until the bones are completely adhered to each other. Generally, interteeth fixation is achieved using wire or metal arch bars. The arch bar is used more frequently because wire is soft and weak for fixation. However, the arch bar has three disadvantages. First, it is difficult to arrange the bones accurately according to the planned model. It is quite difficult to curve the arch bar along the shape of the tooth surface. Also, when the wire that is used to hook the arch bar to the teeth is tightened, bones are pulled and could be moved out of the planned occlusion. Second, the arch bar could inhibit blood circulation to the bones. In ASDO, gum or oral mucosa on one side (either the lip side or the lingual side) remains intact to maintain blood flow to the bone segments. Compression of the gum by the arch bar, or damage to the gum between teeth by the wire, could suppress blood flow. Third, patients experience physical and psychological pain when these appliances are applied, such as pain of the labial mucosa because of mechanical stimuli, occurrence of stomatitis, metal appearance in the anterior segment of the teeth, tooth damage, and secondary carious teeth. Our patients who underwent ribbon fixation did not experience these problems.

Plasma-treated lenowoven polyethylene ribbon

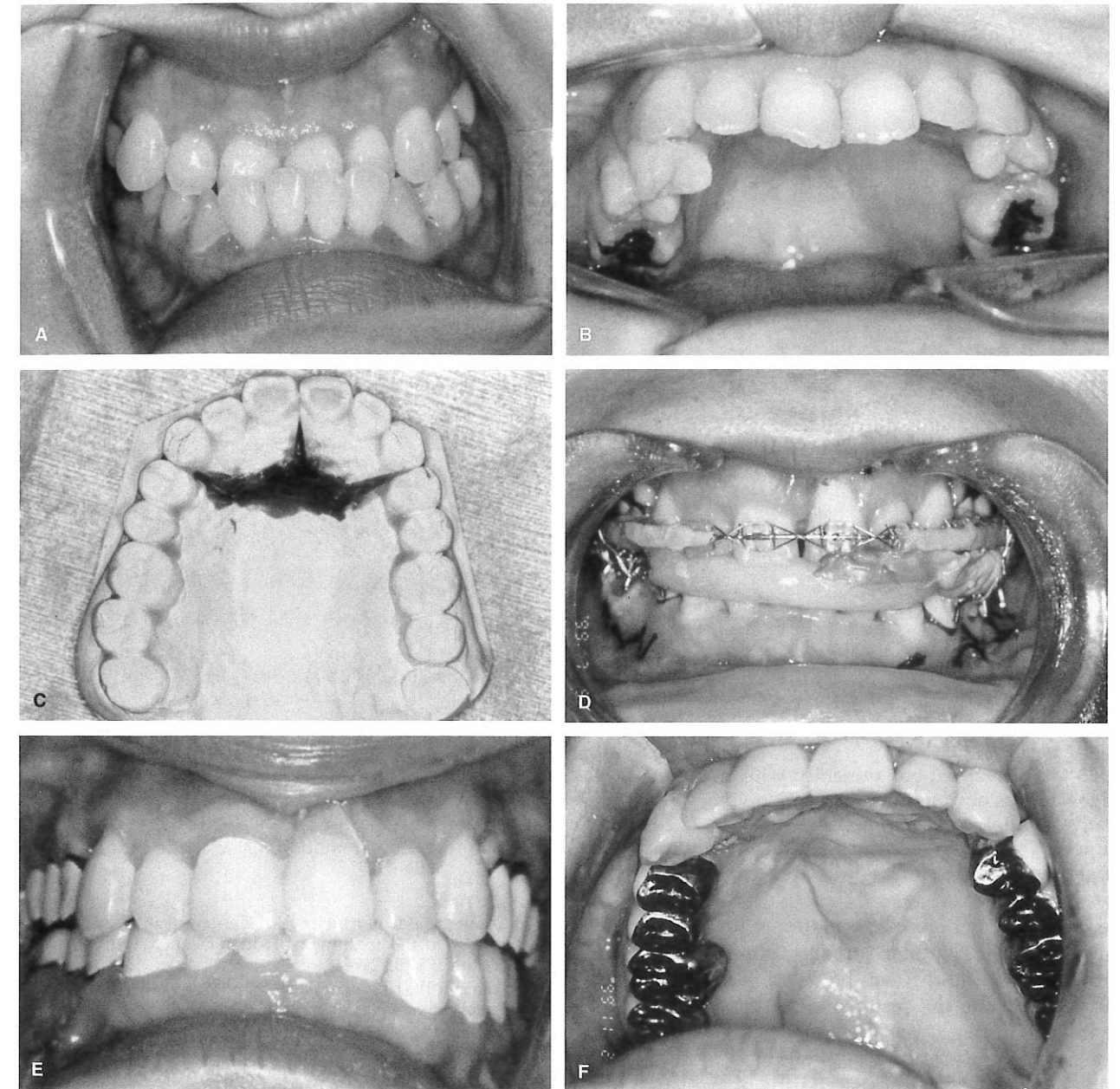


Fig 2 A 34-year-old woman presented with depressed deformation of the anterior segment of the maxilla and with submaxillary protrusion. (A) Occlusion at the initial examination. (B) Preoperative maxillary dental arch. Note the trapezoidal shape. (C) Simulation of osteotomy using a preoperatively prepared occlusion model. (D) While the preoperatively produced model was applied, intermandibular fixation was performed, and the teeth were fixed with the polyethylene ribbon (arrows). (E) Occlusion on completion of the dental treatment 13 months after surgery. (F) The maxillary dental arch. It was adjusted to an arch shape.

is the polyethylene fiber which surface is gas-plasma treated and which is knitted in a ribbon shape.⁶⁻⁸ With plasma treatment, polyethylene fibers react chemically to form a molecular layer on the ribbon. This layer has a high reactivity to hardening agents,

such as dental cement and resin, and achieves polymerized conjugation using these agents.⁵ This treatment also produces a highly durable splint that supports the occlusal weight. This ribbon has been used in the fixation of frail teeth and artificial teeth in the