

Resorbable Skeletal Fixation Systems for Treating Maxillofacial Bone Fractures

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Objective: To evaluate the effectiveness of using resorbable plate and screw systems (RPSSs) compared with metal plate and screw systems (MPSSs) to treat maxillofacial bone fractures.

Design: Retrospective study.

Setting: Chuncheon Sacred Heart Hospital, Chuncheon, South Korea.

Patients: Eighty-two patients diagnosed as having zygomaticomaxillary fractures between February 1, 2004, and December 31, 2008.

Intervention: We used RPSSs in 56 patients and MPSSs in 26 patients.

Main Outcome Measure: Complication rates.

Results: The 82 patients included 72 males and 10 females aged 16 to 83 years. Follow-up ranged from 3 to 12 months. The complication rate was 7% (4 of 56) with RPSSs and 4% (1 of 26) with MPSSs. Using RPSSs, 2 patients experienced device exposure and 1 accompanying infection. With device exposure, the plates were removed. One patient noted paresthesia in the premaxillary area. Using MPSSs, 1 patient had a loosened metal screw; the other patients had no problems.

Conclusions: Based on the present experience, there are many advantages to RPSSs. Nevertheless, we should select the fixation system carefully depending on the fracture site and whether there is accompanying infection. It is important to select the method that best fits the patient's situation.

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VARIOUS BONE FIXATION MATERIALS have been used in maxillofacial surgery. In addition to conventional techniques, such as fixation with suture materials and wires, metal plate and screw systems (MPSSs) have been widely used. The ultimate goal in surgery is to restore structure and function to a natural state.¹ In maxillofacial surgery, stable, reliable osteofixation is absolutely necessary. Metal implants usually provide good osteofixation. However, several complications and adverse effects have been described.^{1,2} Recently, resorbable plate and screw systems (RPSSs) have attracted attention as efficient fixation systems, and they are used more commonly for various indications.³ This retrospective study evaluated the effectiveness of using RPSSs for treating maxillofacial bone fractures.

METHODS

This was a retrospective analysis of 82 patients diagnosed as having zygomaticomaxillary fractures who underwent maxillofacial surgery performed by a single surgeon (C.H.P.)

between February 1, 2004, and December 31, 2008, at Chuncheon Sacred Heart Hospital, Chuncheon, South Korea.

Data were obtained retrospectively from the patients' medical records, which were reviewed for age, sex, cause of trauma, osteofixation material used, and complications. The inclusion criteria were maxillary fractures and maxillozygomatic fractures without orbital wall fractures, skull base fractures, Le Fort fractures, and orbital wall fractures. We excluded patients with a history of maxillofacial surgery. Group 1 was treated using self-reinforced poly-L/DL-lactide polymer (SR-PLDLA), and group 2 was treated using a mini-micro system (titanium) (Solco Intermed, Seoul, Korea).

All the patients underwent a physical examination and computed tomography (CT) (Somatom Sensation 64; Siemens Medical Systems, Forchheim, Germany) preoperatively to evaluate the type and extent of the fracture. Multidetector CT was performed in the axial position using a 3-mm section thickness. Computed tomography obtained 1 axial view only, and then the coronal view was reconstructed using a computer program. The patients' facial deformities were photographed before and after surgery.

After surgery, to evaluate the reduction, 3 otorhinolaryngologists (C.H.P., J.H.L., and S.M.H.) compared the preoperative and post-

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Table 1. Sex and Age Distributions of the 82 Study Patients^a

Age, y	Patients, No. (%)		
	Male	Female	Total
Group 1			
11-20	11 (23)	0	11 (20)
21-30	8 (17)	1 (13)	9 (16)
31-40	15 (31)	3 (38)	18 (32)
≥41	14 (29)	4 (50)	18 (32)
Subtotal	48	8	56
Group 2			
11-20	2 (8)	1 (50)	3 (12)
21-30	6 (25)	0	6 (23)
31-40	3 (13)	0	3 (12)
≥41	13 (54)	1 (50)	14 (54)
Subtotal	24	2	26

^aGroup 1 consisted of patients treated with resorbable plate and screw systems; group 2, metal plate and screw systems.

operative CTs and rated the results using a visual analog scale (5 indicates satisfactory; 1, unsatisfactory). Follow-up ranged from 3 to 12 months (mean, 10.7 months in group 1 and 7.6 months in group 2). We evaluated the outcomes.

Using general anesthesia, the patients were placed in the supine position, and the head was rotated away from the fracture. After local infiltration of the gingivobuccal area, incisions were made. A periosteal elevator was used to dissect the soft tissues and periosteum of the fractured facial bone. Bleeding was controlled with electrical cauterization. The displaced bony segments were reduced to anatomical position and were fixed using BioSorb FX or the mini-micro system.

The RPSS consists of plates of various shapes, lengths, and thicknesses and screws of corresponding sizes and weights. It comes with auxiliary tools to aid their placement, such as drills, taps, and screwdrivers. Plates of varying size according to the site and indications offer varied reconstruction alternatives.

First, plates of a shape and size suitable for the planned reconstruction are selected. Then, appropriate screws are chosen, and the necessary holes are made using a drill and enlarged using a tap. Finally, the system is fixed using special screwdrivers. During this procedure, care should be taken when manipulating the material because it is more fragile than are metal plates and screws.

RESULTS

The 82 patients included 72 males and 10 females aged 16 to 83 years (mean age, 36.4 years) (**Table 1**). The 2 most common causes of fracture were traffic accidents and falls (**Table 2**). We analyzed the degree of bone reduction in the 2 groups using a visual analog scale. The mean (SD) score was 4.43 (0.2) points in group 1 and 4.23 (0.17) points in group 2. The difference was not significant ($P = .32$, unpaired t test).

During hospitalization, no significant complications, such as infection or hematoma, developed. Subsequently, 4 of the 56 patients in group 1 developed complications, including 2 cases of device exposure (**Figure 1**) and 1 case of secondary infection 10 months after surgery (**Figure 2**). After removing the resorbable plate and screws, antibiotics were administered and incisional drainage was performed, and the complications resolved. The final patient noted paresthesia that

Table 2. Causes of Maxillofacial Bone Fracture by Group

Cause	Patients, No. (%) ^a	
	Group 1	Group 2
Traffic accident	23 (41)	8 (31)
Slipping or falling down	14 (25)	10 (38)
Falls	10 (18)	5 (19)
Sports injuries	6 (11)	1 (4)
Others	3 (5)	2 (8)
Total	56	26

^aGroup 1 consisted of patients treated with resorbable plate and screw systems; group 2, metal plate and screw systems.

felt like shifting air bubbles in the premaxillary area. We recommended surgery for plate removal, but she refused. One of 26 patients in group 2 noted metal screw loosening during follow-up, so revision surgery was performed. All the patients are problem free. The total complication rate was 7% (4 of 56) in group 1 (infection rate, 2% [1 of 56]) and 4% (1 of 26) in group 2 (**Table 3**). The difference in the complication rate between the 2 groups was 3.3%, and the 95% confidence interval around the difference was -12% to 14%.

COMMENT

Ideal fixation materials should have adequate biomechanical resistance to distraction and compression forces in the early postoperative course and enable bone healing without causing a foreign body reaction in the later period.^{4,5} The MPSSs are fixation materials that have long been used in plastic and orthopedic surgery. They enable adequate fixation for bone healing. Nevertheless, their negative effects, such as limiting bone growth, especially in the pediatric age group, have prompted investigators to look for alternative fixation materials in the reconstruction of trauma and craniofacial anomalies.⁶

Another disadvantage of MPSSs is that they may undergo intracranial migration.⁷ In some cases, the metal plate and screws have migrated as far as the dura mater and caused seizures, necessitating their removal. Furthermore, the metal plate and screws can lead to destruction and osteoporosis in the surrounding bone tissue.⁸ The metal plate and screws used in regions where the dermis and subcutaneous tissue are relatively thin may be conspicuous on inspection and felt on palpation.⁹ Most patients with subjective concerns require a second operation to remove the plate. In addition, MPSSs may be displaced or cause artifacts on radiographs and affect the magnetic field produced during magnetic resonance imaging.⁵ Moreover, they result in heating problems during radiotherapy.

The RPSSs are broken down completely via physiologic routes. Because they are made of α -hydroxy acid polymers, breakdown occurs via hydrolysis, and the end products are carbon dioxide and water.⁵ The degradation of polylactic acid (PLA) polymers is quite slow owing to their hydrophobic semicrystalline structure. In contrast, polyglycolic acid (PGA) polymers degrade rapidly

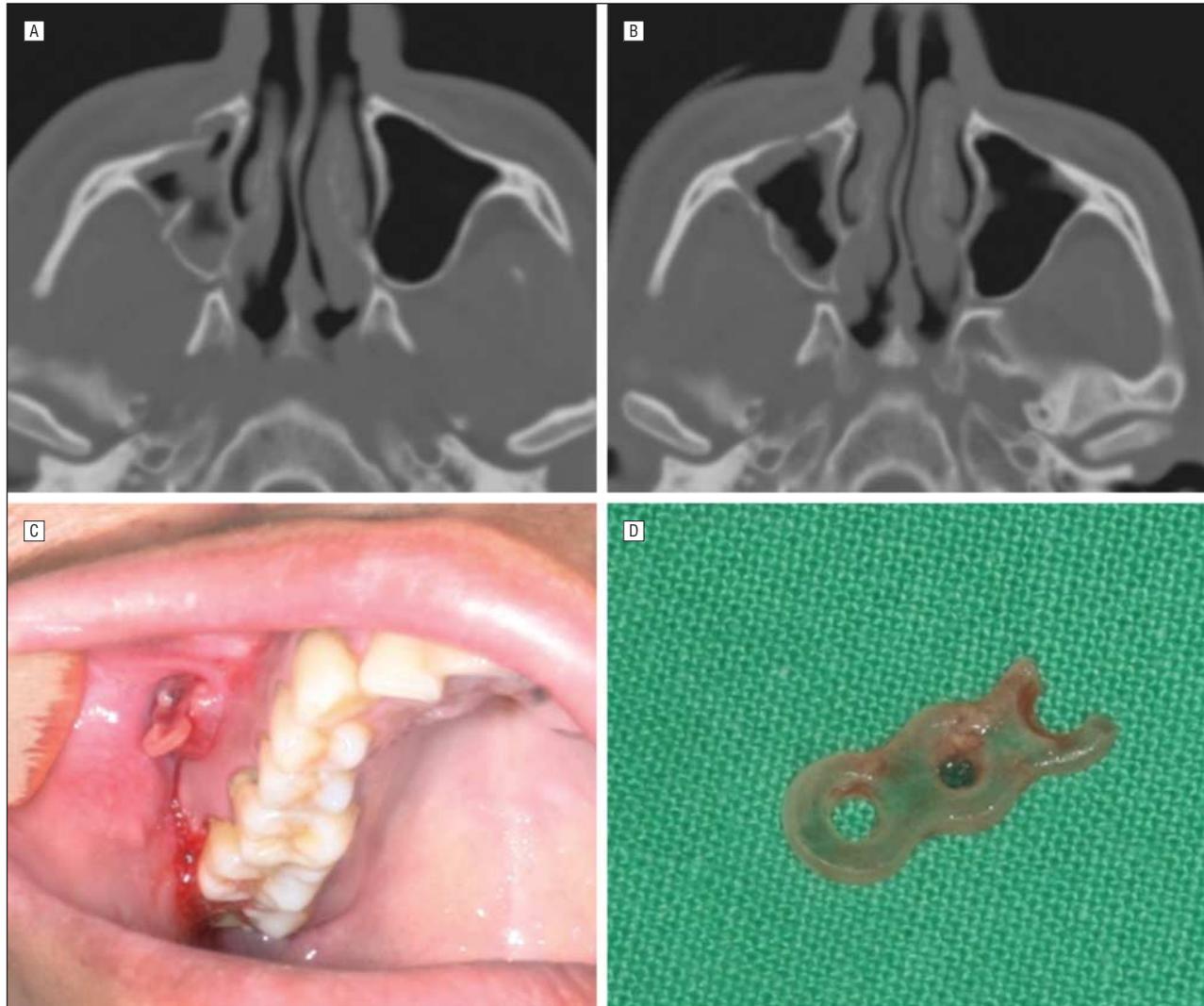


Figure 1. A 19-year-old patient with device exposure 12 months after surgery. Computed tomography shows fracture and displacement of the right maxilla preoperatively (A) and good alignment of the bony fragment after reduction postoperatively (B). C, The resorbable plate was exposed 12 months after surgery. D, A removed fragment of the resorbable plate.

owing to their highly amorphous structure and increased hydrolytic activity.¹⁰

Since the 1960s, RPSSs have been investigated, and homopolymers of PLA and PGA were commonly used in early studies of RPSSs. However, these materials induce late tissue reactions because they take a long time to be resorbed. Several articles^{11,12} have posed problems concerning RPSSs composed of homopolymer. Consequently, a copolymer, PLDLA, was developed to decrease the degradation time and products; PLDLA consists of polymers of D-lactide (30%) and L-lactide (70%) and retains its mechanical strength for 3 to 4 months while degrading over 2 to 3 years. A PGA/PLA copolymer (LactoSorb; Biomet Microfixation, Jacksonville, Florida) composed of polymers of PGA (18%) and PLA (82%) had persistent mechanical strength for 2 to 3 months and degraded over 9 to 15 months.¹ The SR-PLDLA applies a self-reinforcing technique in which fiber structures with a uniform chemical structure are formed at specific temperatures and pressures. This technique increases the physical elasticity and tensile strength of the polymer and shortens the degradation time.¹³

Despite several benefits, few studies regarding complications have been published. Laine et al¹⁴ reported complication rates of 8.6%, including foreign body reactions, wound dehiscence, granulation tissue growth, and device exposure, over 10 years using SR-PLDLA in craniofacial surgery. These complications were treated with antibiotics, wound reclosure, and granulation tissue removal as appropriate. Laine et al also experienced a postoperative infection rate of 0.6%, and they treated infections with antibiotics and incisional drainage. To avoid these complications, the plate should not be placed directly under the incision, and if exposed, the plate should be covered immediately.

In comparison, Tuovinen et al¹⁵ studied titanium miniplates in 279 patients. Complications occurred in 23 patients (8.2%), and postoperative infection occurred in 10 (3.6%). The infections were controlled with antibiotics, and the miniplates were removed after the acute phase.¹⁵ Lamphier et al¹⁶ reported that of 594 fractures treated using titanium plates, 79 (13.3%) developed complications and 35 (5.9%) showed signs of infection.

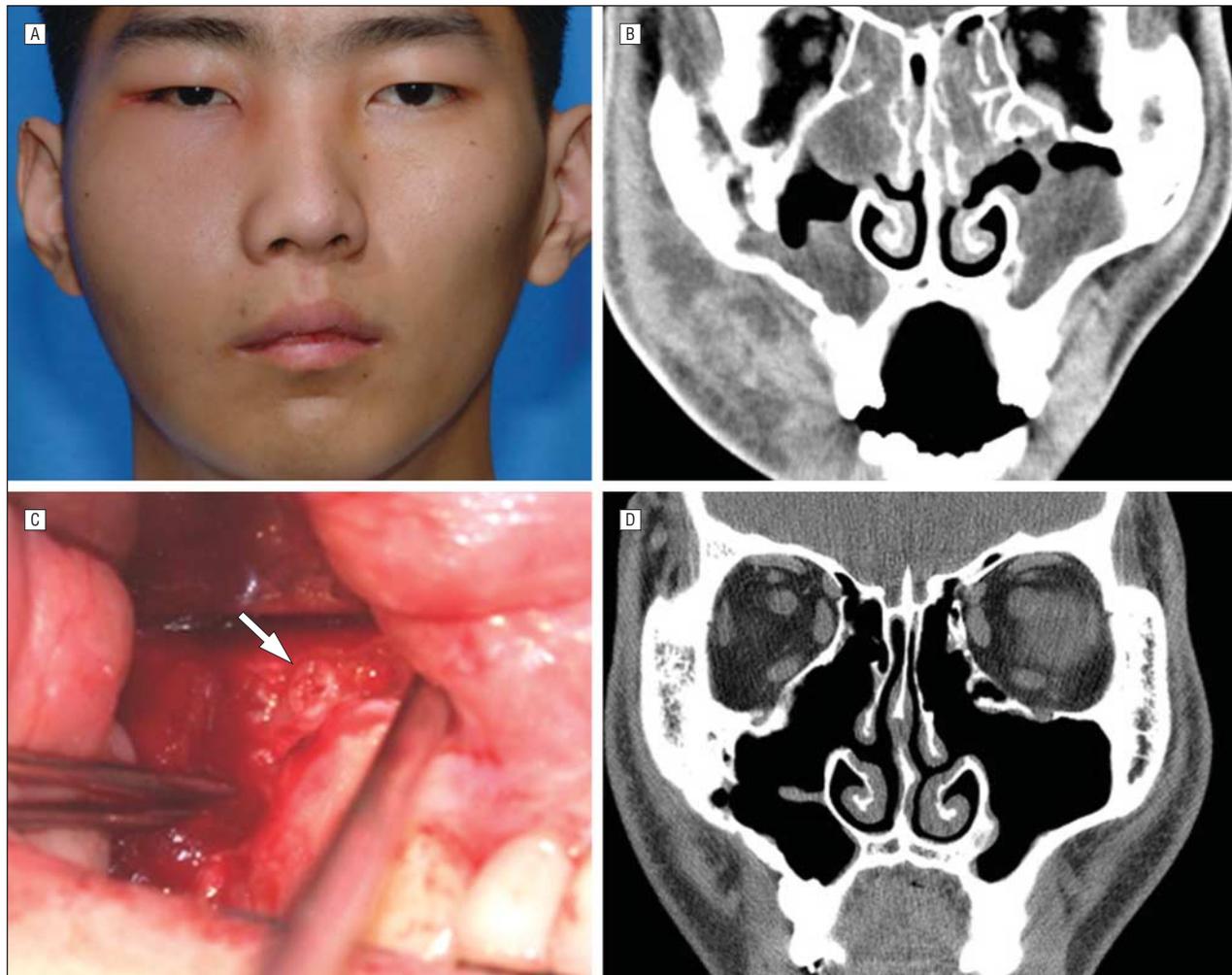


Figure 2. A patient with secondary infection 10 months after surgery. A, A 27-year-old man who underwent surgery using a resorbable plate 10 months earlier; he developed right-sided facial swelling, pain, and tenderness. B, Computed tomography shows pansinusitis and right buccal area abscess formation. C, The resorbable plate and screws (white arrow) were removed, and endoscopic sinus surgery and incisional drainage were performed. D, One month later, the lesions had resolved completely.

Table 3. Comparison of the Complications in Groups A and B^a

Patient Sex/Age, y	Complications	Treatment	Timing of the Complication After Surgery, mo
Group 1			
M/19	Plate extrusion	Device removal	12
M/27	Facial abscess, sinusitis	Device removal, I & D, ESS	10
F/48	Paresthesia	Conservative management	5
M/18	Plate extrusion	Device removal	1
Group 2			
M/48	Screw loosening	Revision surgery	5

Abbreviations: ESS, endoscopic sinus surgery; I & D, incisional drainage.

^aGroup 1 consisted of patients treated with resorbable plate and screw systems; group 2, metal plate and screw systems.

In Chuncheon Sacred Heart Hospital, 56 patients underwent osteofixation using RPSSs, and complications occurred in 4 (7%). Plate extrusion occurred during plate

degradation when the plate was close to the incision; we believe that the accompanying sinusitis led to fixation site infection and plate extrusion. In our experience, the complication rate with MPSSs was 4%. Consequently, RPSSs have no benefit over MPSSs in terms of the complication rate, which was similar with both systems. The complication rate with RPSSs was similar to that in other studies. In contrast, the complication rate with MPSSs was lower than that in other studies. We thought that this may have resulted from the relatively small case series for MPSSs and the short follow-up period.

In the present patients, we believe that the cause of infections with RPSSs was the plate fixation position or associated sinusitis. Therefore, we believe that when plate fixation is close to the incision or sinusitis develops, MPSSs are more useful than are RPSSs. However, when considering the many benefits of RPSSs, we do not doubt that they are more effective than MPSSs.

In conclusion, resorbable skeletal fixation systems are safe for use in maxillofacial bone fractures. Based on the present experience, there are many advantages to using RPSSs. Therefore, we believe that RPSSs can be used as

a substitute for MPSSs in selected patients. Nevertheless, the surgeon must consider accompanying infections and the fracture site. It is important to select the method that is best for the situation in each patient.

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