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Shaft Fractures of Both Forearm Bones: The Outcomes of Surgical Treatment with Plating Only and Combined Plating and Intramedullary Nailing

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Background: Plate fixation is the most commonly used technique for the treatment of shaft fractures of both forearm bones (SFBFBs). However, all fractures are difficult to treat with plate fixation because of soft tissue injuries, fracture patterns, or the patient's condition. The purpose of this study is to compare the functional results of plate fixation only and combined plate and intramedullary (IM) nail fixation in SFBFBs.

Methods: Fifty-nine cases of SFBFBs that were surgically treated from June 2007 to July 2012 were retrospectively reviewed. In this study, 47 cases that were followed up for more than 12 months were included. All SFBFBs were divided into two groups according to the methods used for internal fixation: plate fixation only (group A) and combined plate and IM nail fixation (group B). The fixation methods were determined intraoperatively. Plate fixation was considered as the first option in all cases, but combined plate and IM nail fixation was selected as the second option if it was difficult to be fixed with plate only. Groups A and B comprised of 31 and 16 cases, respectively. The functional results were evaluated by the Grace and Eversmann rating system and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Results: In groups A and B, a radiologic union was achieved in 30/31 and 14/16 cases and average union time was 11.1 and 17.8 weeks, respectively. According to the Grace and Eversmann rating system, group A had excellent results in 15 cases, good in 14, acceptable in one, and unacceptable in one. Group B had excellent results in three cases, good in nine, acceptable in two, and unacceptable in two. The average DASH score was 7.1 points (range, 0 to 19.2 points) in group A and 15.1 points (range, 0 to 29.6 points) in group B. Three cases of nonunion with unacceptable results achieved a bony union by additional procedures and the functional results of these cases improved to good or excellent.

Conclusions: The functional results and the average union time were superior in group A than in group B. However, we think that combined fixation is a useful method for SFBFBs that cannot be treated with plate fixation only.

Keywords: *Forearm, Diaphyses, Fracture, Internal fixation*

The forearm consists of two parallel bones (radius and ulna) and radioulnar joints of the elbow and wrist, which play an important role in forearm rotation. Shaft fractures involving these bones, if inadequately treated, can result in a significant loss of motion of the forearm. Although the displacement of shaft fractures of both forearm bones (SFBFBs) is influenced by the direction of external force, the radial fracture is further influenced by muscle contraction based on the location of shaft fracture. Reduction of anatomical relationships such as the length of both bones,

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rotational alignment, radial bowing, and interosseous space between the radius and the ulna are important to restore the function of the forearm.[1,2]

It is recommended that the displaced SFBFBs in adults should be treated surgically because of unsatisfactory outcomes of conservative management; however, most of the cases in children can be treated with closed reduction and immobilization.[3] The gold standard of operative treatment is anatomical reduction with open reduction and stable internal fixation using the dynamic compression plate (DCP). However, the disadvantages of plate fixation include a relatively large skin incision, interruption of bloody supply due to wide periosteal dissection of the forearm bone, or refracture following plate removal.[3,4] Additionally, this method has some limitations in SFBFBs with extensive soft tissue damage, severe swelling, open fracture, segmental fracture, or a limited operation time due to associated injuries. In order to overcome these problems, intramedullary (IM) nail fixation can be used as an alternative method for treating SFBFBs.[5,6]

In this study, plate fixation was considered as the first option for all shaft fractures of the radius and ulna. If it was not possible to perform plate fixation of both the radius and ulna due to the patient's condition, fracture of

Table 1. Summary of the Patients

Variable	Group A	Group B	Total
No. of patients	31	16	47
Age (yr), mean (range)	46.6 (15–82)	48.6 (15–81)	47.3 (15–82)
Sex (male:female)	20:11	10:6	30:17
Fracture site (right:left)	16:15	8:8	24:23
Injury mechanism			
Traffic accident	12	2	14
Work injury	6	5	11
Slip down	6	4	10
Fall down	4	2	6
Sport injury	1	1	2
Others	2	2	4
Ipsilateral upper extremity injury	14	3	17
Second operation	6	4	10
Operation day, mean (range)	4.7 (0–14)	3.1 (1–7)	4.2 (0–14)
Open fracture (Gustilo & Anderson classification)	11	5	16
I	6	0	6
II	1	2	3
III	4	3	7
Follow-up (mo), mean (range)	16.8 (12–40)	15.1 (12–24)	16.2 (12–40)
Fracture type (AO classification)			
A3	12	5	17
B3	8	6	14
C1	3	1	4
C2	5	1	6
C3	3	3	6

one bone was treated with plate fixation and fracture of the other bone was treated with IM nail fixation. The purpose of this study was to compare the treatment effect between plate fixation only and combined plate and IM nail fixation in SFBFBs.

METHODS

A total of 59 patients with SFBFBs who were surgically managed between June 2007 and July 2012 were retrospectively reviewed. The inclusion criteria were SFBFBs that were fixed with plate fixation or IM nail fixation and at least one fracture of the two forearm bones was fixed with a plate. The exclusion criteria were isolated shaft fractures of forearm bones; SFBFBs that were treated with IM nailing only; a Monteggia fracture; a Galeazzi fracture; and patients who did not follow up for more than 12 months. Patients were divided into two groups according to the methods of internal fixation. Patients, in whom fractures of both the radius and ulna were treated with plate fixation only, were defined as group A (plating group). Patients, in whom fracture of either the radius or the ulna was treated with plate fixation and fracture of the other bone was treated with IM nail fixation, were defined as group B (combined group). The selection of fixation methods was performed intraoperatively according to soft tissue injury, swelling, fracture configuration, or patient's condition.

Based on the study criteria, 47 out of the 59 patients were enrolled in this study. There were 30 men and 17 women with a mean age of 47 years (range, 15 to 82 years). Right and left forearms were involved in 24 and 23 patients, respectively. The mechanisms of injury were traffic accident (14 patients), industrial accident (11 patients), slip (10 patients), fall from a height (6 patients), sports injury (2 patients), and others (4 patients). According to the AO/ASIF classification,[7] type A3 fracture was observed in 17 patients, type B3 was observed in 14 patients, type C1 was observed in 4 patients, type C2 was observed in 6 patients, and type C3 was observed in 6 patients. Sixteen out of the 47 patients had open injuries: 6 patients had grade I injuries, 3 patients had grade II injuries, and 7 patients had grade III injuries according to the criteria defined by Gustilo and Anderson.[8] Seventeen out of the 47 patients had fractures of the ipsilateral upper limb: 1 patient had a fracture of the humeral shaft and skin defect of the forearm, 2 patients had a fracture of the radial head, 6 patients had a fracture of the ulnar styloid, 1 patient had a transscaphoid dorsal perilunate dislocation, 1 patient had a dislocation of the elbow and a fracture of the distal radius, 1 patient had a fracture of the distal radius and ulnar styloid, 1 patient had a fracture of the ulnar styloid and open wound of the elbow, 2 patients had a fracture of the metacarpal, 1 patient had a fracture of the finger, and 1 patient had a crushing injury of the hand. Twenty patients had a

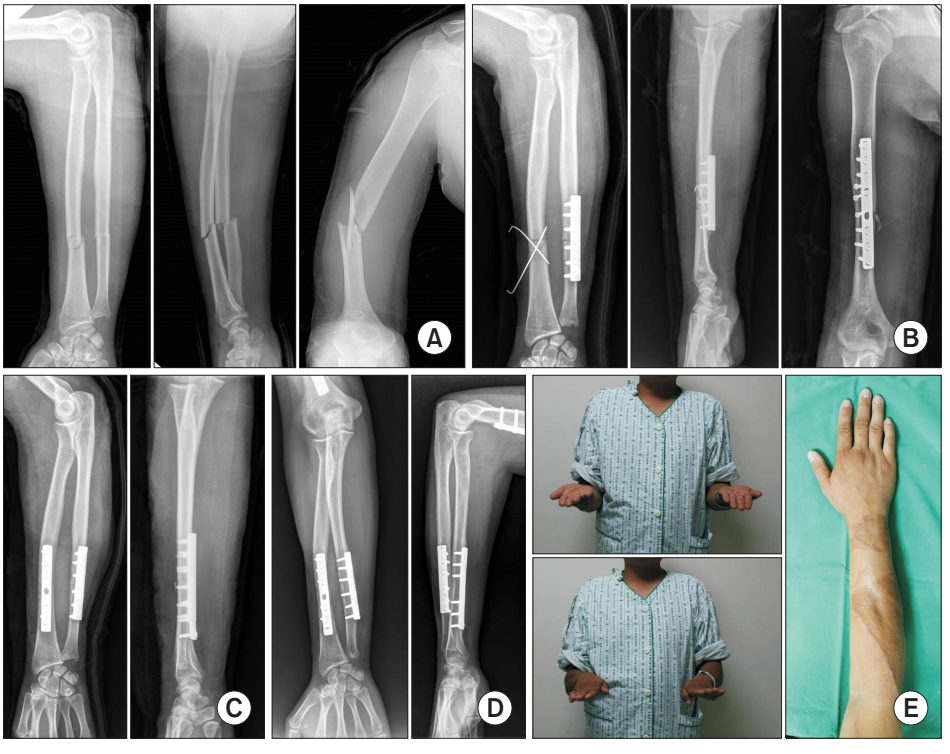

Fig. 1. Case 1. (A) A 36-year-old man with shaft fractures of both forearm bones and an ipsilateral shaft fracture of the humerus caused by belt injury during work. (B) Shaft fractures of the ulna and humerus were initially treated with open reduction and internal fixation. But, the radial fracture was temporarily fixed with two Kirschner wires because of swelling and skin abrasion of the right forearm. (C) The radial fracture was stabilized by plating after 9 days. The necrotic tissue due to abrasion of the skin was debrided and a split-thickness skin graft was placed later. (D) Final follow-up radiographs showed union of shaft fractures of the radius and ulna. (E) Clinical photographs showed normal rotation and satisfactorily healed skin of the right forearm at the 24-month follow-up.

concomitant head, chest, or abdominal injury (Table 1). Of the 47 patients included in this study, 31 patients were categorized into group A (Fig. 1) and 16 patients were categorized into group B (Fig. 2). Detailed information of both groups is described in Table 1. Fractures were stabilized within an average of 4.2 days (range, 0 to 14 days) after the injury.

The procedure was performed by one surgeon under general anesthesia or brachial plexus block. A tourniquet was used in all fractures. Fractures were fixed with plating (DCP) or IM nailing (Intramedullary Forearm Rod, Acumed, Hillsboro, TX, USA), which were selected intraoperatively according to the associated soft tissue injuries, swelling, location or pattern of fractures, and patient's condition. All 16 open fractures were initially treated with debridement and irrigation within 24 hours. Six out of the 16 open fractures were treated with internal fixation of both forearm bones at the same time. However, 10 open fractures (6 in group A and 4 in group B) needed a secondary operation to achieve stabilization after an average of 14 days (range, 7 to 28 days). Two fractures, which had a segmental bone defect caused by open injuries, were treated with plating and iliac bone grafting after 27 and 28 days, respectively (Fig. 3). Mostly, open wounds were repaired with primary or delayed closure, except in 2 patients who needed a split-thickness skin graft.

Postoperatively, a Muenster cast that can partially allow flexion and extension of the elbow and limit rotation of the forearm was applied for 4 weeks in group A and for 6 weeks in group B. In patients with fractures of the ipsilateral upper limb or soft tissue injuries, the method or duration of postoperative immobilization was decided on the basis of the severity of concomitant injuries.

The follow-up period of all fractures was a minimum of 12 months and the average follow-up period was 16.2 months (range, 12 to 40 months). Functional outcome was evaluated by the Grace and Eversmann rating system, which is based on the union of fractures and rotation of

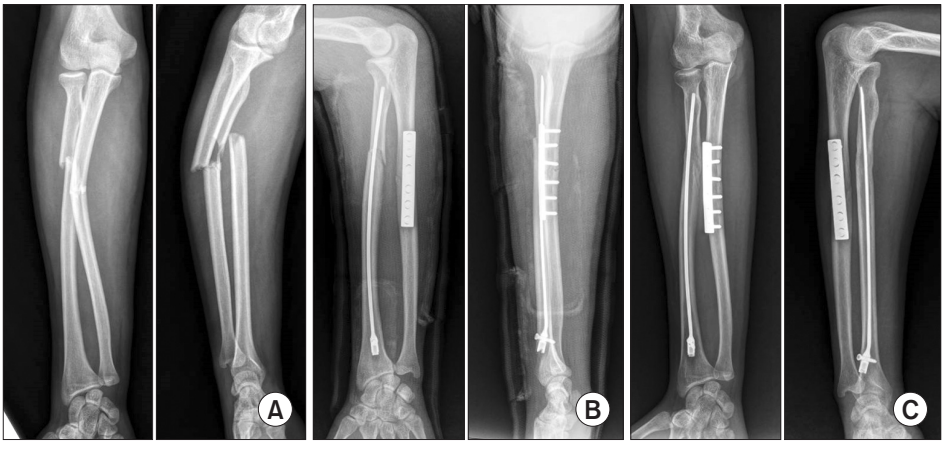

Fig. 2. Case 2. (A) A 20-year-old man with proximal one-third shaft fractures of the left radius and ulna. (B) The ulnar fracture was fixed with plating and the radial fracture was treated with closed reduction and intramedullary nailing. (C) Fractures of the radius and ulna were completely healed at 22 weeks and 10 weeks postoperatively, respectively.

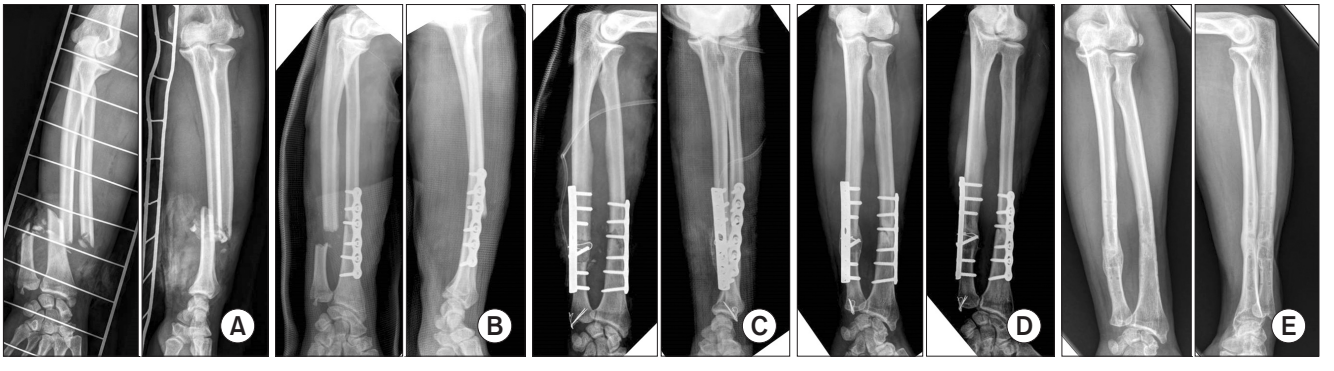

Fig. 3. Case 3. (A) A 50-year-old man with distal one-third fractures of the left forearm bones. The ulna had an open and severely comminuted fracture. (B) The radius was stabilized by plating. The ulna was treated with excision of the contaminated bony fragment and debridement of the open wound, but it was not fixed. (C) Fracture of the ulnar shaft was treated using a plate and an auto-iliac bone graft and fracture of the ulnar styloid process was treated using tension band wiring after 4 weeks. (D) Union of fractures of the radius and ulna was confirmed at postoperative 26 weeks and 12 weeks, respectively. (E) The implant was removed at postoperative 18 months. No complication was noted until 6 months after removal of the implant.

the forearm.[9] The union of fractures was judged by the following findings: extension of trabeculae or bridging callus across the fracture on the anteroposterior, lateral, and oblique radiographs and tenderness at the fracture site. The time to achieve union was defined as the period required for the radius and the ulna to obtain fracture union. The range of forearm rotation was measured with a goniometer; it was evaluated with the elbow in 90° of flexion and the arm at the patient's side, and it was expressed as a percentile of the contralateral rotation arc. If the contralateral rotation range was not available, the normal rotational arc was used with 90° of supination and 90° of pronation. According to the Grace and Eversmann rating system, an excellent result was defined as union of the fracture and at least 90% of normal rotation arc of the forearm, a good result was defined as union of the fracture and 80% to 89% of normal rotation arc of the forearm, an acceptable result was defined as union of the fracture and 60% to 79% of normal rotation arc of the forearm, and an unacceptable result was defined as nonunion or < 60% of normal rotation arc of the forearm. The subjective outcome was assessed with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[10] This questionnaire was used with a score between 0 and 100, and a lower score indicated a more satisfactory recovery. Statistical analysis was performed with Mann-Whitney *U*-test.

RESULTS

Forty-four out of the 47 patients achieved union of fractures and the average time to union was 13.1 weeks (range, 5 to 41 weeks). In group A, 30 out of the 31 patients achieved union of both radius and ulna and the average time to union was 11.1 weeks (range, 6 to 41 weeks). One out of the 31 patients had nonunion of the radius, which was treated with removal of the previous plate and reapplication of a plate with a supplemented autologous iliac bone graft. In group B, 14 out of the 16 patients achieved union of both forearm bones and the average time to union was 17.8 weeks (range, 5 to 30 weeks). Two cases of nonunion in group B occurred in a bone fixed with IM nailing, wherein one was the radius and other was the ulna. One case of nonunion of the radius was treated with removal of the IM nail and application of a plate supplemented with an autologous iliac bone graft. The other case of non-union of the ulna was managed by removal of the IM nail and application of a plate without a bone graft.

The average range of supination and pronation in all patients was 82° (range, 50° to 90°) and 77° (range, 50° to 90°), which was 91% and 88% of the contralateral rotation (mean supination of 90° and pronation of 88°), respectively. In group A, the average range of supination and pronation was 85° (range, 70° to 90°) and 79° (range, 50° to 90°), which was 94% and 89% of the contralateral rotation (mean supination of 90° and pronation of 89°), respectively. In group B, the average range of supination and pronation was 76° (range, 50° to 90°) and 73° (range, 60° to 90°), which was 85% and 83% of the contralateral rotation (mean supination of 89° and pronation of 88°), respectively. The range of supination ($p = 0.001$) and pronation ($p = 0.020$) indicated a significant greater recovery in group A than in group B (Table 2).

Table 2. Clinical Outcomes by the Mayo Elbow Performance Score

Variable	Group A	Group B	Total	*p*-value
Grace & Eversmann functional evaluation				0.022
Excellent	15	3	18	
Good	14	9	23	
Acceptable	1	2	3	
Unacceptable	1	2	3	
Range of motion (°), mean (range)				
Supination	85 (70–90)	76 (50–90)	82 (50–90)	0.001
Pronation	79 (50–90)	73 (60–90)	77 (50–90)	0.020
DASH score, mean (range)	7.1 (0–19.2)	15.1 (0–29.6)	9.8 (0–29.6)	0.001
Union time (wk), mean (range)	11.1 (6–41)	17.8 (5–30)	13.1 (5–41)	0.001

DASH: Disabilities of the Arm, Shoulder and Hand.

According to the Grace and Eversmann rating system, group A showed an excellent result in 15 patients, good in 14 patients, acceptable in 1 patient, and unacceptable in 1 patient. Group B showed an excellent result in 3 patients, good in 9 patients, acceptable in 2 patients, and unacceptable in 2 patients. Group A showed more satisfactory results than group B in the Grace and Eversmann rating system (p = 0.022). Three cases of non-union had an unacceptable result, in which the union of fractures was achieved by additional operation. In 1 case with an unacceptable result in group A, the result was improved to an excellent result; and in 2 cases with an unacceptable result in group B, the result was improved to a good result. One case with an acceptable result in group A was attributed to a decreased rotation arc (80° supination and 60° pronation, 78% of the normal rotation arc). However, as this case was of a 73-year-old man, he had almost no discomfort in daily activities and his DASH score was assessed as 3 points. One of the 2 patients with an acceptable result in group B were attributed to ipsilateral open dislocation of the elbow and fracture of the ulnar styloid as well as open fracture of the forearm caused by a crushing injury during work. Although debridement, irrigation, and temporary fixation were performed for an open fracture with a segmental bone defect, the other case with an acceptable result in group B was attributed to the delay in secondary operation and rehabilitation time due to subdural hemorrhage associated with skull fracture. According to the DASH score, group A had an average DASH score of 7.1 points (range, 0 to 19.2 points) and group B had an average DASH score of 15.1 points (range, 0 to 29.6 points). Group A showed more satisfactory results than group B in terms of the DASH score (p = 0.001). In group B, the 2 patients with high DASH scores greater than 22 points were the same patients whose Grace and Eversmann rating assessment was acceptable.

Incomplete ossification of the interosseous membrane between the radius and ulna occurred in 2 patients. This ossification affected the rotation of forearm in 1 patient whose Grace and Eversmann rating assessment showed a good result after the excision of ossification. The range of motion of the forearm in the other patient was not affected. There was no case of infection, compartment syndrome, failure of fixation, or refracture after implant removal.

DISCUSSION

It is generally recommended that SFBFBs should be surgically treated with open reduction and internal fixation because an anatomical reduction is required for the functional recovery of the forearm. Even though nonsurgical treatment can be applied in nondisplaced fractures, patients in a poor condition, or diaphyseal fractures in children, this management may induce a functional impairment of the forearm because the risk of delayed union, nonunion, malunion, or cross-union between forearm bones is relatively high.[3,5,11] An anatomical reduction is especially important because malunion of the forearm affects the range of supination-pronation. Matthews et al.[2] described the effect of angular malalignment of SFBFBs on supination-pronation. Residual angulation of less than 10° was associated with little loss of forearm rotation and residual angulation of 20° or more was associated with a functionally important loss of forearm rotation. Dumont et al.[1] described the effect of rotational malunion of the forearm bones on supination and pronation. Malunion of the radius in supination markedly affected rotation of the forearm. Malunion of either the radius or ulna had a moderate effect on pronation and malunion of the ulna had little effect on pronation. Also, a combination of malunion in the opposite direction resulted in the largest limitation in supination and pronation of the forearm. Therefore, surgical correction of malalignment of SFBFBs is critical for improving the range of motion of the forearm. Compression plate technique for a simple diaphyseal fracture and bridging plate technique for a comminuted diaphyseal fracture have become the surgical treatments of choice.[3,12]

IM nailing can also be performed for the stabilization of SFBFBs. In the past, nonlocking devices such as Rush pin, Kirschner wire, Steinmann pin, or Lottes nail showed satisfactory outcomes in an isolated shaft fracture of the ulna. However, these methods have a higher risk of nonunion or decreased rotational motion of the forearm because of the lack of rotational and axial stability and under-reduction of radial bowing.[11,13] Recently, with the improvement in implant design, IM nailing was reported to provide satisfactory results in the management of both-bone shaft fractures as well as that of an isolated shaft fracture of the forearm bone.[11,14] Because the fixation using IM nails is less stable than that with plates, IM nailing requires a longer period of postoperative immobilization.[15] But, in a recent report by Saka et al.,[16] early initiation of forearm rotation as well as flexion/extension of the elbow and wrist did not affect the stability of a fracture in patients who were treated with the new interlocking IM nails without additional postoperative support. Therefore, precontoured and interlocking IM nails may be a good alternative to plate osteosynthesis of SFBFBs.[3-6]

There were different advantages and disadvantages between the use of plate fixation and IM nail fixation. Plate

fixation can achieve recovery of anatomical relationships such as the length of both bones, rotational alignment, radial bowing, and interosseous space between the radius and ulna. Also, because fractures are fixed rigidly, early motion of the forearm can be allowed, which is helpful in recovery of the function of the forearm. Disadvantages of this procedure include a large skin incision, disruption of blood supply caused by extensive soft tissue dissection, or refracture after plate removal. In contrast, IM nail fixation has advantages such as small skin incision, minimal soft tissue stripping, and a short operation time. However, it is difficult to reduce anatomical relationships in comminuted or long oblique fracture with this technique. Other disadvantages include higher radiation exposure caused by closed reduction, longer duration of immobilization, and longer time to achieve complete union than plate fixation. Indications for this procedure are inappropriate surrounding soft tissue for plate fixation, severe swelling, segmental fracture, multiple fractures, and severe osteopenia. Contraindications include small diameter of the medullary canal, acute infection, open physis, and fracture extension to the metaphysis or articular surface.

Combined fixation by the plate and IM nail can be used as an alternative method for treating SFBFBs. In the clinical outcome reported by Kang et al.,[17] on comparing between the group treated with compression plates only vs. the group treated with Rush pin in the radius and compression plate in the ulna, the immobilization period, radiologic bone union, and functional results were not significantly different. Likewise, Kim et al.[18] described the comparison between plate fixation and Rush pin IM nailing for the treatment of SFBFBs. Seventeen out of 18 patients achieved favorable results with plate fixation only of both forearm bones, 12 out of 14 patients achieved favorable results with Rush pin fixation of the radius and plate fixation of the ulna, 7 out of 11 patients achieved favorable results with plate fixation of the radius and Rush pin fixation of the ulna, and 4 out of 8 patients achieved favorable results with Rush pin fixation only. Patients in a poor condition caused by head, chest, or abdominal injury, time-saving for the operation of multiple injuries, and lower risk of posterior interosseous nerve injury in proximal shaft fracture of the radius were mentioned as the advantages of combined fixation. They recommended that at least one bone should be fixed with a plate since the fixation of SFBFBs using the Rush pin only could not provide rigid stabilization and recovery of anatomical alignment. The IM nail with a interlocking screw and a precontoured shape used recently was reported to successfully prevent shortening and rotation of both forearm bones.[11,16]

In this study, the authors evaluated the results of plate fixation only versus combined plate and IM nail fixation for treatment of SFBFBs. Plate fixation yielded more excellent results than combined fixation in terms of the functional outcomes according to the Grace and Eversmann rating system, the rotation range of the forearm, the DASH score, and the time to union. Fixation methods were selected by considering the associated soft tissue injuries, swelling, open fracture, segmental fracture, or a limited available operation time due to associated head/chest/abdominal injuries. Plate fixation was initially performed in one forearm bone with stable soft tissue. If the soft tissue of the forearm was not compromised and the patient's condition was stable, the other bone was also fixed with a plate. However, if the soft tissue of the forearm was compromised or the patient's condition was unstable, the other bone was stabilized with an IM nail. We think that patients in a poor condition may have been included to a greater extent in the combined group than in the plating group, and such nonrandomized grouping may have affected the results of this study. In group B, 13 out of the 16 cases were treated with IM nailing of the radius and plating of the ulna and 3 cases were treated with plating of the radius and IM nailing of the ulna. Features of fractures in this group were as follows: (1) A proximal shaft fracture of the radius that develops within distal 2–3 cm of the radial tuberosity is difficult to be fixed with a plate and is associated with a risk of posterior interosseous nerve injury. Therefore, the radius was treated with IM nailing after the ulna was fixed with a plate for restoring the length of forearm bones in seven cases. (2) Seven cases had severe swelling or soft tissue injury. One bone (4 ulna bones and 3 radius bones) with a comminuted fracture was fixed with a plate for restoring the length of forearm bone. The other bone with a relatively simple fracture was treated with IM nailing. (3) In one case, segmental shaft fracture of the radius was fixed with an IM nail and comminuted shaft fracture of the ulna was treated with plating. (4) Incomplete (green-stick) fracture of the radius developed in one case. Therefore, the radius and ulna were treated with IM nailing and plating, respectively. Acute bone grafting is not generally recommended in diaphyseal forearm fractures.[19,20] Acute bone grafting was performed in two cases with a segmental defect caused by an open fracture (Fig. 3). Except for two cases with an initial segmental defect, most of the patients achieved union without acute bone grafting.

Use of plating and IM nailing has been described in many literatures. Because combined fixation is not a new fixation technique, there is no specific indication for com-

bined fixation. Also, it is difficult to specify the fractures of the forearm which were managed with combined fixation because the decision was based on the experience or preference of the operator, although several factors affected the choice. Our first option is plating of both the radius and ulna for forearm shaft fractures. We follow several principles regarding the use of combined fixation. First, a comminuted shaft fracture is fixed using the plate because it is difficult to control the rotation or length of a comminuted forearm bone with IM nailing. A more simple fracture is fixed with IM nailing. Second, we prefer IM nailing than plating if soft tissue problem is around the skin incision for plating. Third, if the forearm is swollen, it is limited of two large incisions to be performed for plating of both the radius and ulna. Fourth, some fractures such as segmental or incomplete shaft fractures can be easily treated by IM nailing than plating.

Several limitations of this study should be noted. Firstly, this study compared heterogeneous groups of forearm shaft fractures. Also, the implant (plate vs. IM nail) for stabilization of SFBFBs was selected based on the surgeon's personal experience after considering the assessed patient parameters. In addition, this was a nonrandomized and retrospective study and hence selection bias has to be considered in plating and combined group assignments. Secondly, we measured rotation of only the forearm because of the evaluation of functional outcomes based on the Grace and Eversmann rating system. It has been generally accepted that motion of the wrist and the elbow is not affected by postoperative immobilization in SFBFBs. However, Goldfarb et al.[21] and Bot et al.[22] reported that the outcome scores worsened with reduction in range of motion of the wrist as well as of the forearm. We did not include range of motion of the wrist/elbow because of incidence of ipsilateral upper limb fractures, which can affect the function of the wrist/elbow. Thirdly, the severity of open fractures may have affected the clinical results. According to the report by Duncan et al.[23] for immediate internal fixation of open diaphyseal fractures of the forearm, patients with grade I, II, or IIA injuries (45/50 patients, 90%) had satisfactory results and patients with grade IIIB or IIIC (4/4 patients) had unacceptable results. Although 16 cases of open fractures were included in this study, unsatisfactory results (3 cases) were related to nonunion. If open fractures are immediately debrided and are not associated with infection, it is thought that the final outcome is rarely affected by the initial open injuries.

On the basis of these results, we concluded that the clinical results of plate fixation were superior to combined plate and IM nail fixation. However, it is difficult to manage all SFBFBs with plate fixation only because of the soft tissue condition, fracture configuration, or the patient's condition. Combined fixation can be used as an alternative choice in patients with SFBFBs that are difficult to treat with the plate only because the differences in final results between plate fixation and combined fixation are imperceptible.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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