



Case Report

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Additional fixation using a metal plate with bioresorbable screws and wires for robinson type 2B clavicle fracture

Woo Jin Shin, Young Woo Chung, Seon Do Kim, Ki-Yong An

Department of Orthopedic Surgery, Gwangju Veterans Hospital, Gwangju, Korea

Simple clavicle fractures can achieve satisfactory results through conservative treatment, and the less frequency of nonunion. Non-union or malunion can occur in displaced clavicle fractures or comminuted shaft fractures. Treatment of displaced comminuted clavicle shaft fractures is performed by holding together the free fragments with interfragmentary screws or wires and fixing them to the clavicle with a plate. Therefore, we performed interfragmentary fixation using open reduction and internal fixation with bioresorbable screws (Mg-Ca alloy, Resomet bioresorbable bone screw; U&I Corp.) and bioresorbable wires (Mg-Ca alloy, Resomet bioresorbable K-wire and pin, U&I Corp.) for displaced comminuted clavicle fractures (Robinson type 2B) and additionally used a metal plate. We expected decreased irritation and infection due to absorption after surgery. We report four cases that were treated in this way.

Keywords: Clavicle; Midshaft fracture; Comminuted fracture; Interfragmentary screw; Bioresorbable screw

Simple clavicle shaft fractures can be treated conservatively and typical involve minimal complications [1]. However, the incidence rate of displaced fracture and comminuted fracture in the clavicle caused by high energy injury has increased recently, and there is high likelihood of malunion or non-union, such as angulation or shortening [2,3]. Successful results have been reported with use of a metal plate, screw, or intramedullary nailing after open reduction [4,5]. As a result, such surgical treatment has been increasing [6,7]. If there are multiple comminuted fragments (such as Robinson type 2B), metal plate fixation is preferred. However, if open reduction is performed solely for plate fixation, soft tissue and periosteal detachment may be severe, imparting a high chance of nonunion or metal failure. To prevent those complications, interfragmentary screws are generally used

between broken bones. Metal implants can irritate the surrounding tissue of fixed bones or can lead to difficulties in removing the fixed implant after bone union.

Therefore, bone union and improvement in symptoms were identified in four cases of Robinson type 2B clavicle shaft fracture that were treated using bioresorbable screws (Resomet bioresorbable bone screw, U&I Corp., Seoul, Korea) and K-wires and pins (Resomet bioresorbable K-wire and pin, U&I Corp.) (Fig. 1) to perform reduction and fixation, followed by fixation to a metal plate.

CASE REPORT

Owing to the retrospective design of this study, approval of the Institutional Review Board and the requirement for informed con-

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Correspondence to: Ki-Yong An

Department of Orthopedic Surgery, Gwangju Veterans Hospital, 99 Cheomdanwolbong-ro, Gwangsan-gu, Gwangju 62284, Korea
Tel: +82-62-602-6162, Fax: +82-62-602-6164, E-mail: mdaky@hanmail.net, ORCID: <https://orcid.org/0000-0003-3583-6425>

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sent were waived.

Case 1

A 72-year-old male patient fell off the bed after arthroscopic surgery for a right torn rotator cuff and experienced pain in the left clavicle area. Radiological images showed a Robinson type 2B2 fracture with 10-mm displacement and shattered bones (Fig. 2A). Before surgery, consent was obtained from the patient for use of the resorbable implant. For surgery, general anesthesia was used, and the patient was placed in a beach chair position. The surgical area was exposed, and the arm of interest was placed to allow free movement. Using a C-arm intensifier, the fracture location was checked from multiple angles and a skin incision was performed. Next, the excised skin was opened to expose the fractured area. Reduction was performed on the broken bones, and two resorbable bone screws and a resorbable K-wire and pin were used to readjust the bones to a simple fracture from a comminuted fracture (Fig. 2B and C). A metal plate (TDM clavicle shaft plate; Salt

Lake City, UT, USA) was used to fix the clavicle (Fig. 2D). After surgery, an arm sling was worn, and the patient started joint exercises based on tolerance to suture stability and pain. At 1 month after surgery, the pain had disappeared; range of motion was not limited at 10 weeks of follow-up. Radiological imaging showed successful bone union (Fig. 2E).

Case 2

A 74-year-old male patient was admitted to the emergency room due to right shoulder pain after falling from his motorcycle. Radiological findings were a Robinson type 2B2 right clavicle shaft fracture with 20-mm displacement (Fig. 3A). Surgery was performed as stated for the case 1 patient, and a resorbable bone screw and resorbable K-wire and pin were used to fix the bone fragments, which were then stabilized on a metal plate (Synthes LCP superior-anterior clavicle plate 8H; Synthes, Oberdorf, Switzerland) and fixed to the clavicle (Fig. 3B, C). Post-surgery rehabilitation was conducted as for the case 1 patient, and no pain was reported in the operated area at 45 days after surgery (Fig. 3D). The patient showed no restriction of range of motion, and bone union was achieved at 9 weeks of follow-up (Fig. 3E).

Case 3

A 72-year-old male patient was admitted to the emergency room due to pain in his left shoulder after falling. Radiological imaging showed a Robinson type 2B2 left clavicle shaft fracture with 10-mm displacement. The same surgical procedure was conducted, and a resorbable bone screw, K-wire, and pin were used to fix the

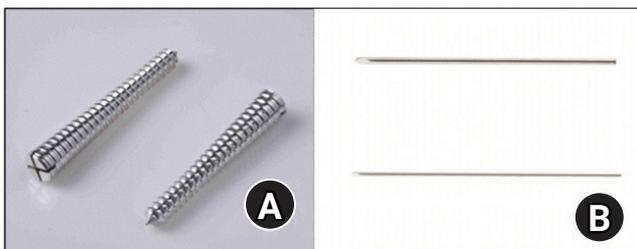


Fig. 1. Bioresorbable implant. (A) Bioresorbable screw. (B) Bioresorbable wire.

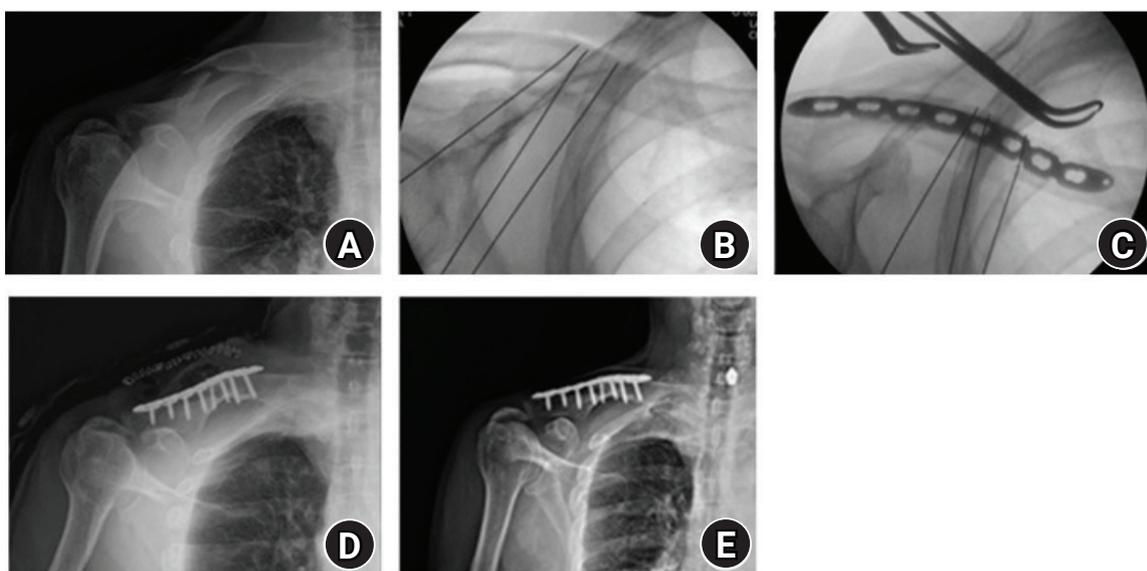


Fig. 2. Case 1. (A) Preoperative radiography. (B) Intraoperative C-arm image showing fixation of free fragments using guide wire for bioresorbable screws. (C) Intraoperative C-arm image showing fixation of free fragments using bioresorbable implants and metal plate. (D, E) There were no prominent specific findings on the postoperative and follow-up radiography.

broken bones. A metal plate (Synthes clavicle end plate 8H) was used to fix the broken bones to the clavicle, and post-surgery rehabilitation was conducted as above. The patient reported no pain 7 weeks after surgery, and bone union and full range of motion of the operated shoulder were observed at 11 weeks of follow-up. No complications were noted at 1-year follow-up.

Case 4

A 73-year-old male patient was admitted to the emergency room due to pain in his right shoulder after falling. Radiological imaging showed a Robinson type 2B2 left clavicle shaft fracture with 18 mm displacement. The same surgical procedure was conducted, and a resorbable bone screw, K-wire, and pin were used to fix the broken bones. A metal plate (TDM clavicle shaft plate 9H) was used to fix the bones to the clavicle, and post-surgery rehabilitation was conducted as in the above cases. The patient reported no pain at 40 days after surgery, and bone union and full range of motion of the operated shoulder were observed at 13 weeks of follow-up. No complications were reported at follow-up.

DISCUSSION

Traditionally, clavicle shaft fracture was treated conservatively with a figure of 8 bandage or with an arm sling, and surgical procedures were thought to be the cause of bone nonunion [8]. However, when displacement is severe or there are many fragments, non-surgical treatments showed a 15%–20% bone nonunion rate compared to the much smaller bone nonunion rate (2%–3%) of surgical approaches [3]. Therefore, surgery was performed in cases of Robinson type 2B fracture with multiple fragments and comminution, who were high activity and smooth shoulder movements before injury. The bone nonunion that occurs after surgery is thought to be caused by severe soft tissue and periosteal detachment [9]. To minimize these events, non-invasive reduction with intramedullary fixation [10] or minimal invasive plate osteosynthesis (MIPO) with locking compression plate is utilized [11].

However, for severe comminuted fracture, noninvasive reduction with intramedullary fixation is not a viable option because the fixation process is difficult, the fixture stability is weak, and the anti-rotation power is weak. Thus, open reduction is performed for Robinson type 2B fracture, reserving MIPO for special cases (e.g., refracture). Additional precautions are needed during rehabilitation after this procedure, and there are more possible complications such as displacement of the pin and shortening of the clavicle. Furthermore, minimally invasive surgical procedures use a locking compression plate as an indirect fixa-

tion method can be problematic and can result in difficulties in properly fixing the plate in the absence of proper analysis of the anatomical structure of the clavicle. Furthermore, percutaneous reduction is difficult for novices and requires ample experience. Additionally, iatrogenic damage can occur at the blood vessels under the clavicle, the nerves, and the lungs, indicating the need for caution.

Koh et al. [12] reported that comminuted clavicle shaft fracture can be more effectively and accurately treated with open reduction to clearly localize the bone fragments. Reduction then can be performed at the specific area, the free fragments can be attached using cannulated or mini screws, and the whole bone can be stabilized against a metal plate. However, to fix all the bone fragments, one to more than four screws might be used, in addition to six or more than 10 screws to fix the plate. This excessive use of screws may lead to irritation and difficulties in removing the implant after bone union or if complications arise. Even when screws are successfully removed, loss of such a volume of material can leave the bone hollow and weak, imparting a higher chance of fracture recurrence. Rather than removing a whole screw, it might be better to remove the protruding part with a burr to prevent further irritation and soft tissue injury.

Therefore, the authors used a hybrid surgical procedure where resorbable screws, K-wires, and pins were used for reduction and fixation, followed by attachment of a metal plate to stabilize the whole bone. A 1-year follow-up showed no complications, and all cases achieved bony union. Generally, there are difficulties in fixing a resorbable screw when using a C-arm image intensifier because they are radiolucent. However, open reduction allows screw visualization and decreases difficulty fixing the screw. Additionally, because the resorbable screw was not visible in the C-arm image intensifier, it did not cover the fracture line and allowed a more accurate reduction procedure. Since the screw and wire were inserted along the guide, it was easy to confirm their trajectory.

Though the resorbable K-wire and pin do not produce specific complications, they are much weaker than the traditional K-wire and must be manipulated with caution. Additionally, because the resorbable materials are made of magnesium, their absorption produces CO₂ gas, which can be visible in follow-up radiologic imaging; however, this eventually is naturally absorbed by the body and shows no persisting complications. The resorbable K-wire and pin start to be absorbed at about 6 months and are completely resorbed by about 1 year and 6 months, though this differs by patient. This should be sufficient time to ensure bone union.

Additionally, at post-surgery follow-up, the resorbable screw,

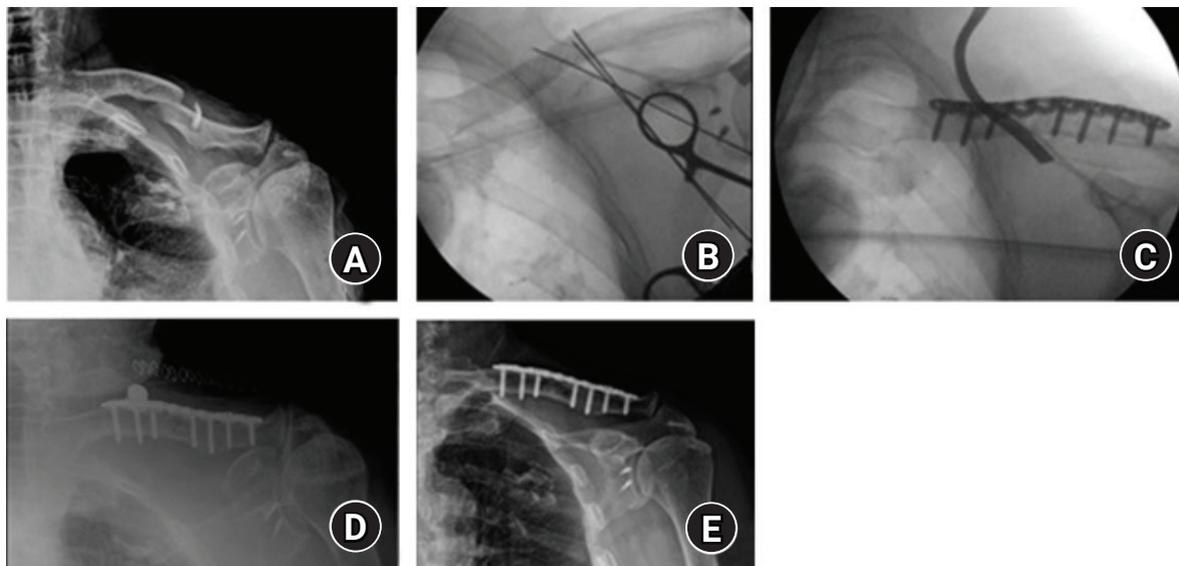


Fig. 3. Case 2. (A) Preoperative radiography. (B) Intraoperative C-arm image showing fixation of free fragments using guide wire for bioresorbable screws. (C) Intraoperative C-arm image showing fixation of free fragments using bioresorbable implants and checking plate. (D, E) There were no prominent specific findings on the postoperative and follow-up radiography.

K-wire, and pin are radiolucent, allowing easy visualization of fractural displacement or fixation complication. If displacement is noted on follow-up X-ray, screw breakage and pull out should be assessed by computed tomography and magnetic resonance imaging. When removing regular metal screws, K-wires, and pins, the callus formed over the top of regular metals need to be removed, which is much more difficult than natural absorption during bone union. As a result, only the metal plate and its screws need to be removed, a much simpler process.

Use of resorbable material showed successful bone union, and follow-up studies have shown no allergic reactions and no additional complications. Furthermore, there were no cases of metal failure, bone nonunion, infection, and ankylosis. Hybrid fixation using resorbable screws, K-wires, and pins for minor fixation and a metal plate for whole-bone fixation allows for effective anatomical reduction of Robinson type 2B clavicle fracture. Furthermore, the metal plate allows stable clavicle fixation, and the resorbable materials impart minimal risk of refracture. Therefore, use of this hybrid fixation technique may be effective in treating these types of fractures.

ORCID

Woo Jin Shin <https://orcid.org/0000-0001-5606-8635>
 Young Woo Chung <https://orcid.org/0000-0001-9929-6769>
 Seon Do Kim <https://orcid.org/0000-0001-9161-9391>
 Ki-Yong An <https://orcid.org/0000-0003-3583-6425>

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