1. Introduction

The locking plate system has recently been in the limelight. This system utilizes a bridge-plating technique, and it has become a standard procedure used primarily to treat comminuted fractures.\(^1\) Even in the treatment of distal radius fractures, this system is a useful technique, and many authors have reported excellent clinical results.\(^1,5-7\) Several authors have reported breakages of the locking plate system in femur and tibia, but to our knowledge there have been no reports concerning breakages of the volar-type locking plate used to treat distal radius fractures.\(^1,3,5-9\) We report herein a case of breakage of a volar-type locking plate in a patient with distal radial fracture.

2. Case report

A 56-year-old man fell on his right hand and immediately experienced severe wrist pain and was unable to move. He was brought to our hospital, where physical examination revealed a fork-like deformity, severe swelling, and tenderness of the right wrist without an open wound, with no sensory or motor disturbance. Plain radiography demonstrated a distal intra-articular radial fracture with a dorsal tilt of 12\(^\circ\), a radial inclination of 14\(^\circ\), and a radial height of 7 mm, and the fracture type was AO/ASIF classification C2 (Fig. 1a and b). After manual reduction under local anesthesia, unacceptable angulation remained, so we performed surgery on this displaced fracture 2 days after the initial injury.

We exposed the fracture site with a 5-cm skin incision using the trans-FCR approach. We performed a manual reduction anatomically under direct visualization and stabilized the fracture using a volar-type Matrix Locking Plate\(^6\) (Stryker, Kalamazoo, MI) that did not require bending (Fig. 2a and b). The plate was fixed in the distal fracture fragment with 4 angular locked monocortical screws penetrating three-fourths of the epiphysis, and in the proximal fracture fragment with 1 non-locked bicortical screw and 2 locked bicortical screws. After surgery, the volar tilt was 5\(^\circ\), the radial inclination 25\(^\circ\), and the radial height 15 mm. No additional splint was applied. One day after the surgery, the patient was allowed to begin active range-of-motion exercise of the affected wrist without strenuous activity.

One week after surgery, the patient had moderate pain and swelling. He had no trauma during that time. Plain radiography demonstrated breakage of the plate over the fracture site and unacceptable dorsal angulation of the distal fragment (Fig. 3a and b). The breakage line ran transversely from hole to hole; the side parts were not broken (Fig. 4a and b). We removed the broken plate using the same approach employed during the initial surgery. There were no findings of suspected infections. After prefixing the reduced fracture with 2.0-mm Kirschner’s wire, we refixed it using a volar-type Symmetry Plate\(^6\) (ACE Medical, El Segundo, CA). The plate was fixed in the distal fracture fragment with 3 conventional cancellous screws penetrating the epiphysis, not including the opposite cortex, and in the proximal fracture fragment with 4 conventional bicortical screws, and the Kirschner’s wire was left due to the augmentation. After surgery, the volar tilt was 4\(^\circ\), the radial inclination 25\(^\circ\), and the radial height 13 mm. The patient wore a short arm cast for 2 weeks. When the cast was removed, the patient was allowed to begin active range-of-motion exercise of the affected wrist.

One year after surgery, the patient had no pain. The range of motion of the right wrist was a palmarflexion of 85\(^\circ\), a dorsiflexion of 66\(^\circ\), a radial deviation of 25\(^\circ\), and an ulnar deviation of 25\(^\circ\), and that of the right forearm was full (supination and pronation were each 90\(^\circ\)). The patient’s score on the Disabilities of the Arm, Shoulder, and Hand questionnaire was 95 points, and his range of motion according to the modified Gartland and Werler scoring system was excellent.\(^4,10\) The plain radiographs showed good alignment of the fracture site (a volar tilt of 4\(^\circ\), a radial inclination of 24\(^\circ\), and a radial height of 13 mm) and no degenerative changes.

3. Discussion

The locking plate system has become a standard procedure, even in the treatment of distal radial fractures, and many...
Fig. 1. Plain radiographs made at the time of the initial injury. The anteroposterior view (a) and the lateral view (b) showed a distal radial fracture, which was classified as being of the C2 type in the AO/ASIF classification system.

Fig. 2. Plain radiographs made immediately after the first surgery. The anteroposterior (a) and lateral views (b) showed an acceptable reduction.
surgeons have used this system. The displacement of distal fragments after surgery caused by screw loosening, especially in elderly patients with osteoporotic bones, has been one of the most important problems in the treatment of distal radial fractures when using a non-locking plate.\(^1,5–7\) The locking plate system has been used to address such problems.\(^3\) One of the presumed advantages of this system is the ability to maintain the stability of the reduced fracture site, i.e., the axial forces are transmitted to the plate because the screws are locked into the plate, thereby preventing displacement of the distal fragment, even in the presence of a segmental bone defect.\(^6\) This feature allows for early rehabilitation with bare essential immobilization, allowing users of this system to expect a reduced incidence of secondary complications such as range-of-motion restriction and prolonged swelling. With regard to the clinical results, several authors have reported excellent or good outcomes.\(^1,5,7\)

Although several complications from using volar-type locking plates to treat distal radial fractures, including tendon injuries and median nerve dysfunction, have been reported, to our knowledge there have been no previous reports of breakage of volar-type locking plates in a distal radial fracture.\(^1,3,5–9\)

Several authors have reported failure cases when using the locking plates, and in each case the cause was an inappropriate fixation technique, rather than features of the locking plate itself.\(^8,9\) One failure was caused by an error of screw position. Gautier et al. have reported that an appropriate distance between the two screws adjacent to the fracture allows for stress distribution on the plate at the fracture site, which leads to a lowered risk of plate

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**Fig. 3.** Plain radiographs made 1 week after the first surgery. The anteroposterior view (a) showed breakage of the plate. The lateral view (b) showed dorsal angulation of the distal fragment (a dorsal tilt of 15°) accompanied by plate breakage.

**Fig. 4.** The broken plate. The anteroposterior (a) and lateral projections (b). The breakage line ran transversely from hole to hole, but the side parts were not broken (white arrow).
breakage. At the same time, Stoffel et al. have advised placement of the innermost screws as close as practicable to the fracture in fractures with a large fracture gap such as in comminuted fractures. On the other hand, Sommer et al. have reported that the free plate segment is distributed on a larger surface area, i.e., there is less risk of plate breakage through reduced stress concentration.

In our case, we think that plate breakage was caused by an error in screw position. We believe that too much stress was inserted in the distal fragment and the most distal screw was inserted in the proximal fragment, which was the breakage point. Our consideration for this stress concentration is the principle of leverage. We placed most distal screws inserted in the proximal fragment as close as practicable to the fracture site and in such circumstances, loads added to the wrist were concentrated on the volar side of the fracture which was not comminuted and reduced correctly under direct visualization (fulcrum point). In contrast, the dorsal side was comminuted and this determined the volar fulcrum point as the breakage point. More distance between the fracture site and the most distal screw inserted in the proximal fragment may resolve this rare complication. In contrast, Frigg has reported that plate failure occurs through the plate holes because the plate cross-section is the smallest in this area and the highest stress is concentrated there. In our case, the breakage line ran transversely from hole to hole in the area with the smallest cross-section. In addition, we investigated the removed plate and verified that there was no material issue such as deterioration or micro damage of metal.

We conclude that the cause of plate failure in our case was stress concentration in the area with the smallest cross-section as a result of inappropriate screw position. With regard to plate design, we cannot discuss it categorically because this is a case report; however, we consider that the predominant cause of plate breakage is a more technical problem than the material issue in this case. We believe that plate breakage may occur as a result of inappropriate screw position even in non-weight-bearing areas, and that this problem may be resolved by avoiding the most distal screw insertion close to the fracture site.

References