Therapeutic Effects of Volar Anatomical Plates Versus Locking Plates for Volar Barton’s Fractures

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abstract

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Volar Barton’s fractures are uncommon and extremely unstable. Various surgical techniques have been reported in the literature, but open reduction and internal fixation using a volar plate system is currently advocated for the treatment of volar Barton’s fractures. The purpose of this study was to compare the therapeutic effects of volar anatomical plates and volar locking plates in the treatment of volar Barton’s fractures.

A retrospective comparative study was performed of 33 patients with volar Barton’s fractures treated between October 2005 and November 2010. One group was treated with a volar anatomical plate (n=16) and the other with volar locking plates (n=17). Radiological and functional results were compared between groups. All patients’ fractures healed. Mean union time in the anatomical plate group was 12.93 weeks and in the locking plate group was 11.76 weeks (P>.05). No significant difference was noted between the 2 groups in terms of radial inclination, volar tilt, and ulnar variance. No significant differences were noted between the 2 groups in Disabilities of the Arm, Shoulder and Hand scores; however, according to Sarmiento’s modification of the Gartland and Werley score, the excellent and good rate was 75% in the anatomical plate group and 94.1% in the locking plate group, which was statistically significant (P<.05).

Anatomical and locking plates give satisfactory results in the treatment of volar Barton’s fractures, but locking plates may provide better wrist function recovery.

Figure: Preoperative anteroposterior radiograph of a 57-year-old man who sustained a left volar Barton’s fracture due to a fall from a height showing a large volar fracture fragment (A). Three-month postoperative anteroposterior radiograph showing the healed fracture (B).

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Baron’s fracture, named after the American surgeon John Rhea Barton, is a fracture of the distal end of the radius that involves the articular surface and is usually accompanied by subluxation or luxation of the radiocarpal joint.1-2 These fractures may result from high- or low-energy injuries, and they account for approximately 1.2% to 4.2% of distal radial fractures.3 On the basis of the site and shifting direction of fragments, Barton’s fractures are classified into volar or dorsal Barton’s fractures.4

According to AO classification, volar Barton’s fractures are type B3 fractures of the distal radius. Conservative treatment is usually unsuccessful and fraught with complications, such as early osteoarthrosis, deformity, subluxation, and instability. Various surgical techniques have been reported in the literature,5-8 but open reduction and internal fixation using a volar plate system is currently advocated for the treatment of volar Barton’s fractures, resulting in good reduction and providing immediate stability.1,2,9,10 Furthermore, patients can mobilize and use their wrists more quickly, potentially reducing wrist stiffness.

The common surgical treatment of volar Barton’s fractures is by volar incision with volar anatomical plate or locking plate fixation.8,11,12 Fragment displacement receives stability from anatomical plate support, whereas the volar locking plate provides significant structural stability by dynamic locking compression and good buttress of the fragments. The purpose of this study was to compare the therapeutic effects of the volar anatomical plate vs the volar locking plate for volar Barton’s fractures.

**Materials and Methods**

Inclusion criteria were age 18 years or older, open reduction and internal fixation with a volar anatomical plate or volar locking plate performed on fresh volar Barton’s fractures, and no prior injury and surgery to the same limb. Exclusion criteria included the second surgery, concomitant fractures of the same limb, and patients with high blood pressure, coronary heart disease, cerebrovascular disease, diabetes mellitus, or uncontrolled medical problems.

According to the criteria, 36 patients who were treated for volar Barton’s fractures by volar anatomical plate or locking plate in the authors’ institution between October 2005 and November 2010 were included in the study. The patients were instructed on the advantages and disadvantages of the 2 plate systems and chose the system they wanted to use. During follow-up, 2 patients could not be located and 1 declined to participate, leaving 33 patients in the study group.

The anatomical plates group included 16 patients (9 men and 7 women) with a mean age of 47.6 years (range, 22-69 years). Fifteen fractures were closed and 1 was an open type II fracture. The dominant hand was involved in 14 patients. Fractures were concomitant with median nerve injury in 2 patients, other fractures in 4 patients, and osteoporosis in 4 patients (verified preoperatively by dual-energy x-ray absorptiometry). According to the Comprehensive Classification of Fractures (AO classification),13 all fractures were type B3: 5 were B3.1 subtype, 8 were B3.2 subtype, and 3 were B3.3 subtype. The interval between injury and index operative procedure averaged 5.2 days (range, 0-11 days). Fourteen fractures were caused by high-energy injuries (9 motor vehicle collisions, 5 falls from a high height) and 2 by low-energy injuries (2 falls from a standing height).

The locking plate group included 17 patients (10 men and 7 women) with a mean age of 49.8 years (range, 23-72 years). Fifteen fractures were closed and 2 were open (type I and II, respectively). The dominant hand was involved in 12 patients. Fractures were concomitant with median nerve injury in 1 patient, other fractures in 3 patients, and osteoporosis in 5 patients. According to AO classification, 4 fractures were type B3.1 subtype, 9 were type B3.2 subtype, and 4 were type B3.3 subtype. The interval between injury and index operative procedure averaged 4.3 days (range, 0-9 days). Thirteen fractures were caused by high-energy injuries (10 motor vehicle collisions, 3 falls from a high height) and 4 by low-energy injuries (3 falls from a standing height and 1 from sports activity).

**Surgical Technique**

Under a brachial plexus block, the distal radius was exposed by a palmar approach along the flexor carpi radialis tendon, forming a 6- to 8-cm longitudinal incision. Then, the dissection plane

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**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Anatomical Plate Group (n=16)</th>
<th>Locking Plate Group (n=17)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (range), y</td>
<td>47.6 (22-69)</td>
<td>49.8 (23-72)</td>
<td>.66</td>
</tr>
<tr>
<td>Female, No. (%)</td>
<td>7 (43.7)</td>
<td>7 (41.2)</td>
<td>.73</td>
</tr>
<tr>
<td>Open fracture, No. (%)</td>
<td>1 (6.3)</td>
<td>2 (11.8)</td>
<td>1.0</td>
</tr>
<tr>
<td>Dominant hand injury, No. (%)</td>
<td>14 (87.5)</td>
<td>12 (70.5)</td>
<td>.40</td>
</tr>
<tr>
<td>High-energy injury, No. (%)</td>
<td>14 (87.5)</td>
<td>13 (76.4)</td>
<td>.66</td>
</tr>
<tr>
<td>Mean operative time, min</td>
<td>78.2±23.55</td>
<td>75.2±22.41</td>
<td>.71</td>
</tr>
<tr>
<td>Mean blood loss, mL</td>
<td>176.1±67.26</td>
<td>158.3±71.78</td>
<td>.47</td>
</tr>
<tr>
<td>Mean union time, wk</td>
<td>12.93±2.23</td>
<td>11.76±2.61</td>
<td>.18</td>
</tr>
</tbody>
</table>
between the flexor carpi radialis and the palmaris longus was developed. The radial artery was retracted radially and the median nerve ulnarly. After release of the pronator quadratus muscle from its radial insertion, the fracture site and palmar surface of the distal radius was exposed. The fracture was reduced using direct and indirect means. When necessary, the wrist capsule was incised to enable examination of the articular surface.

Either an anatomical plate (Weigao Orthopaedic Device Co Ltd, Weihai City, China) or a locking plate (Synthes, Bettlach, Switzerland) was applied to the volar aspect of the radius. The anatomical plate had to be precontoured to fit the volar surface of the distal radius. Commonly, the anatomical plate was temporarily fixed through a cortical bone screw in the proximal end, adjusting the plate to be conducive to reduction and fixing the distal end with cancellous screws. The resulting defects of reduction were filled with autogenous cancellous bone or artificial bone. The reposition of the fragments and localization of the plate were rechecked with C-arm radiography. After the wound was closed, a short arm plaster cast was applied in some cases. The hand was kept in a position of ulnar deviation and slight flexion, ensuring good stability of osteosynthesis.

Function exercises were encouraged 2 to 3 days postoperatively, but for some cases of serious comminuted fracture or osteoporosis, function exercises were recommended 2 to 3 weeks postoperatively.

Operative time, blood loss, complications, and union time of the 2 groups were recorded. Volar inclination, ulnar angulation, and ulnar variance were measured on anteroposterior and lateral radiographs during follow-up. Fracture union was determined by physical examination of the wrist and radiological study. Each patient was evaluated according to the modification of the Gartland and Werley score by Sarmiento et al and completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire during follow-up. The Gartland and Werley score is a physician-based demerit scoring system. The score ranges from 0 to 52 points: excellent, 0-2 points; good, 3-8 points; fair, 9-20 points; poor, more than 21 points. The DASH questionnaire is a validated health status questionnaire that results in a score ranging from 0 points, representing no disability, to 100 points, representing maximum disability.

### Statistical Analyses
Statistical analyses were performed with the SPSS version 13.0 statistical software package (SPSS Inc, Chicago, Illinois). Continuous variables were recorded as mean±SD. They were tested using the t test or analysis of variance, and the rates were compared using Fisher's exact test. \( P < .05 \) was considered statistically significant.

### RESULTS
Mean follow-up was 34.8 months (range, 12-68 months) in the anatomical plate group and 38.2 months (range, 16-73 months) in the locking plate group. No superficial or deep wound infection, nonunion, or malunion existed. No statistically significant differences existed between the 2 groups in terms of age, sex, dominant hand injury, open fractures, and causes of injuries (Table 1).

In the anatomical plate group, mean operative time was 78.2 minutes (range, 50-140 minutes). Mean blood loss was 176.1 mL (range, 100-400 mL), and mean union time was 12.93 weeks (range, 10-17 weeks). No significant differences in mean volar inclination, ulnar angulation, or ulnar variance were found immediately, 3 months, or 1 year postoperatively (Table 2). Two patients with osteoporosis had loose implants within 1 month, 1 of them
with loss of reduction. They required conservative treatment, so closed reduction and plaster casting were performed.

In the locking plate group, mean operative time was 75.2 minutes (range, 45-120 minutes). Mean blood loss was 158.3 mL (range, 100-350 mL), and mean union time was 11.76 weeks (range, 9-19 weeks). No significant differences in mean volar inclination, ulnar angulation, or ulnar variance were found immediately, 3 months, or 1 year postoperatively (Table 2). At final follow-up, no significant differences existed between the groups’ DASH scores; however, according to the modification of the Garland and Werley score by Sarmiento et al., the anatomical plate group had 3 excellent results, 9 good results, 3 fair results, and 1 poor result (an excellent and good rate of 75%). Two complications occurred during follow-up: 1 case of wrist joint stiffness and 1 case of traumatic arthritis. The locking plate group had 5 excellent results, 11 good results, 1 fair result, and no poor results (an excellent and good rate of 94.1%). Mean modified Garland and Werley score in the locking plate group was lower than that in the anatomical plate group, and the difference was statistically significant (Table 3).

**DISCUSSION**

Volar Barton’s fracture is an unstable fracture of distal radial, commonly accompanied by subluxation or luxation of wrist joint. The primary goal in treatment of this injury is to provide good reduction and immediate stability to achieve anatomic fracture union, allow the quick return of hand function, and avoid complications. Fracture healing depends on a minimal gap, adequate stability, and sufficient blood supply. In theory, the locking plate minimizes the compressive forces exerted on the bone to achieve stability, which may prevent periosteal compression and associated impairment of blood supply, and it is favored for fracture healing. However, no statistical advantage of the locking plate existed in the current study and the union times of the 2 groups were similar, which may be due to the small sample size of the study.

Radiologically, no significant differences in mean volar inclination, ulnar angulation, or ulnar variance were found immediately, 3 months, or 1 year postoperative.

**Table 3**

<table>
<thead>
<tr>
<th>Item</th>
<th>Anatomical Plate Group (n=16)</th>
<th>Locking Plate Group (n=17)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASH score</td>
<td>7.04±4.40</td>
<td>5.96±3.48</td>
<td>.61</td>
</tr>
<tr>
<td>Modified Garland and Werley score</td>
<td>7.75±6.06</td>
<td>4.06±2.82</td>
<td>.03</td>
</tr>
</tbody>
</table>

Abbreviation: DASH, Disabilities of the Arm, Shoulder, and Hand.
tively ($P>.05$); however, in the anatomical plate group, 2 of 3 patients with osteoporosis had loose implants and loss of reduction within 1 month postoperatively, whereas no loose implants, loss of reduction, or other complications occurred in all 5 patients with osteoporosis in the locking plate group. The results showed that although both the anatomical plate and locking plate could provide enough stability for volar Barton’s fractures, the locking plate may have more advantages for the treatment of osteoporosis.

Clinically, the volar anatomical plate had to be precontoured to fit the volar surface of the distal radius so the displaced fragments could receive stability from the buttress of the plate. However, the fixation system is not stable in all directions, and loose or broken implants may occur, especially in patients with osteoporosis. Postoperatively, patients often had to be immobilized in plaster casts for approximately 2 to 3 weeks. Therefore, they were not permitted to mobilize and use their wrists earlier, potentially leading to joint stiffness.

The locking plate and its screws act as a single unit to hold the bone fragments, which is a more stable system compared with an anatomical plate, which needs compression between the plate and the fragment. The locking plate is particularly useful in preventing unstable fracture displacement and maintaining good reduction.$^{17,22}$ No loose screws occurred in the locking plate group in the current study. The patients had almost no need with the colar locking plate for the treatment of volar Barton’s fracture. In the current study, wrist function was evaluated according to Sarmiento et al.$^{15}$ modification of the Gartland and Werley$^{14}$ system and the DASH at final follow-up, and the results showed an excellent and good rate of 75% in the anatomical plate group and 94.1% in the locking plate group, similar to those reported in the literature. The mean modified Gartland and Werley$^{14}$ score in the locking plate group was lower than that in the anatomical plate group, and the difference was statistically significant ($P<.05$). The results may be due to poor stability of the anatomical plate and the plaster cast, which may lead to loose implants, wrist joint stiffness, and traumatic arthritis.

The locking plate has relatively better efficacy for volar Barton’s fracture, but for some serious cases of comminuted fractures and osteoporosis, loose implants are possible. Therefore, for these patients, the use of a plaster cast for 2 to 3 weeks is recommended to increase the stability of the reduction and improve the success rate of surgery. To avoid poor joint function, active-assisted exercises of the wrist are initiated when use of the volar plaster cast is discontinued.

The current study was a nonrandomized, comparative trial rather than a prospective, randomized trial, and some limitations existed, such as small sample size, short follow-up, and lack of multiple factors analysis. Therefore, the advantages and disadvantages of the 2 plates may be further elucidated by prospectively randomized, comparative studies of larger sample sizes.

**Conclusion**

Both anatomical plates and locking plates can give a satisfactory results in the treatment of volar Barton’s fractures, but locking plates may provide better wrist function recovery.

**References**


