ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Acta Orthop Traumatol Turc 2009;43(4):303-308
doi:10.3944/AOTT.2009.303

Volar locking plate fixation of unstable distal radius fractures

Radius alt uç instabil kırıklarının volar yerleşimli kilitli plakla tespiti

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Amaç: Volar yerleşimli kilitli plak vida tespitleri ile tedavi edilen instabil radius alt uç kırıklarının radyografik ve işlevsel sonuçları değerlendirildi.

Çalışma planı: Radius alt uç instabil kırığı nedeniyle volar yerleşimli kilitli plak tespiti uygulanan 27 hasta (15 erkek, 12 kadın, ort. yaş 45; dağılım 18-77) incelendi. AO sınıflamasına göre kırıkların 22'si (%81.5) tip C, beşi (%18.5) tip B idi. İki hastada (%7.4) tip I açık kırık vardı. Kırıkların 21'inde (%77.8) dorsal, altısında (%22.2) volar açılanma vardı. Dört hastada (%14.8) kırığa dirsek çıkığı ve/veya kırık eşlik etmekteydi. Dokuz hastada (%33.3) distal radioulnar eklem sorunları vardı. On hastada (%37) kırık tespitine ek olarak otolog krista iliyka grefti kullanıldı. Hastaların hareket açıklıkları, kavrama kuvvetleri ölçüldü, Stewart ölçütlerine göre radyografik değerlendirmeleri yapıldı. Fonksiyonel değerlendirmede Quick-DASH-T (Disabilities of the Arm, Shoulder and Hand-Türkçe) sorgulaması ve Gartland-Werley değerlendirme formu kullanıldı. Ortalama takip süresi 18 ay (dağılım 12-34 ay) idi.

Sonuçlar: Kırıkların tümü ortalama 6.5 haftada (dağılım 6-8 hafta) sorunsuz kaynadı. Yirmi bir hastada (%77.8) ulnar varyans, 13 hastada (%48.2) radial inklinasyon açısı, sekiz hastada (%29.6) radial tilt açısı, 11 hastada (%40.7) radial yükseklik sağlam tarafla eşitlendi. Stewart ölçütlerine göre ortalama radyografi puanı 0.5 (dağılım 0-3) bulundu. Tedavi edilen tarafta kavrama gücü, sağlam tarafın ortalama %72.4'ü (18 kg) idi. Quick-DASH-T skoru ortalaması 8.3 (dağılım 0-70.5), Gartland-Werley puanı ortalaması 4.7 (dağılım 0-16) bulundu. Gartland-Werley değerlendirmesine göre, 12 hastada (%44.4) mükemmel, 12 hastada iyi, üç hastada (%11.1) ise orta sonuç alındı. İki hastada dizilim kaybı ve bir hastada çevre dokularda uyumsuzluk olmak üzere üç (%11.1) hastada komplikasyon görüldü.

Çıkarımlar: Volar yerleşimli kilitli plak uygulamaları radius alt uç anatomisinin düzeltilmesinde ve korunmasında etkilidir.

Anahtar sözcükler: Kemik plağı; kırık tespiti, internal/enstrümantasyon; radius kırığı/cerrahi; el bileği eklemi.

Objectives: We evaluated radiographic and functional results of volar locking plate fixation of unstable distal radius fractures.

Methods: The study included 27 patients (15 males, 12 females; mean age 45 years; range 18 to 77 years) who were treated with volar locking plate fixation for unstable distal radius fractures. Twenty-two patients (81.5%) had AO type C and five (18.5%) had type B fractures. Two patients (7.4%) had type I open fractures. Dorsal and volar angulation were present in 21 (77.8%) and six (22.2%) fractures, respectively. Four patients (14.8%) also had elbow dislocation and/or fracture and nine patients (33.3%) had disruption of the distal radioulnar joint. Autologous iliac crest graft was used in 10 patients (37%). Postoperative assessments included range of movement and grip strength measurements, and radiographic parameters using the Stewart criteria. Functional results were assessed using the Q-DASH (Quick-Disabilities of the Arm, Shoulder and Hand) questionnaire and the Gartland-Werley scale. The mean follow-up was 18 months (range 12 to 34 months).

Results: All fractures united without a problem within a mean of 6.5 weeks (range 6 to 8 weeks). The following parameters became equal to the unaffected side: ulnar variance (n=21, 77.8%), radial inclination angle (n=13, 48.2%), radial tilt angle (n=8, 29.6%), and radial height (n=11, 40.7%). The mean radiographic Stewart score was 0.5 (range 0 to 3). The mean grip strength of the operated side was 72.4% (18 kg) of the normal side. The mean Q-DASH and Gartland-Werley scores were 8.3 (range 0 to 70.5) and 4.7 (range 0 to 16), respectively. According to the Gartland-Werley scale, the results were excellent in 12 patients (44.4%), good in 12 patients, and moderate in three patients (11.1%). Three complications (11.1%) occurred, including loss of alignment in two patients, and screw-related discomfort in one patient.

Conclusion: Volar locking plate fixation is an effective treatment in the anatomical and functional restoration of unstable distal radius fractures.

Key words: Bone plates; fracture fixation, internal/instrumentation; radius fractures/surgery; wrist joint.

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Submitted / *Başvuru tarihi:* 07.11.2008 **Accepted / *Kabul tarihi:*** 07.04.2009

Distal radius fractures are the most frequently seen upper extremity fractures. The main objective of its treatment is the re-establishment of anatomic integrity and functioning. In unstable intra-articular fractures, re-establishment of inter-articular integrity of the wrist and maintaining the radial length are often not possible with closed methods. In such cases, where an open positioning is required, various surgical methods and fixation materials can be used.[1-6] A better understanding of wrist anatomy and functioning through the studies conducted in the recent years, as well as the increasing expectations of patients have expanded the borders of surgical treatment. Besides, improvements in fixation materials have provided new opportunities. [7-9]

Due to their intra-articular and unstable nature, B and C type were classified AO system distal radius fractures are treated surgically. Today, open positioning and plate fixation are the widely recognized surgical methods. [2, 5, 6] Locked plates are in the progress of replacing conventional support plates. While facilitating the positioning, those anatomical plates with screw-plate interlocking feature have more biomechanical strength against forces applied on the fracture surfaces. [8-10] Because of their biomechanical strength, locked plates are preferred in osteoporotic and/or multiple fractures. [5, 6, 11] However, there is no consensus neither about how to approach to distal radius nor the positioning of the plate. During the recent years, volar approach has become more popular. [7, 8, 12-15]

In this prospective study, radiographical and functional results of volar plate fixation of unstable distal radius fractures were evaluated.

Patients and method

Between 2004 and 2007, volar locked plate fixation was made to 36 patients with unstable distal radius fractures in our clinics. Among those patients, 27 (15 males, 12 females, mean age of 45, range 18-77) with a minimum follow up of one year were included in to the study. 14 wrist fractures (51.9%) were on the dominant side. Three fractures were B2 (11.1%), two were B3 (7.4%), two were C1 (7.4%), fourteen were C2 (51.9%) and six were C3 (22.2%), in reference to AO classification. All fractures were attributed to falling. As the first intervention to fractures, emergency reduction and circular casting were done. The mean pre-treatment angulation was 30° (20°-45°). Distal part of the fracture was dorsally inclined in 21 wrists (77.8%) and inclined to volar side in six wrists (22.2%). In 9 wrists (33.3%), there were comorbid distal radioulnar joint problems. Four patients (14.8%) had comorbid ankle dislocation and/or fracture.

Surgical treatment was required in case of volar angulation exceeding 10°, radial inclination angle below 15°, a loss in radial height above 10 mm, intra-articular stepping over 2 mm, comorbid ulnar fracture, excessive disintegration radius dorsal cortex and/or failure related to positioning losses in cast treatment. Age, profession, hobbies and concomitant lesions of patient were additional factors accounted in the selection of treatment. In unstable fractures headed towards the joint, open positioning and locked plate fixation were decided to re-establish the anatomy and fix the fracture. Locked plate systems that are known to provide early mobility were preferred for their biomechanical advantages. LCP distal radius plate (2.4 mm, Synthes, Paoli, PA, USA), Acu-Loc (2.3 mm, Acumed, Beaverton, OR, USA) and Vario (3.5 mm, Königsee, Allendorf, Germany) were used as locked plate systems.

The mean pre-surgical period was 4 days (range 1-8). All surgical interventions were done with volar approach under tourniquet while radioscopy was used for joint alignment (Fig 1).

Cortical-spongious graft harvested from crista iliaca was used in 10 patients (37%) in order to ensure radial lengthening and support the bone tissue stock in metaphyseal area. In two patients with alignment problems of distal radioulnar joint, a temporary Kirschner wire fixation was conducted. An additional bone fixation was not done for those patients with ulnar styloid fracture, whose distal radioulnar joint was observed to be stable during the surgery. Following the post-surgical short arm casting for 20 days, active wrist exercises were started. After radiographical and clinical re-union, exercises were initiated to increase the joint motion distance and muscular power. For two patients (7.4%) with Gustillo type I open fracture, open fracture treatment protocol was implemented. Among four patients with ankle dislocation (14.8%), close repositioning were done for two and open repositioning were done for the others. In patients to whom, open positioning was done, comorbid coronoid processes and radial neck fractures were treated surgically.

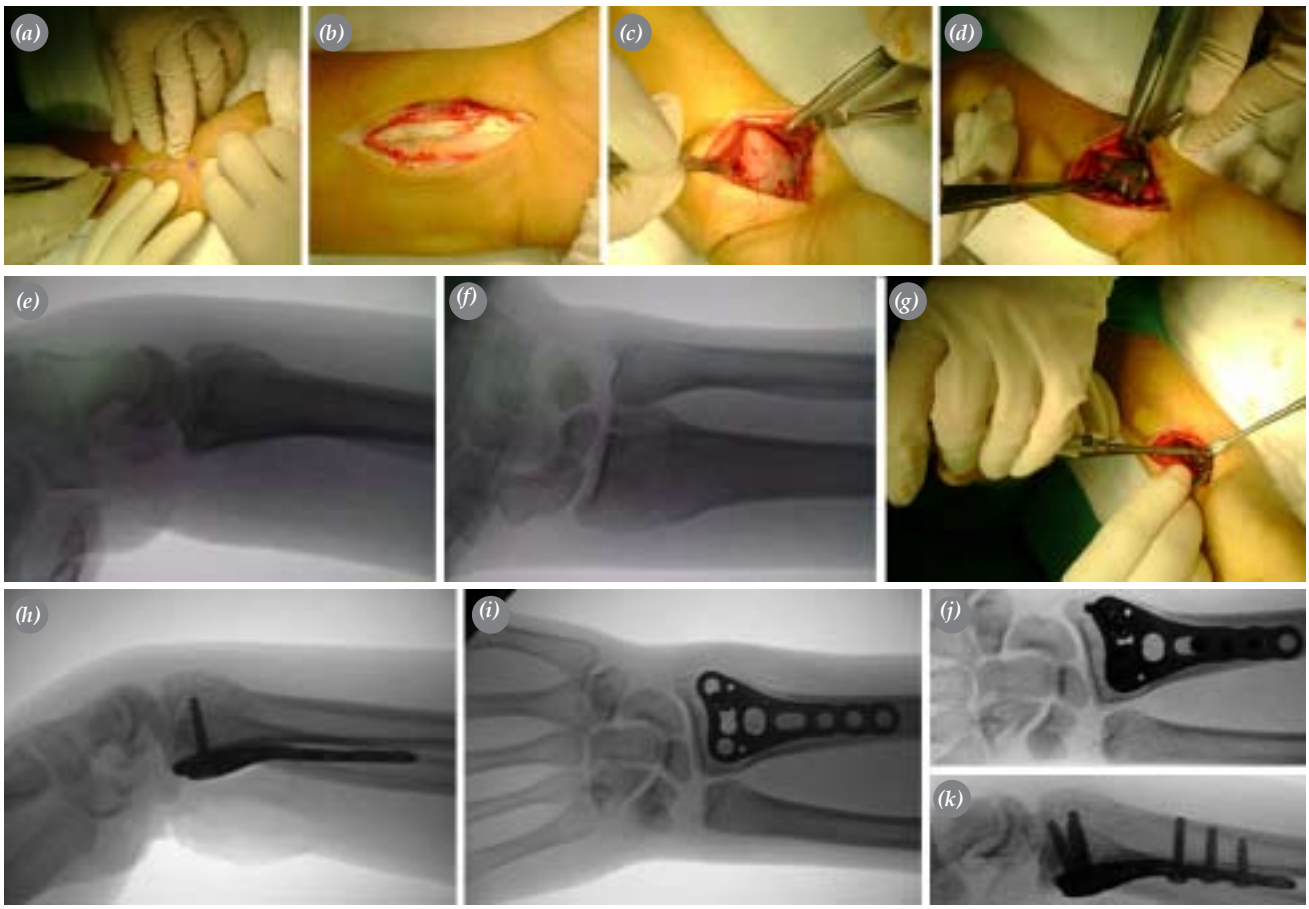

Figure 1. Indirect positioning and surgical fixation technique implemented in the dorsally angulated C2 type (AO) fracture. **(a-d)** Distal radius was accessed through pronator quadratus muscle cut following volar incision. Then **(e, f)** radioscopic control of the alignment was done. **(g, j)** plate positioning was and distal screwing was done and (k) After indirect reduction proximal screwing was completed.

Additional to the post-operative control graphics (anterior-posterior and bi-directional lateral), real anterior-posterior and real lateral wrist graphics were examined to evaluate the relationship between distal screws and the joint (Fig 2).

The lack of pain in the palpated fracture area was considered as clinical re-union. Follow ups were done at week 2, week 6 and at 3rd, 6th and 12th months. Anterior-posterior and bi-directional lateral as well as real anterior-posterior and real lateral wrist graphics were examined comparatively to healthy side for radiographical controls. Tilting angle of radius, radial inclination angle, radial height and ulnar variance were measured and evaluated in reference to Stewart criteria. [16] Joint motion angles were measured by using a standard goniometer. Grasping forces were measured by using a dynamometer (Sammons Preston Inc, Bolingbrook, IL, USA) and compared to the healthy side. Functional subjective outcome was measured with the Turkish version of Quick DASH (Disabilities of the Arm, Shoulder and Hand Questionnaire) and Gartland-Werley. [19] The mean follow up period was 18 months (range 12-34 months).

All statistical analyses of the entire data set were done by using SPSS 11.5 software. Comparative analyses were done by using Mann-Whitney U-test.

Results

All fractures were healed in a mean period of 6.5 weeks (range 6-8 weeks). The mean radiographical score on Stewart rating scale was 0.5 (range 0-3). Ulnar variance has been equalized in 21 patients (77.8%). In six patients (22.2%), a mean positive ulnar variance of 0.4 mm (range 0-3) was observed. In almost half of the patient population, radial inclination angles have been equalized with the healthy side. In those 14 patients (51.9%), whose inclination angles have not been equalized, the mean angle for

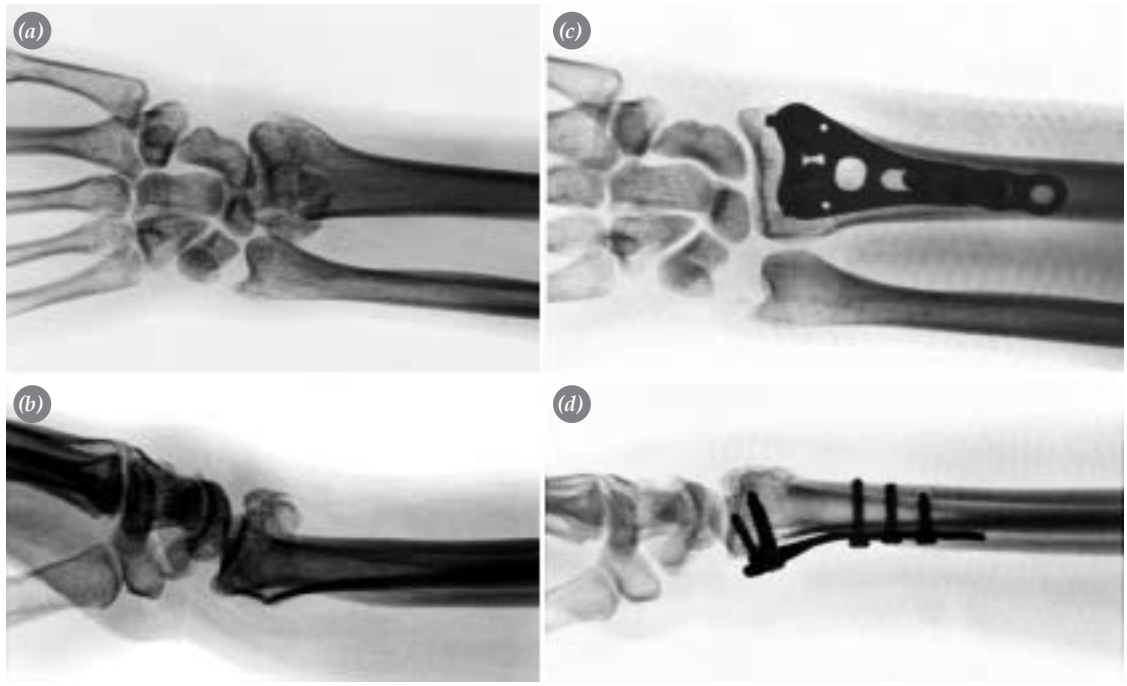

Figure 2. (a, b) Pre-operative and **(c, d)** post-operative anterior-posterior and lateral graphics of a 20 years old male patient with AO C2 fracture in the left hand wrist due to falling. Figure shows the recovery in the joint surfaces and radial height.

the healthy side was 26.8° (range 22°-30°) while the mean angle for the operated side was 24.8° (range 20°-28°). In eight patients (29.6%), radial tilting angle was equalized with the healthy side. In other patients, the mean radial tilting angle was 6.2° towards volar direction (range dorsal 1° - volar 14°) on the healthy side and 3° towards volar direction (range dorsal 10° - volar 18°) on the operated side. While having equal radial height in 11 patients (40.7%), the mean loss on the operated side was 1.3 mm (range 0-5 mm) on the operated side in other patients. In two patients (7.4%), stepping above 1 mm in the radiocarpal joint was observed.

Motion distances of the patients at the end-point visit were as follows: Mean flexion angle was 55° (range 0°-70°), mean extension angle was 40° (range 35°-70°), mean radial deviation was 18° (range 10°-26°), mean pronation was 86° (range 0°-90°) and the mean supination angle was 83° (range 0°-90°). In two patients (7.4%), development of synostosis and loss in forearm rotations were observed. There were unrecognized ankle dislocation and caput radii fracture in one of those patients and a multiple fracture with insufficient distal radioulnar joint alignment in the other one.

The mean grasping power was measured as 72.4% (18 kg; mean 5-30 kg) of the healthy side, during the dynamometric assessment. The mean Quick DASH-T score was 8.3 (range 0-70.5). On Gartland-Werley evaluation scale, 12 patients (44.4%) were excellent, 12 patients were good and three patients (11.1%) were moderate. The mean Gartland-Werley score was 4.7 (range 0-16). In the top two patients of the Quaick-DASH-T ranking, there was fractured ankle dislocation comorbid to unstable distal radius fracture.

In ten patients (37%), metaphyseal spaces were supported with Cortical-spongious crista graft additional to the plate fixation. Supporting or osteoinductive grafting was not required in other patients.

In two patients (7.4%), joint alignment deficiency due to insufficient fixation was observed while having one patient (3.7%) with complaints about surrounding tissue disturbances related to screws in the early phase. Following the re-union, fixation materials were extracted. During that secondary surgical operation, two distal screws were evacuated by cutting at the neck due to the unlocked screw-lock mechanism.

There was statistically significant difference between pre- and post operative radial tilting angles, inclination angles and radial heights ($p<0.05$); however

except radial tilting angles, there was no statistically significant difference in reference to the healthy side ($p>0.05$). The increase in the Stewart radiographical scores was considered to adversely impact Gartland and Werley functional scores ($r=0.35$, $p<0.01$) while leading to a raise in the DASH-T scores ($r=0.53$, $p<0.01$). Moreover, a significant relationship between Quick DASH-T and Gartland and Werley evaluation scores was observed ($r=0.827$, $p<0.001$).

Muscular powers in reference to the healthy side were statistically significantly different ($p<0.05$) whereas the differences in joint motions (except extension) compared to the healthy side were not significant ($p>0.05$).

Discussion

On the basis of Stewart criteria, a significant correction was obtained for all fractures, in our study. By the end of a mean follow up period of one year, a mean recovery of 80% in the wrist motion distance and a mean recovery of 72.4% in grasping power, compared to the healthy side, were observed. The Quick DASH-T score used for daily functioning measurement was 8.3. On Gartland and Werley evaluation scale, 12 patients were excellent, 12 patients were good and three patients were moderate. Moreover, no grafting was used in 60% of the patients.

Locked plates that are widely used provide successful results especially for the treatment of intra-articular unstable fractures of distal radius. [1, 5, 11, 14, 15] This method, which is effective in anatomic re-alignment, allows early joint motion, owing to its fixation strength.[16, 20] Close placement to joint interface and screwing capability in different orders are its biomechanical superiorities. Volar approach provides both access with minimal surgical trauma on distal radius and fixation with a better adaptation to surrounding tissues. [5, 6, 8, 11, 12, 14, 21, 22] In the subjects of our study, a successful anatomic alignment was acquired with volar approach, regardless of the direction of fracture angulation. The patients who were young adults in majority, went back to their daily activities with 90% recovery.

Loss of alignment on the joint interface, collapse and surrounding tissue disturbances related to the fixation material are the most frequently seen early-phase complications of the treatment of distal radius with open positioning and fixation plates. [4-7, 21, 22] In two patients, joint alignment was observed while having one patient with complaints about surrounding tissue disturbances three patients in total (11.1%).

We believe that, our study would provide additional knowledge and experience about the treatment of unstable distal radius fractures. Few patients involved and short follow up duration are the limitations of our study.

As a result, locked plates are effective in the correction and maintenance of distal radius anatomy. By using those plates, joint motions and daily functioning is recovered in a shorter time.

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