

## WRIST ARTHRODESIS USING AO DYNAMIC COMPRESSION PLATE AO dinamik kompresyon plağı kullanılarak yapılan el bileği artrodezleri

Vedat Şahin<sup>1</sup>, Ali Bakır<sup>2</sup>, C Yıldırım Türk<sup>3</sup>, İlhan Demiryılmaz<sup>4</sup>

**Summary:** Between January 1993 and October 1995, the results of nine wrist fusions with an autogenous iliac crest bone graft and an AO dynamic compression plate are reviewed in this study. Six patients were male and three were female. The average age at the operation time was 33.7 years. In six patients the problem involved the dominant wrist. Five of the patients who were operated for the wrist fusion had primary or post-traumatic osteoarthritis. All wrist fusions were performed using a dynamic compression plate and a cancellous bone graft obtained from the iliac crest. Radiological union occurred after an average of 11 weeks. Complication occurred in none of the patients. The follow-up time ranged from 6 months to 40 months (19.3 months average on). All of the patients were evaluated according to their own announce, clinical and radiographic examination. The criterias of Rayan and Clark was used in this evaluation. By these criterias, excellent and very good results were obtained in seven cases, one case had good and one case had fair results. We conclude that wrist arthrodesis using AO dynamic compression plate increased wrist strength and stability, and diminished pain, and allowed improved function.

**Key Words:** Wrist arthrodesis, AO dynamic compression plate

A stable and pain-free wrist is essential for normal hand function. If either of these prerequisites for normal function are lost, some form of operative intervention is usually required. Ligament reconstruction, limited intercarpal arthrodesis, and proximal row carpectomy have provided stability

**Özet:** Bu çalışmada Ocak 1993-Ekim 1995 tarihleri arasında dokuz hastada otojen iliak kemik grefti ve AO dinamik kompresyon plağı kullanılarak yapılan el bileği artrodezleri gözden geçirildi. Hastaların altısı erkek, üçü kadındı. Ameliyat sırasında hastaların yaşı ortalama 33.7 yıl idi. Altı hastada dominant elde problem mevcuttu. Artrodez yapılan hastaların beşinde primer veya post-travmatik osteoartrit vardı. Bütün hastalarda el bileği füzyonu dinamik kompresyon plağı ve iliak kanattan alınan kansellöz kemik greftleri kullanılarak gerçekleştirildi. Radyolojik olarak kaynama ortalama 11 haftada oluştu. Hastaların hiç birisinde komplikasyon görülmedi. Hastalar 6-40 ay, ortalama 19.3 ay takip edildiler. Hastaların tamamı kendi beyanlarına, klinik ve radyolojik muayene bulgularına göre değerlendirildi. Bu değerlendirmede Rayan ve Clark'ın kriterleri kullanıldı. Buna göre yedi hastada mükemmel ve çok iyi, bir hastada iyi ve bir hastada yeterli sonuç elde edildi. Sonuç olarak dinamik kompresyon kullanılarak yapılan el bileği artrodezlerinin, el bileğinin gücünü ve stabilitesini artırıp, ağrıyı azaltarak fonksiyonu düzelttiği kanaatine vardık.

**Anahtar Kelimeler:** Elbileği artrodezi, AO dinamik kompresyon plağı

and relief of pain while preserving some useful wrist motion (1). On the other hand, wrist arthrodesis is a well-established procedure that is useful for stabilizing the hand in a predictable position and for relieving pain in conditions such as intercarpal or radiocarpal arthritis. In contradistinction to fusion of most other large joints, wrist fusion is indicated at least as frequently as arthroplasty for advanced arthrosis (2). Arthrodesis of the wrist has been advocated for treatment of various disorders of the joint, such as tuberculosis, rheumatoid arthritis, osteoarthritis, traumatic lesions, cerebral

Erciyes Üniversitesi Tıp Fakültesi 38039 KAYSERİ  
Ortopedi ve Travmatoloji. Y.Doç.Dr.<sup>1</sup>, Prof.Dr.<sup>2</sup>, Doç.Dr.<sup>3</sup>,  
Araş.Gör.Dr.<sup>4</sup>.

Geliş tarihi: 12 Eylül 1996

palsy, residual paralysis after poliomyelitis, congenital deformities, tumors and Volkmann's contracture (3,4).

The first wrist arthrodesis was performed by Ely in 1910 for the treatment of tuberculous arthritis. Many techniques have been described to accomplish total wrist arthrodesis (1, 5-9). The techniques for wrist arthrodesis differ in surgical approach, amount of carpal resection, extent of fusion, use of bone graft, bone graft donor site, fixation and position of fusion (10).

The purpose of this study is to examine the efficiency of rigid internal plate fixation with the use of iliac crest bone graft in providing a reliable fusion. In this study all patients were treated in Erciyes University School of Medicine, Department of Orthopaedic Surgery and Traumatology, Hand Surgery Section, Kayseri, Turkey.

#### **PATIENTS AND METHODS**

From January 1993 to October 1995, nine consecutive patients underwent wrist arthrodesis using a standard technique of internal fixation with a rigid plate extending from the distal radius, across the carpus, to the third metacarpal bone. Fixation is achieved with a 3.5 mm AO dynamic compression plate (usually an eight hole plate). In all patients augmentation performed at the arthrodesis site using bone graft from the iliac crest.

There were six men and three women. The average age at the operation time was 33.7 years (range, 16 to 68 years). Five patients had involvement of the right side, and four had involvement of the left side. Six wrists were on the dominant side and three were on the nondominant side. Wrist pain had been present for an average of 24 months (range, 5 months to 6 years). Four patients were heavy manual laborers. Standard posteroanterior and lateral x-ray films of the wrist were used to establish preoperative diagnosis. The underlying pathology in these patients included post-traumatic arthritis in four, rheumatoid arthritis in two, osteoarthritis in one, cerebral palsy in one and brachial plexus injury in one (Table I). Pain was the main indication for wrist fusion in patients

with primary or post-traumatic osteoarthritis and in patients with rheumatoid arthritis. In these cases the radiocarpal and intercarpal joints were severely arthritic. In patients with cerebral palsy and brachial plexus injury, wrist fusion was performed in order to improve hygiene and position of the wrist, and to obtain a useful hand function.

Pre and postoperative hand and wrist motions and grip strength measurements were done. Six wrists were painful during passive flexion, extension, and radial and ulnar deviation. Clinical signs of synovitis were evident in two patients.

Following the operation, patients participated in a rehabilitation program with the aid of a physiotherapist. The patients were encouraged to actively and passively exercise the joints that were not immobilized, especially the digital joints. Immediately after the cast was removed, the patients started resistive exercises to restore muscle power of the forearm and hand. Functional activities were also carried out to help the patients to use their stiff wrists in daily living activities.

Evaluation of patients included interview, physical examination, x-ray films, and chart review.

#### **SURGICAL TECHNIQUE**

The procedure was performed through a straight dorsal longitudinal incision centered over the radiocarpal joint and Lister's tubercle. The third dorsal retinacular compartment was opened longitudinally. The distal radius was exposed subperiosteally, and the longitudinal incision in the periosteum was extended distally through the capsule out to the radial base of the third metacarpal. The insertion of the extensor carpi radialis brevis was cut and reflected radially. The dorsal portion of the third metacarpal was exposed subperiosteally, and the interosseous fascia between the index and middle metacarpals was incised. The interosseous muscles on the ulnar side of the third metacarpal were not disturbed. To allow flat apposition of the plate on the radius, Lister's tubercle was removed by an osteotome. The dorsal cortices of the base of the third metacarpal and the

carpal bones were removed. Articular cartilage and subchondral bone were removed down to cancellous bone from all of these joints, including the radioscapoid, radiolunate, lunocapitate, scaphocapitate and third carpometacarpal (CMC) joints. Unless involved with arthritic deformity, the ulnar mid-carpal joints and second carpometacarpal joints are not included. All joints to be fused were packed with cancellous bone prior to plate fixation. An autogenous iliac crest cancellous bone was used for grafting in all cases. A dynamic compression plate was then used to stabilize the third metacarpal-carpal-radius unit. All of the patients had plate fixation using a 3.5 mm AO dynamic compression plate. Final wrist position was 0°-15° extension. Dorsal capsule and the skin were closed over a suction drain (11).

Postoperatively a short arm cast was used for 4-6 weeks. Active and passive range of motion of the digits and the elbow was started immediately. At the end of the second week, all sutures were removed. At the end of six weeks the cast was removed and a molded protective plastic wrist splint was applied. The protective splint was discontinued when there was union on the x-ray film. Usually, union occurred in 6 to 15 weeks.

## RESULTS

All nine patients were available for follow-up examination at an average of 19.3 months (range, 6 to 40 months). Patients were evaluated according to the wrist arthrodesis score evaluation criterias modified from Rayan and Clark (12) (Table II). There was no pain and tenderness in the fusion site with manipulation of the wrist in seven cases. In cold weather and heavy work, two patients with rheumatoid arthritis had a mild pain in the fused wrist. No motion at fusion site of patients was noted. In evaluation, most patients indicated that they found some difference in the use of their hands after the operation except two patients with cerebral palsy and brachial plexus injury. Immediately after the casts were removed, some patients had difficulty performing some precision activities that require wrist motion, such as writing on a high surface, placing earrings, and etc. All adapted with time and were able to carry out

these activities. Two patients with cerebral palsy and brachial plexus injury had improvement in hygiene and cosmesis. In these patients nonfunctional hands were not deteriorated basically. Seven patients were satisfied with the result of their surgery. Other two patients were dissatisfied with the operation despite the improvement in function and strength.

In the postoperative evaluation, all patients were found to have solid fusion clinically, as well as radiologically (Figure 1 A,B,C,D). All wrists showed complete fusion in follow-up x-ray film evaluation at an average of 11 weeks (range, 6 to 15 weeks). No evidence of plate loosening, screw migration, fibrous union and pseudoarthrosis were noted in any of the follow-up x-ray films. When the posteroanterior radiometacarpal angle (longitudinal axis of radius and third metacarpal) was evaluated, all of the patients' wrists were found postoperatively to be fused in neutral. On the other hand, when the lateral radiometacarpal angle was evaluated, all the patients' wrists were found to be fused in extension that varied from 0° to 15° (average on 7.8°). In the lateral projection, the position was neutral (0°) in three cases, 10° extended in four cases and 15° extended in two cases (Table I).

Goniometric assessment of the active range of motion of each upper extremity was made preoperatively and postoperatively in all patients except two patients with cerebral palsy and brachial plexus injury (13). The total range of motion for each digital joint and pronation / supination of forearm was measured. The average total active motion of the thumb was 124° (range, 90° to 145°) preoperatively, and 125° (range, 90° to 145°) postoperatively. The average total active motion of the other fingers was 240° (range, 190° to 272°) preoperatively, and 232° (range, 200° to 270°) postoperatively. On the other hand, the average pronation / supination of forearm was 65° / 73° preoperatively, and 70° / 79° postoperatively. The grip power varied from 2 to 35 kg with a mean of 17 kg preoperatively, and varied from 5 to 36 kg (average on 21 kg) postoperatively. Postoperatively, digital motion, pronation/supination and

grip strength did not change significantly from the preoperative status (Table III).

No complications occurred in any of the patients.

All of the patients returned to their same job. Screws and plates were not routinely removed unless complications occurred. Eighty-nine percent of patients had an excellent or very good results.

Table I. Results of patients

Patient	Sex	Age	Pathology	Occupation	Side	Dominant	Radiographic fusion	Position	Follow-up	Patient's satisfaction
R.D.	M	31	Post-traumatic arthritis	Laborer	L	N	7 wk	0° E	40 mo	Excellent
A.K.	M	44	Primary osteoarthritis	Farmer	R	Y	9 wk	0° E	36 mo	Excellent
G.S.	F	39	Rheumatoid arthritis	Housewife	L	Y	15 wk	10° E	28 mo	Good
Ş.S.	M	16	Cerebral palsy	Student	R	N	12 wk	15° E	16 mo	Fair
M.T.	M	28	Rheumatoid arthritis	Civil servant	L	Y	13 wk	10° E	16 mo	Excellent
A.Ş.	F	68	Post-traumatic arthritis	Housewife	R	Y	13 wk	15° E	16 mo	Excellent
B.D.	M	30	Post-traumatic arthritis	Laborer	R	Y	15 wk	10° E	9 mo	Excellent
M.G.	F	21	Brachial plexus injury	Civil servant	L	N	9 wk	0° E	7 mo	Very good
A.G.	M	26	Post-traumatic arthritis	Laborer	R	Y	6 wk	10° E	6 mo	Excellent

M, male; F, female; L, left; R, right; Y, yes; N, no; E, extension

Table III. Clinical data

	Preoperative	Postoperative
Extension/flexion:	35°/47°	-
Radial deviation/Ulnar deviation	12°/20°	-
Pronation/supination:	65°(range,58°-76°)/73°(range,60°-85°)	70°(range,58°-80°)/79°(range,70°-85°)
Grip strength:	17 kg (range, 2 kg-35 kg)	21 kg (range, 5 kg-36 kg)
Total active motion:		
• Index to small	240° (range, 180°-272°)	232° (range, 200°-270°)
• Thumb	124° (range, 90°-145°)	125° (range, 90°-145°)

**Table II.** Wrist Arthrodesis Evaluation Score (Modified from Rayan and Clark)

---

<b>Pain</b>	
20	No pain or cold intolerance at any time
15	Mild pain with heavy work or cold
10	Moderate pain with heavy work
5	Severe pain with heavy work
0	Severe pain all the time
<b>Motion</b>	
20	No motion at fusion site, no limitations of motion at unfused sites
10	Any limitation of pronation, supination, or finger motion
0	Motion at fusion site
<b>Function</b>	
20	Improved postoperatively
10	Same
0	Worse
<b>Patient satisfaction</b>	
20	Very satisfied
10	Satisfied
0	Unsatisfied
<b>X-ray film</b>	
20	No pseudoarthrosis, graft fracture, or deformity with alignment 0°-25° extension, 0°-20° ulnar deviation
10	No pseudoarthrosis, no graft fracture or deformity with alignment <0° or >25° extension, <0° or >25° ulnar deviation
5	Fibrous union
0	Pseudoarthrosis
<b>Rating</b>	
91-100	Excellent
81-90	Very good
71-80	Good
65-70	Fair
<65	Poor

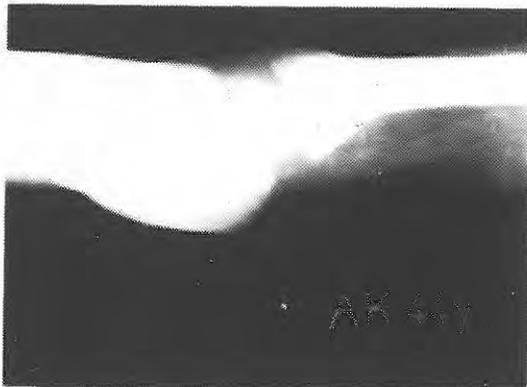
---



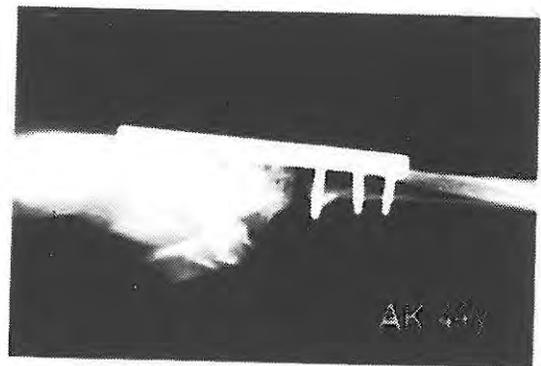
(A)



(C)



(B)



(D)

**Figure 1.** (A), (B) Preoperative posteroanterior and lateral radiographies of a patient with primary osteoarthritis (C), (D) Posteroanterior and lateral radiographies 2 years after operation showing solid fusion between the radius and the 3rd metacarpal.

## DISCUSSION

Although the function of the various joints of the upper extremity is to position the hand in space so that it can perform activities of daily living, the wrist seems to be the key to hand function. The function of the hand depends on joint mobility, muscle strength, sensibility and coordination. Wrist position not only affects the digital flexors and extensors, but its stability also allows proper function of these muscles (14). Wrist arthrodesis has been an integral part of the upper extremity surgery since it was first reported in 1910 (15). Wrist fusion relieves pain, provides permanent stabilization of the joint, and improves the overall function of the hand. The relief of the pain is the primary and most satisfactory result of arthrodesis. Increased strength in the digits and more functional positioning of the hand are secondary gains (5).

At the present time, arthrodesis of the wrist is used as part of the surgical management of a variety of conditions. We performed wrist arthrodesis in nine patients with primary and post-traumatic arthritis, rheumatoid arthritis, cerebral palsy and brachial plexus injury. Arthritis affecting the wrist is a frequent cause of significant morbidity and disability (16). For this reason, wrist arthrodesis is indicated for all conditions of arthritis (9). Although several different arthroplasty methods are currently available, none has replaced arthrodesis, which usually results in a painless wrist and a functionally good position (17). Wrist arthrodesis meets the functional requirements of patients with primary or post-traumatic arthritis, and of a young person engaged in heavy manual labor, and can also be used as a salvage procedure for unsuccessful arthroplasty. On the other hand wrist arthrodesis for the patient with rheumatoid arthritis is an acceptable procedure with a high degree of success and patient satisfaction. In patients with both primary or post-traumatic arthritis and rheumatoid arthritis, we obtained excellent and good results with wrist arthrodesis. Wrist fusion has had a controversial role in the management of cerebral palsy. Many authors believe that it is not effective for function, but may aid hygiene

and positioning (18,19). On the other hand, we think that arthrodesis of the wrist followed by tendon transfers improves hand function in paralytic conditions. In our patients with cerebral palsy and brachial plexus injury, we performed wrist fusion to control deformity and to allow hygiene.

The important factors in securing arthrodesis are: (a) internal fixation, (b) bony contact, (c) bone graft if necessary, (d) compression, and (e) obtaining or maintaining rotation of the forearm (6). The wrist is a difficult joint to treat with arthrodesis. Perhaps that explains the multiplicity of techniques described for wrist arthrodesis by many authors. Most contemporary reports of wrist arthrodesis emphasize the value of internal stabilization. Such stabilization may range from the use of Kirschner wires or Steinmann pins to techniques involving the insertion of Rush rods, staples, screws and compression plates (2). Depending on the type of fixation, postoperative cast immobilization is used (5-7, 17). Plate fixation probably affords the greatest stability requiring the least amount of external immobilization (20). Also the use of a rigid internal fixation plate to fuse the wrist provides a stable construction during the immediate postoperative period, allowing intensive therapy to the hand, elbow, forearm and shoulder (1). On the other hand the use of a bone graft is recommended by many authors (1,2,5,7,9,15,18,20,21). The apparent advantage of iliac grafting is the large quantity of bone available and the predominantly cancellous composition of bone from this site (2). In addition with cases of severe bone erosion as seen in a rheumatoid wrist, iliac grafting may be warranted (20). However, iliac bone graft shares the distinct disadvantage of a distant donor site (2). The use of a second incision to obtain the bone graft from the iliac crest does present significant morbidity for some patients (1). The iliac bone graft with plate fixation has been proved to be highly reliable method of wrist fusion for various pathologies with a 100 % union rate in our small series, which compares favourably with published non-union rates of 5 to 17 %.

The ideal functional position for fusion is unclear. According to Brumfield et al (14), most daily tasks

are performed in a range of 10° of flexion to 35° of extension. They suggest that 10° of extension is probably the most versatile position for wrist fusion. The usual recommendation has been fusion in some dorsoflexion(7,20,22). Larsson (8) performed wrist arthrodesis with a plate and screws, positioning the wrist in 0 to 15 degrees of extension, and noted increased grip strength in both rheumatoid and nonrheumatoid patients. Weiss et al (1) performed wrist fusion using a plate and local bone graft, and demonstrated that there is an eliminated wrist pain in all patients and slightly improved grip strength postoperatively. However Wright and Mc Murtry (22) using AO fixation for wrist fusion in 10 to 15 degrees of extension, failed to demonstrate the improvement of grip strength in rheumatoid and nonrheumatoid patients. We performed wrist fusion in 0 to 15 degrees of extension in all patients, and noted a slight increase

of grip strength. Pronation / supination of forearm did not appear to be affected after the procedure in our study.

In conclusion, total wrist arthrodesis using a rigid plate with augmentation by bone graft obtained from the iliac crest demonstrates an excellent fusion rate. This method offers a reliable and straight-forward technique for securing fusion with a low complication rate and a shorter period of postoperative immobilization. This allows earlier rehabilitation of the patient and permits a quicker return to the independent function. On the other hand this method also stabilizes the wrist adequately in patients with rheumatoid arthritis whose muscle power is markedly decreased. However, the loss of wrist motion decreases dexterity for some tasks and must be taken into consideration when recommended.

## REFERENCES

1. Weiss AP, Hastings II H. Wrist arthrodesis for traumatic conditions: A study of plate and local bone graft application. *J Hand Surg* 1995; 20A: 50-56.
2. Wood MB. Wrist arthrodesis using dorsal radial bone graft. *J Hand Surg* 1987; 12A: 208-212.
3. Louis DS, Hankin FM. Arthrodesis of the wrist: Past and present. *J Hand Surg* 1986; 11A: 787-789.
4. Mittal RL, Jain NC. Arthrodesis of the wrist by a new technique. *International Orthop* 1990; 14: 213-216.
5. Carroll RE, Dick HM. Arthrodesis of the wrist for rheumatoid arthritis. *J Bone Joint Surg* 1971; 53A: 1365-1369.
6. Clayton ML, Ferlic DC. Arthrodesis of the arthritic wrist. *Clin Orthop* 1984; 187: 89-93.
7. Haddad RJ, Riordan DC. Arthrodesis of the wrist: A surgical technique. *J Bone Joint Surg* 1967; 49A: 950-954.
8. Larsson SE. Compression arthrodesis of the wrist. A consecutive series of 23 cases. *Clin Orthop* 1974; 99: 146-153.
9. Rayan GM. Wrist arthrodesis. *J Hand Surg* 1986; 11A: 356-364.
10. Bolano LE, Green DP. Wrist arthrodesis in post-traumatic arthritis: A comparison of two methods. *J Hand Surg* 1993; 18A: 786-791.
11. Dick HM. Wrist arthrodesis. In: Green DP, ed. *Operative Hand Surgery*. 3rd ed. Churchill Livingstone, New York 1993, pp 131-142.
12. Rayan GM, Clark GL. Combined radiocarpal intercarpal arthrodesis. *Orthopedics* 1982; 5: 541-550.
13. Rayan GM, Brentlinger A, Purnell D, Garcia-Moral CA. Functional assesment of bilateral wrist arthrodeses. *J Hand Surg* 1987; 12A: 1020-1024.
14. Brumfield RH, Champoux JA. A biomechanical study of normal functional wrist motion. *Clin Orthop* 1984; 187: 23-25.
15. Viegas SF, Rimoldi R, Patterson R. Modified technique of intramedullary fixation for wrist arthrodesis. *J Hand Surg* 1989; 14A: 618-623.
16. Howard AC, Stanley D, Getty CJM. Wrist arthrodesis in rheumatoid arthritis: A

- comparison of two methods of fusion. *J Hand Surg* 1993; 18B: 377-380.
17. Vahvanen V, Tallroth K. Arthrodesis of the wrist by internal fixation in rheumatoid arthritis: A follow-up study of forty-five consecutive cases. *J Hand Surg* 1984; 9A: 531-536.
  18. Hoffer MM, Zeitzew S. Wrist fusion in cerebral palsy. *J Hand Surg* 1988; 13A: 667-670.
  19. Skoff H, Woodbury DK. Management of upper extremities in cerebral palsy. *J Bone Joint Surg* 1985; 67A: 500-503.
  20. Lee DH, Carroll RE. Wrist arthrodesis: A combined intramedullary pin and autogenous iliac crest bone graft technique. *J Hand Surg* 1994; 19A: 733-740.
  21. Sorial R, Tonkin MA, Gschwind C. Wrist arthrodesis using a sliding radial graft and plate fixation. *J Hand Surg* 1994; 19B: 217-220.
  22. Wright CS, McMurtry RY. AO arthrodesis in the hand. *J Hand Surg* 1983; 8A: 932-935.