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Intermediate-Term Outcomes of Patients Treated by Distal Radial Osteotomy

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Abstract: Between 1982 and 1998, 40 patients were treated by osteotomy following distal radius fracture malunion. Thirty-five of the 40 qualified for analysis having had at least 24 months of follow-up after their osteotomy. However, nine were lost to follow-up or had inadequate documentation, leaving 26 patients for inclusion in the study. All patients had their initial fracture care elsewhere. We performed opening wedge osteotomy of the radius with wedge bone grafting. All radii except one were stabilized using A.O. principles with plates and screws.

All patients in the series improved in terms of reduced deformity, roentgenographic appearance, stiffness, discomfort, and nerve irritation symptoms. Nine patients were rated as excellent, eleven as good, five as fair, and one as poor using a modified Sarmiento's rating system. Overall, 77% of the patients were rated either good or excellent. One patient required a second osteotomy for progressive radial shortening and limited motion due to tendons catching on the plate.

Despite the increased awareness of the potential for complications in Colles' fracture, certain individuals are still seen with symptoms related to malunion who can be helped by distal radial osteotomy.

Introduction

Current orthopaedic expositions indicate that complications of Colles' fractures may run as high as 30% [5]. Recent papers have described various methods by which the results of Colles' fracture might be improved. Unfortunately, despite our awareness of Colles' fracture complications and our use of more elaborate treatment methods, patients are still seen who have disabling symptoms of pain, deformity, stiffness, and nerve compression syndromes associated with distal radial malunion. Some patients may be able to tolerate such impediments, but certain younger individuals deserve improvement by corrective distal radial osteotomy.

Distal radius fractures are very common and expectations for recovery are usually high. Many reports [3,6,10–12,15,16] testify to the good results to be expected from treatment of a Colles' fracture. Even Colles [4] said that the injured limb would eventually regain "perfect freedom in all its motions." Optimism regarding the outcome of distal radial fractures has pervaded our thoughts regarding the Colles' fracture and deemphasized vigorous treatment [3,6,12]. Certainly, many patients will do quite well with an imperfectly aligned Colles' fracture as has been pointed out many times, including the report by Lucas and Sachtjen in 1981 [17]. However, some patients will have disabling symptoms from a healed malaligned fracture [6,10,11,17,22]. Although anatomic alignment is not the only factor influencing the clinical result in a Colles' fracture, it is assumed that anatomic reduction will contribute greatly to improved results. An osteotomy to restore alignment at the distal radius when imperfect alignment exists is a logical step [7–9,13,14,20,24]. This review of a significant number of patients followed for at least 24 months was prompted by a desire to examine the utility and indications for the procedure.

Materials and Methods

Between 1982 and 1998, 40 patients were treated for malunited distal radius fracture by distal radial osteotomy. Patients who had a follow-up of at least 24 months were included in the series. Follow-up included review of patient records and patient contact by telephone. Roentgenographic parameters were recorded at the time of the last x-ray examination. None of the patients contacted refused to answer a short questionnaire. Five patients who did not have adequate duration of follow-up and nine patients who were lost to follow-up or had inadequate documentation were not included. Thus, 26 patients with an average follow-up period of 78 months were available for this retrospective study. There were 19 women and 7 men with a mean age of 40 years (17–78 years).

Distal radial osteotomy was performed an average of 9.2 months (range 1–43) following the original fracture. Four patients were treated within weeks of their original fracture as suggested by Jupiter and Ring [13]. All patients had their initial fracture care elsewhere and were treated by a variety of standard methods for both extra- and intra-articular fractures. Although three patients had an intra-articular component to their fracture, all osteotomies were done to correct the malunion at the extra-articular site. One patient had actually had a prior osteotomy that required a revision. Patients who were selected for osteotomy had pain and loss of

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function or were dissatisfied with the appearance of their wrists.

All radii, except one, were stabilized using A.O. principles with plates and screws. Stability in Patient 6 was attempted with K-wire fixation, which was inadequate. Further refinements were added after becoming aware of a report published by Fernandez [8] in 1982. Eight of the 26 patients had additional procedures done at the same sitting as the radial osteotomy. These procedures included two ulnar osteotomies, three distal radioulnar joint (DRUJ) arthroplasties, one flexor digitorum superficialis to flexor pollicis longus transfer, one external fixation for carpal stabilization, and one excision of the proximal pole of the scaphoid with palmaris longus interposition.

Rating system

In 1981, Lucas and Sachtjen [17] modified Sarmiento's rating system for Colles' fracture to analyze a series of distal radial fractures treated by Rush rod immobilization (Table 1). This system was applied to this series of patients to evaluate them before and after the osteotomy. A retrospective review of patients' office records provided data relative to pre- and postoperative status. Roentgenographic indices were obtained from the last roentgenograms available as well as from clinical measurements. The last follow-up for all patients, except for two, was obtained by delivering a questionnaire over the telephone that corresponded to the previously mentioned rating system. The final score was derived as a composite of roentgenograms, office records, and the patient interviews.

Table 1. Demerit point rating system

Results	Demerit point system
Residual deformity	
Prominent ulnar styloid	1
Residual dorsal tilt	1–2
Radial deviation	2–3
Subjective	
Excellent (no pain)	0
Good (rare pain)	1–2
Fair (occasional pain)	1–4
Poor (frequent or steady pain)	1–6
Objective	
Loss of dorsiflexion	1–5
Loss of ulnar deviation	1–3
Loss of supination	1–2
Loss of volar flexion	1
Loss of radial deviation	1
Pain in DRUJ	1
Loss of pronation	1–2
Complications	
Minimal arthritis	1
Minimal arthritis with pain	1–3
Moderate arthritis	1–2
Moderate arthritis with pain	1–4
Severe arthritis	1–3
Severe arthritis with pain	1–5
Median nerve impairment	1–6
Finger stiffness	1–6
Reflex sympathetic dystrophy	1–6
End result	
Excellent	0–2
Good	3–6
Fair	7–18
Poor	19 or more

Technique

The patients are operated on under either axillary block or general anesthesia in the hospital. A straight dorsal incision is used, starting 2 cm distal to Lister's tubercle and extending approximately 8 cm proximally in line with the radial shaft. The extensor retinaculum is elevated as a flap and the radius approached between the extensor carpi radialis brevis and the extensor communis with careful retraction of the extensor pollicis longus. Subperiosteal dissection is performed at the site of the fracture and Lister's tubercle is removed with an osteotome to allow better plate apposition.

Preoperative planning with measurement of dorsal tilt, the amount of radial shortening, and radial slope was done (Fig. 1A). Preoperative tracings of the roentgenograms were made and analyzed. Based on the preoperative measurements, a Steinman pin is driven vertically into the shaft of the radius 4 cm proximal to the osteotomy site. The osteotomy is usually placed at the original site of the fracture or approximately 2 cm proximal to the joint surface. A second Steinman pin is inserted into the distal part of the radius just proximal to the articular surface to create an angle with the perpendicular pin that is equivalent to the premeasured deformity in the sagittal plane. Intraoperative radiographs are taken to ensure proper placement of the pins. An osteotomy is made between the two pins from dorsal to volar with either an osteotome or an oscillating saw, taking care to preserve the volar periosteum. A Cloward distractor is utilized to open the osteotomy dorsally until the two Steinman pins are parallel to one another. If pin placements are correct, correction of radial shortening and restoration of volar tilt will be accomplished. Restoration of radial slope is accomplished by opening the osteotomy site more on the dorsoradial side until the opening corresponds with the distance measured on the preoperative x-ray [8].

Next, an appropriately sized tricortical wedge graft is harvested from the ipsilateral iliac crest, shaped, and firmly tamped into the defect in the radius. Any pronation or supination deformity can also be corrected at this time by rotating the distal fragment. It indicated, patients had concomitant DRUJ arthroplasty or ulnar osteotomy done through the same incision. The T- or angled T-plate is carefully contoured to fit the dorsal surface of the radius and secured with cortical screws. The periosteum cannot usually be closed completely over the plate, so the extensor tendons are protected by placing all or part of the dorsal retinacular flap under the tendons. The wound is drained and the hand and forearm are immobilized with a volar plaster splint.

The plaster remains in place 7–10 days until the sutures are removed and an orthoplast splint is constructed for part-time use. The patient is encouraged to exercise the hand and

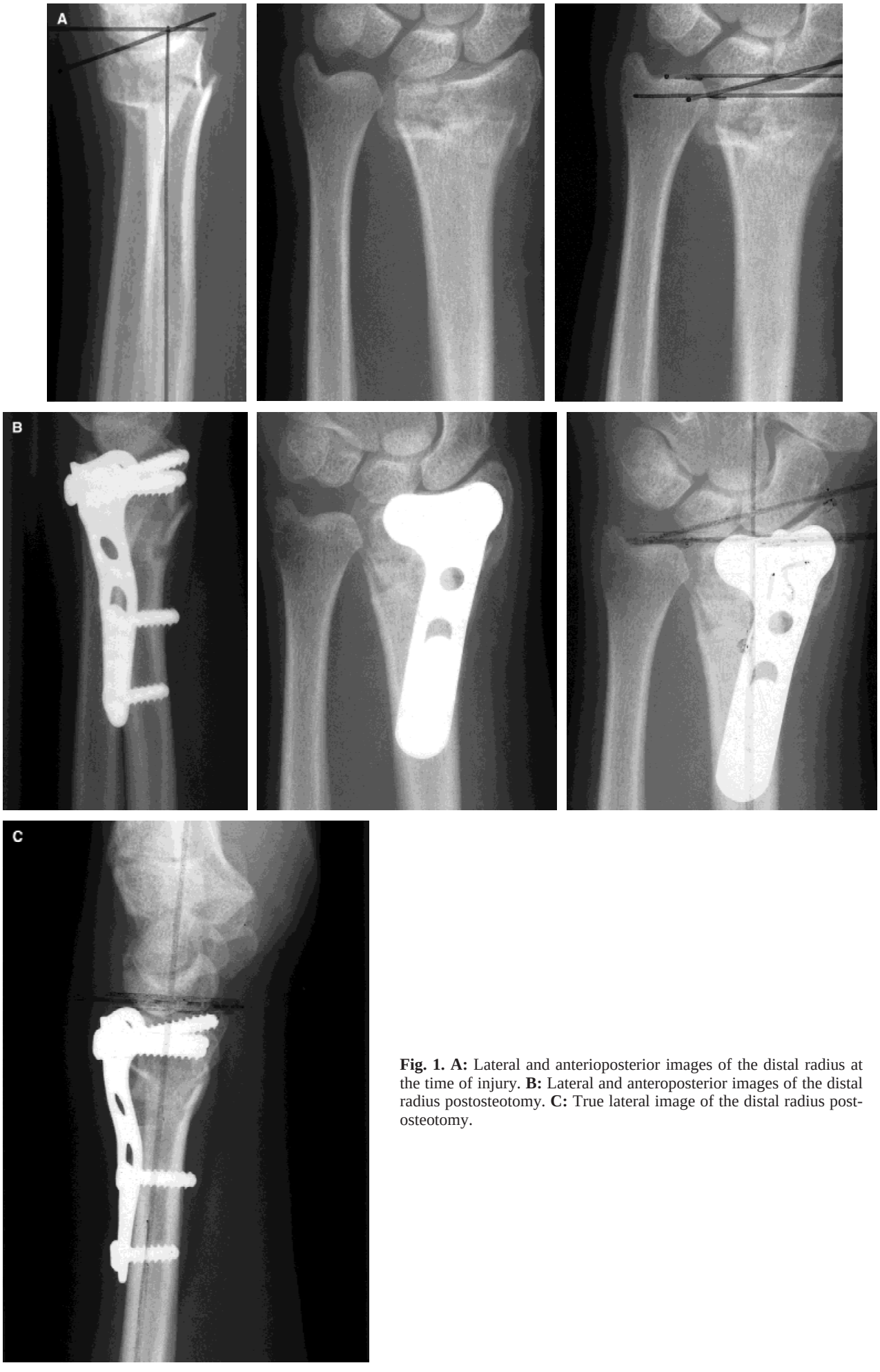

Fig. 1. A: Lateral and anterioposterior images of the distal radius at the time of injury. **B:** Lateral and anteroposterior images of the distal radius postosteotomy. **C:** True lateral image of the distal radius post-osteotomy.

wrist, but heavy use is contraindicated until radiographic healing of the osteotomy is evident. Refer to Figure 1 for examples of pre- and postosteotomy x-rays.

Results

Table 2 summarizes the results of our review. Most patients were rated poor or fair before the osteotomy. All patients, except one, showed improvement from their preoperative score. The osteotomy of the distal radius provided improved appearance and function in all patients. Of 26 patients, 20 improved in catergory and 6 remained in the same category (Fig. 2). However, even these six patients improved but not enough to move to a higher category. Ultimately, 9 patients were graded excellent, 11 were rated good, and 6 were graded fair or poor for an overall good or excellent result in 77% of the patients. All patients were subjectively pleased with their outcome.

Improvement in the radiographic measurement parameters was obvious, although complete anatomic restoration was usually not possible (Table 2, Figs. 3–5). We considered 25 degrees of radial slope and 10 degrees of volar tilt as normal. Five patients had a dorsal intercalated segmental instability (DISI) configuration that was corrected by surgery. Four patients were relieved of nerve symptoms simply by restoring alignment with the osteotomy (one patient had mild median nerve symptoms without atrophy postosteotomy, but decompression was not required). One patient developed reflex sympathetic dystrophy prior to osteotomy that significantly improved after surgery. Another patient exhibited a positive Tinel's sign over the ulnar nerve prior to osteotomy that resolved after the surgery.

Bony healing, as assessed by standard radiographs, occurred by 6 weeks in this series. There was no delayed or nonunion. There were four perioperative complications. One patient had a partial ulnar nerve palsy with a persistent abducted small finger. One older woman had iliac crest donor site pain. There were persistent median nerve symptoms in two patients—one older woman's symptoms improved compared to preosteotomy and another patient had a carpal tunnel release 9 months after the osteotomy.

One patient had a late complication of an ulna fracture following a secondary ulnar shortening. She ultimately improved from the preosteotomy state. One other patient had another osteotomy (a total of three) performed secondary to subsequent radial shortening and limited motion due to her extensor tendons catching on the plate. Three patients had hardware removal for late tendon irritation problems (Table 2).

Discussion

Despite increased awareness of the potential complications of Colles' fracture, certain individuals are still seen

Table 2. Study results

Patient	Sex	Age	Side	Time between injury and osteotomy (months)	Preoperative dorsal tilt (degrees)	Preoperative shortening (mm)	Preoperative radial slope (degrees)	Postoperative dorsal tilt (degrees)*	Change in dorsal tilt (degrees)
1	F	39	R	12	8	4	4	2	−6
2	F	51	R	4	45	4	15	−4	−49
3	F	78	L	4	25	5	15	13	−12
4	F	55	R	5	5	5	20	−15	−20
5	F	36	L	14	5	4	11	−20	−25
6	F	18	R	14	41	4	18	28	−13
7	M	19	L	5	26	4	23	0	−26
8	F	46	L	6	10	5	25	−21	−31
9	F	50	L	11	15	2	15	−8	−23
10	F	34	R	20	20	0	19	−6	−26
11	F	32	L	4	11	3	20	−15	−26
12	F	29	R	3	20	2	20	7	−13
13	M	64	R	5	52	8	8	18	−34
14	F	67	L	24	30	10	10	5	−25
15	F	32	L	7	19	5	12	0	−19
16	F	42	L	2	20	4	17	0	−20
17	F	58	L	3	20	5	0	2	−18
18	M	17	R	15	25	1	26	−5	−30
19	M	19	R	2	25	12	10	5	−20
20	F	55	L	7	6	3	30	−10	−16
21	M	17	L	43	25	0	16	0	−25
22	M	45	L	2	25	6	6	10	−15
23	M	23	R	1	18	0	21	−5	−23
24	F	45	L	15	25	4	−5	10	−15
25	F	69	L	5	40	8	18	11	−29
26	F	55	L	6	35	10		5	−30
$n = 26$	F/7	g = 40	R/16	Avg = 9.2	23 degrees	4.5 mm	15 degrees ($n = 25$)	0.27 degrees	−22.6 degrees

with symptoms related to malunion of the distal radius who can benefit from distal radial osteotomy and bone grafting. The candidates for this procedure are younger individuals who have limited wrist motion, deformity (both cosmetic and radiographic), pain, and median or ulnar nerve dysfunction following healing of a Colles' fracture in an anatomically imperfect position. Fernandez stated the indication for osteotomy as a deformity of 25 to 30 degrees in either the frontal or sagittal plane, although some patients were operated on to eliminate deformity even when they had good wrist motion. DRUJ arthritis was said to be a contraindication, although this point is somewhat disputed by Ekenstam et al. [7] and Fernandez [8]. Restoration of the DRUJ relationship is an extremely important concept in considering this procedure [18]. If adjustment of the radius does not restore radioulnar joint congruity, additional steps (e.g., either radioulnar arthroplasty or ligamentous repair) should be taken [9]. We agree with Ekenstam et al. [7] that complete ulnar head resection (Darrach) should be restricted to patients with obvious degenerative changes in the DRUJ.

Strength is also a consideration and measurement of grip strength would have been a valuable addition to this study, but not enough preoperative values were available to make comparisons. Fernandez [8], however, has shown an average grip strength improvement in his patients of nearly 100% postosteotomy. Improvement in grip strength following osteotomy has also been recorded by Ekenstam et al. [7].

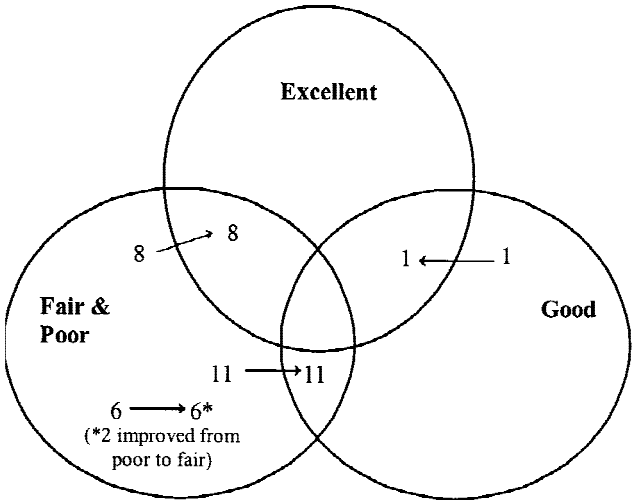

Fig. 2. Venn diagram of patient rating change from pre- to postosteotomy.

Although an earlier report [12] suggested that good or excellent results in Colles' fractures could be obtained with-

Table 2. Study results

Postoperative shortening (mm)	Change in shortening (mm)	Postoperative radial slope (degrees)	Change in radial slope (degrees)	Preoperative score	Postoperative score	Change in score	Result	Follow-up (months postop)
2	−2	19	15	13	4	−9	Good	81
3	−1	13	−2	15	9	−6	Fair	68
5	0	25	10	20	2	−18	Excellent	87
9	4	15	−5	16	2	−14	Excellent	125
0	−4	20	9	20	4	−16	Good	101
0	−4	23	5	20	4	−16	Good	66
2	−2	19	−4	15	4	−11	Good	134
2	−3	25	0	11	11	0	Fair	26
2	0	17	2	18	2	−16	Excellent	92
0	0	31	12	17	13	−4	Fair	128
2	−1	24	4	23	2	−21	Excellent	150
1	−1	22	2	13	4	−9	Good	76
5	−3	15	7	21	20	−1	Poor	75
0	−10	20	10	9	4	−5	Good	137
1	−4	31	19	19	1	−18	Excellent	90
2	−2	15	−2	8‡	4	−4	Good	85
0.5	−4.5	17	17	13	4	−9	Good	68
3	2	19	−7	14	4	−10	Good	24
1	−11	5	−5	17‡	2	−15	Excellent	42
3	0	17	−13	14	3	−11	Good	38
1.5	1.5	15	−1	9	1	−8	Excellent	45
1	5	11	17	18‡	2	−16	Excellent	53
0	0	34	13	4‡	0	−4	Excellent	29
4	0	0	−5	21	18	−3	Fair	38
4	−4	16	−2	19	9	−10	Fair	28
4	−6			16	4	−12	Good	137
2.2 mm	−2.1 mm	18.7 degrees (n = 25)	3.8 degrees (n = 25)	15.5	5.3	−10.2		Avg = 78.1 months

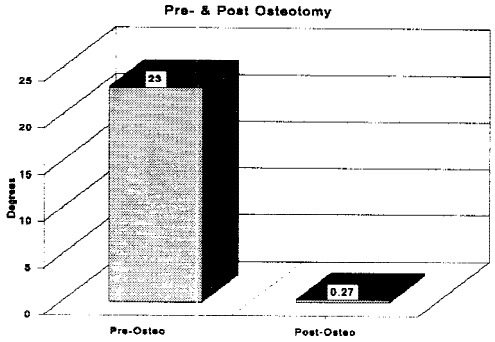

Fig. 3. Average pre- and postosteotomy dorsal tilt.

out restoring volar tilt, more recent initial treatment efforts have focused on accurate anatomic alignment even if this requires pins, external fixators, or even open reduction and internal fixation [3,6,11,15,17,23].

Precisely how much malalignment can be tolerated by the wrist joint has not been determined, but certainly some imperfection is not incompatible with long-term satisfactory function [1,2,17,19,21,23]. A study by Short et al. [21] demonstrates fairly conclusively, by pressure-sensitive film measurements, that loss of normal palmar tilt after simulated radial fracture leads to progressive load on the ulnocarpal and radioscaphoid joints. Loads become concentrated along the dorsal rim of the articulation, resulting in pain and ultimately joint degeneration [21]. Their study demonstrates that at 40 degrees of dorsal tilt, the majority of load is carried by the distal ulna, which they believe contributes to pain and early DJD development. Radial shortening has also been described as causing the greatest change in the DRUJ mechanics, leading to distortion of the triangular fibrocartilage, joint stiffness, and impairment of function with increased risk of permanent disability [1,2,18,19]. Therefore, radial length should be restored as close as possible. The development of midcarpal instability following malunited fractures of the distal radius has also been described [23]. Obviously, the spectrum of problems with any sort of distal radial malunion is a continuum.

It follows from these indicators and from our intuition that malunion of the distal radius should be corrected in some patients by performing an osteotomy. Modern papers, from Ekenstam et al. [7], Fernandez [8,9], Jupiter et al. [13,14], Posner and Ambrose [20], and Watson and Castle [24], attest to the value of distal radial osteotomy. Prior procedures of Campbell, Speed and Knight, Merle D'Aubigne, and Tubiana used nonstable fixation methods and cannot really be compared to the more recent series. Although the papers cited above provide a considerable body of knowledge regarding distal radial osteotomy, medium or long-term follow-up of patients has not been frequently done. Although Ekenstam et al. [7] report 39 patients treated by osteotomy with an average follow-up of 1.5 years (6–48 months), they do not identify which patients in the series were followed for at least 24 months. Ninety-two percent of the group was considered to have a good or excellent result [7]. Posner and Ambrose [20] reported improvement in each of 14 patients treated by biplanar osteotomy. However, they report only an average follow-up of 62 months (ranging from 19 to 118 months) and did not identify patients who were followed for at least 24 months. Watson and Castle [24] reported 15 patients treated by trapezoidal osteotomy at an average follow-up of 46 months (18–116 months). All patients were "pleased" with the outcome. All of Fernandez' [8] patients were followed for at least 24 months. Seventy-five percent of his patients were rated good or excellent. In a second paper, Fernandez [9] describes his results in 15 patients treated with osteotomy plus resection arthroplasty of the DRUJ. Eighty percent of these patients, followed for at least 24 months, were rated "very good" or "good." It has been the belief of one of us (G.L.L.) that even a short follow-up, i.e., the time for healing of the osteotomy and rehabilitation of the hand and wrist, provides meaningful information and that results would not necessarily be expected to deteriorate with further time. This notion has been borne out by this study where longer follow-up was done. Although rating systems vary among studies, our intermediate-term results indicate comparable and sustainable results to other published studies. This indicates that there is a definite indication for the procedure in certain individuals.

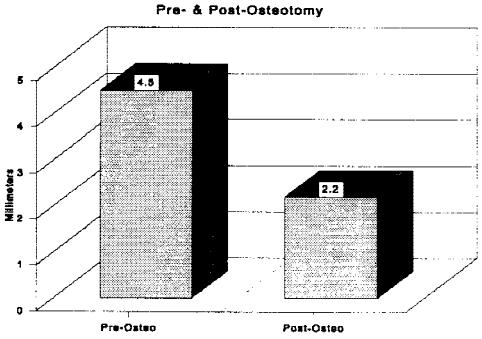

Fig. 4. Average pre- and postosteotomy radial shortening.

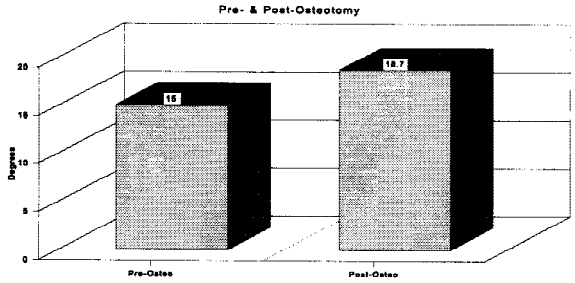

Fig. 5. Average pre- and postosteotomy radial slope.

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