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ORIGINAL STUDY

The Darrach procedure for post-traumatic reconstruction

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Over a 6-year-period, 15 women and 11 men with a mean age of 53 years (range, 24 to 80 years) had resection of the distal part of the ulna (Darrach's procedure) to address stiffness, instability, non-union, or substantial radioulnar length discrepancy after trauma. At an average follow-up of 21 months (range, 4 to 60 months), the improvement in total arc of forearm rotation averaged 87° (range, 0° to 160°), from an average of 49° to an average of 136° ($p < 0.001$). The proportion of patients with occasional or continuous pain after the Darrach procedure (7 after vs. 16 prior ; $p = 0.04$) was significantly reduced. Only two patients had reoperation related to the residual ulna.

In this study, the Darrach procedure improved forearm rotation and pain in patients with posttraumatic stiffness, instability, nonunion, or substantial radioulnar length discrepancy with a low complication and re-operation rate.

Keywords : distal ulna resection ; Darrach.

INTRODUCTION

Resection of the distal ulna as credited to Darrach (*7, 19*) may be considered for patients with dysfunction of the distal radial ulnar joint (DRUJ) resulting from trauma, inflammatory arthritis, or congenital deformities. In patients with post-traumatic DRUJ dysfunction, the indications for the Darrach procedure include pain, instability, and limited range of forearm motion.

Most studies have reported satisfactory results of the Darrach procedure, with marked improvement in pain relief and range of movement, and minimal loss of grip strength (*1,5,8,14,17,22,25-27*). However, the Darrach procedure has fallen out of favour recently as a result of publications that reported failure of pain relief and poor outcome in some patients (*2,3,9,12,13,23,24*).

Persistent pain after the Darrach procedure has been ascribed to instability of the ulnar stump, with or without impingement of the ulnar stump on the radius as described by Bell *et al* (*2*). Concern regarding ulnar stump instability has greatly reduced the appeal of the Darrach procedure to the point that many surgeons seem reluctant to consider this

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procedure nowadays. Reported alternatives for DRUJ reconstruction include the Sauve-Kapandji procedure (*16*), partial resection of the distal ulna as described by Watson (*28*) or Bowers (*4*), an ulna diaphyseal shortening osteotomy (*6*), a distal ulna wafer resection (*10*), or ulnar head replacement (*15*), but all of these procedures have mixed results (*11,13,18, 21,24*) and the optimal treatment for DRUJ dysfunction remains uncertain and debatable.

An argument can be made that Darrach resection of the distal ulna is the simplest and one of the most predictable ways to address complex post-traumatic DRUJ dysfunction including stiffness, instability, substantial radioulnar length discrepancy, or non-union of the distal ulna. It can also be argued that the primary perceived failure of the Darrach procedure is in pain relief, which remains the most challenging and unpredictable of indications at any anatomical site. Our hypothesis was that when the Darrach procedure is used not solely for pain relief, but rather primarily to gain forearm mobility or to address distal radioulnar dislocation, distal ulnar non-union, or severe radioulnar length discrepancy, it relatively predictably achieves these goals without a substantial risk of disabling pain or re-operation.

MATERIAL AND METHODS

Between 2000 and 2006, two surgeons performed the Darrach procedure in 66 patients. During this period only 7 patients had alternative procedures for DRUJ dysfunction (2 hemiresection arthroplasties, 2 Sauve-Kapandji procedures, 1 distal ulna wafer resection, 1 Darrach procedure combined with a extensor carpi ulnaris stabilization, and 1 ulnar head prosthesis).

We were interested in adult patients in whom Darrach's resection of the distal ulna was performed for post-traumatic reconstruction to treat stiffness, instability, non-union of the ulna or prior Sauve-Kapandji procedure, or substantial radioulnar length discrepancy in the setting of a complex post-traumatic skeletal deformity of the radius (non-union, mal-union, or radiocarpal arthritis), greater than 4 months after the original injury. We excluded patients under age 18 (1 patient), patients in whom the Darrach procedure was performed for the sequelae of rheumatoid arthritis (9 patients), for problems arising from other non-traumatic illnesses (tumour, burn, or compartment syndrome ; 7 patients), when the Darrach procedure was part of the management of an acute traumatic injury (within 4 months of injury ; 6 patients), and in post-traumatic patients for whom the primary indication for surgery was pain relief (10 patients), and patients with fewer than 4 months follow-up after the Darrach procedure that we were unable to contact (7 patients), leaving a cohort of 26 patients satisfying the inclusion and exclusion criteria.

Using an Institutional Review Board approved protocol, we reviewed the medical records of these 26 patients and invited patients with fewer than 12 months follow-up to return for a free evaluation. Six patients had a specific research evaluation by an investigator not involved in the care of the patients an average of 37 months (range, 11 to 60 months) after the index procedure. The mean follow-up in these 26 patients was 21 months (range, 4 to 60 months). Among these 26 patients there were 15 women and 11 men with a mean age of 53 years (range, 24 to 80 years) at the time of surgery. On average, the Darrach procedure was performed 18 months (range, 4 to 127 months) after the original injury.

The original traumatic injury was a fracture of the distal radius in 21 patients, diaphyseal fractures of the radius and ulna in 2 patients, two posterior olecranon fracture-dislocations of the elbow (one with ipsilateral transcaphoid perilunate fracture dislocation), and a crush injury with hand fractures but no forearm fractures in 1 patient. The initial treatment was operative in 23 patients and non-operative in 3 patients. An average of 1.4 surgeries (range 0 to 3) was performed prior to the index Darrach procedure. Two patients had a wrist arthrodesis to address radiocarpal arthritis at the time of the Darrach procedure.

Indications

The indication for Darrach's procedure was severe restriction of forearm rotation in 16 patients, substantial radioulnar length discrepancy in the setting of an ununited fracture of the radius treated simultaneously in 5 patients (4 distal radius, and one radial diaphysis), chronic instability of the distal radioulnar joint in 2 patients, non-union of a fracture or osteotomy of the ulna in 2 patients, and an ununited Sauve-Kapandji procedure in 1 patient (figures 1 and 2). Three of the patients treated for stiffness had concomitant release of a proximal radioulnar synostosis related to an associated elbow injury. These were performed concurrently with the Darrach procedure in 2 patients, and 5 months before the Darrach procedure in 1 patient. Two patients had a wrist arthrodesis to address radiocarpal arthritis at the time of the Darrach procedure.

Fig. 1. — A 32-year-old man with long standing malunion of the radius and distal radioulnar joint instability presented with complaints of pain and supination limited to 10°.
a : An oblique radiograph shows the malunion and malalignment of the distal radioulnar joint.
b : After Darrach resection of the distal ulna, his pain was resolved and he had full forearm rotation.

Evaluation

An investigator not involved in the initial care of the patients evaluated pre-operative and latest follow-up wrist flexion and extension, forearm rotation, and pain status from the medical records. Standard posteroranterior and lateral radiographs were evaluated for signs of chronic radioulnar impingement defined by a mark or groove on the distal radius.

The 6 patients that returned for a research-specific evaluation had a specific radiographic evaluation including standard posteroanterior and lateral radiographs, and stress-loaded (patient holding a 2.5-kg weight) posteroanterior radiographs with the shoulder at the side, the elbow flexed at 90°, and the forearm in neutral rotation (*20*). The stress-loaded radiographs were used in order to evaluate signs of radiographic dynamic radioulnar convergence, as reported by McKee and Richards (*23*). The minimum distance between ulnar stump and radial shaft was measured and compared in resting and stress-loaded radiographs. A smaller radioulnar distance in stress-loaded radiographs represents "dynamic radioulnar convergence", signs of actual contact between the bones was described as radioulnar impingement.

Pre-operative evaluation

Prior to the index Darrach resection of the distal ulna, the average arc of wrist flexion and extension was 55° (range, 20° to 140°) with an average flexion of 29° (range, 10° to 70°) and an average extension of 26° (range, 0° to 70°). In three patients with severe instability of a non-united fracture of the distal radius, it was not possible to measure wrist flexion arc.

The average arc of forearm rotation was 49° (range, 0° to 160°), with an average pronation of 30° (range, 0° to 80°) and an average supination of 19° (range, 0° to 80°). There were 24 patients with a forearm arc of rotation 100° or less, 3 of whom had concomitant proximal radioulnar synostosis.

Six patients had rest pain, 10 reported pain with some activities of daily living, and 9 patients had no pain before the Darrach procedure. In one patient, pain status was not recorded.

Statistical analysis

We compared pre-operative data to data at the latest post-operative follow-up moment. For continuous data (range of motion) a paired t-test was used. Categorical data (pain-score) were evaluated using McNemar's test. P-values of less than 0.05 were considered statistically significant.

RESULTS

Complications and subsequent surgery

One patient with residual pain had a second procedure to remove bony protuberances from the ulnar stump, combined with an extensor carpi ulnaris tenodesis. One patient had radioulnar impingement related to malunion of the radius that resolved with radial osteotomy. One

Fig. 2. — A 65-year-old woman had a nonunion of her ulna after an ulnar shortening osteotomy and 2 subsequent surgeries to try to gain union.
a and b : Posteroanterior and lateral radiographs after removal of the distal part of the ulna. Her pain was resolved and function fully restored.

patient had removal of a distal radius plate and another had revision of a hypertrophic scar.

Final evaluation

Patients were evaluated an average of 21 months (range, 4 to 60 months) after the index Darrach procedure and after all subsequent surgeries. Seven patients reported pain during activities of daily living. Nineteen patients reported no complaints of pain at all. One patient had occasional non-painful clicking with forearm rotation, but no radiographic signs of radioulnar impingement.

Excluding the 2 patients that had a wrist arthrodesis, the average arc of wrist flexion and extension was 83° (range, 30° to 140°) with an average flexion of 42° (range, 5° to 70°) and an average extension of 41° (range, 10° to 70°). The average arc of forearm rotation was 136° (range, 20° to 160°), with an average pronation of 71° (range, 10° to 80°) and an average supination of 65° (range, 10° to 80°). At the final evaluation after the Darrach procedure, there were only 3 patients with an arc of forearm rotation less than 100°, and 2 of these 3 patients were also treated for a proximal radioulnar synostosis.

In 2 patients (8%), there were radiographic signs of contact between the ulna and radius, defined by a mark or groove on the distal radius. Neither patient reported pain or clicking.

Comparison of pre-operative and final evaluation

The improvement in total arc of forearm rotation averaged 87° (range, 0° to 160° ; from an average of 49° to an average of 136° ($p < 0.001$) with an average improvement in supination of 46° (range, 0° to 80° ; from an average of 19° to an average of 65° ($p < 0.001$) and an average improvement in pronation of 41° (range, 0° to 80° ; from an average of 30°to an average of 71° ($p < 0.001$).

Excluding patients with severe pre-operative instability and patients treated with arthrodesis, the average improvement in total wrist flexion-extension arc was 23° (range, -15° to 90°), from an average of 58° to an average of 81° ($p = 0.004$), with an average improvement in wrist flexion of 11° (range, -5° to 45°, from an average of 30° to an average of 41°, ($p = 0.004$) and an average improvement in wrist extension of 12° (range, -20° to 55° , from an average of 28° to an average of 40° ($p = 0.01$).

The number of patients with occasional or continuous pain after the Darrach procedure (7 after vs. 15 prior ; $p = 0.04$) was significantly reduced.

Research-related follow-up visit

The average DASH-score of the six patients that returned for a research-specific evaluation was 30.6 points (range, 3 to 68 points). None of these 6 patients reported rest pain or clicking. On radiographic evaluation 5 of the 6 patients had some dynamic radioulnar convergence (average of 8.4 mm ; range, 2.5 to 13.3 mm) and one patient had a larger radioulnar distance on the stress-loaded radiograph (-2.1 mm, from 0.7 to 2.8 mm). In one patient, there was evidence for chronic radioulnar impingement, defined by grooving on the radius on standard radiographs. Additionally, two patients without signs of impingement on standard radiographs demonstrated radioulnar contact on the stress-loaded radiograph.

DISCUSSION

Our results suggest that Darrach's resection of the distal ulna is a useful procedure for patients with posttraumatic forearm stiffness or instability, or substantial radioulnar length discrepancy in the setting of a complex reconstructive procedure. In particular, the Darrach procedure achieved substantial gains in forearm rotation in our patients.

Very few patients had a groove on the radius as evidence of convergence. Most patients in whom stress radiographs were obtained had some dynamic radioulnar convergence. Nonetheless, pain was uncommon and not clearly related to radioulnar convergence, either dynamic or with a groove on radiographs.

Several reports document the utility of the Darrach procedure, describing consistent improvement in range of motion, diminished pain in most patients, and no instances of increased disability (*1,5,8,17,22*). Others have not been as satisfied (*2,3,9,12,13,23,24*). For instance, Bieber *et al* documented persistent complaints of pain, limitation of motion, snapping, or weakness in 20 of 288 patients (7%) treated with the Darrach procedure (*3*), a rate that might be considered acceptable in the treatment of complex reconstructive problems.

More striking is the report of Ekenstam *et al* that 12 of 24 (50%) patients treated with the Darrach procedure after fracture of the distal radius rated themselves as not improved. Range of motion improved in 75% of patients, and none had a worse range of motion. Pain was unchanged in 54% and improved in 33%. Of the 13 patients with a relatively normal DRUJ alignment, only 4 (31%) were satisfied with the procedure (*9*). This supports our opinion that the Darrach procedure is most useful when there is a discrete, objective problem at the DRUJ with associated impairment of forearm rotation, where the potential benefit of resection of the distal ulna is clear, in contrast with surgery where the primary indication is pain relief and the anatomy is relatively preserved.

Both George *et al* and Minami *et al* compared the Darrach procedure to the Sauve-Kapandji (SK) procedure retrospectively and found relatively comparable results (*13,24*). Both procedures have the potential disadvantage of symptomatic instability of the ulnar stump, the most severe type of which results in impingement of the ulnar stump on the radius. Reports such as that of Bell *et al* describing 10 patients referred for painful impingement

between the ulnar stump and the radius after a Darrach procedure (*2*) have increased our concern about potential radioulnar impingement.

On the other hand the report of McKee and Richards was more reassuring, identifying dynamic radioulnar convergence in 14 of 25 patients that had a Darrach procedure for posttraumatic complications (*23*), but no correlation between convergence and Gartland and Werley wrist scores. In 5 of their patients, the radius and ulna demonstrated actual contact on radiographs, but only 2 of these patients had pain.

Our study is consistent with that of McKee and Richards (*23*). Radioulnar impingement was uncommon and inconsistently symptomatic. The same was true for dynamic radioulnar convergence, although we evaluated this in a very small subset of patients. Only two patients (8%) had surgery to address residual symptoms at the distal radioulnar joint, and one of these patients had osteotomy of a malunited radius.

The weaknesses of our study are common to most studies of DRUJ reconstruction, including the relatively small patient cohort, the fact there was no control group, the relatively short follow-up period, and the lack of specific radiographic tests in all patients. Our patients had complex problems and often had concomitant procedures, which would be expected to be detrimental to our results. Since our aim was to reinforce that Darrach's procedure can be useful for complex post-traumatic forearm impairment, we believe that our results reflect what patients and surgeons should expect.

We chose to exclude the ten patients treated during the study period that had limited impairment and relatively preserved anatomy in whom the primary indication for the Darrach procedure was pain relief rather than stiffness, nonunion, instability, or length discrepancy. Ten patients is too few to make any meaningful comparisons.

Keeping these limitations in mind, we believe that our retrospective case series supports the use of the Darrach procedure for patients with discrete problems (stiffness, instability, nonunion, and marked radioulnar length discrepancy) that are clearly related to distorted anatomy at the distal radioulnar joint. Until more definitive, controlled data are produced, our experience would suggest that the problems related to dynamic convergence and radioulnar impingement after Darrach's procedure are probably an acceptable trade off for the diminished impairment achieved in these complex post-traumatic forearm problems.

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