Reconstruction of Mason type-III and type-IV radial head fractures with a new fixation device

23 patients followed 1–4 years

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Background **Treatment options in radial head fractures of Mason types III and IV range from open reduction and internal fixation (ORIF) to radial head resection with or without prosthetic replacement.**

Patients **In a prospective study, the radiographic and clinical outcome was evaluated in 23 patients (age median 51 years) with 23 complex radial head fractures median 2 (1–4) years after ORIF using a new fixation device (FFS; Orthofix). 14 Mason type-III fractures with 2 concomitant olecranon fractures and 1 ulnar nerve lesion, and 11 type-IV fractures with 2 olecranon fractures and 2 fractures of the coronoid process were treated. 2 patients were lost to follow-up. In 7 cases of joint instability, an elbow fixator with motion capacity was applied after ORIF of the radial head.**

Results **No radial head resection was necessary. No secondary dislocations or nonunion occurred. The Morrey elbow score was excellent in 8 and good in 4 Mason type-III fractures and excellent in 5, good in 3, and fair in 3 Mason type-IV fractures.**

Interpretation **Reconstruction of comminuted radial head fractures can be performed with this device and radial head resection can be avoided.**

Nonoperative treatment with early mobilization is well accepted in the management of minimally displaced radial head fractures (Broberg and Morrey 1986, Colemann et al. 1987, Esser et al. 1995). With an intraarticular step of 2 mm or more, early arthritic changes are more likely to occur, and therefore open reduction and internal fixation is recommended (Mason 1954, Lindemann-Sperfeld et al. 2002, Herbertsson et al. 2004, King 2004). There are different treatment concepts for comminuted radial head fractures (Mason type III) and radial head fractures with concomitant elbow dislocation (Mason type IV). Besides several reconstruction techniques, removal of the radial head with or without prosthetic replacement is recommended, but long-term results have shown that although good or fair results can be achieved, the outcome is less favourable in Mason type-IV fractures (Lindemann-Sperfeld et al. 2002, Ring et al. 2002, Herbertsson et al. 2004, Obert et al. 2005). Several studies have indicated that there may be serious problems after radial head resection, making reconstruction more desirable (Esser et al. 1995, Hotchkiss 1997, Pomianowski et al. 2001). A recent study showed the value of the FFS system in medial malleolar fractures (Rovinsky et al. 2000). A mechanical study with bovine cancellous bone has proven the superior holding power of these machine-threaded implants (FFS) relative to conventional cancellous screws (Gausepohl and Pennig 2000. Gausepohl et al. 2001). We evaluated this implant in a prospective study in Mason type-III and type-IV fractures.

Patients and methods

From 1997 to 2002, 90 patients (48 males) with 90 displaced radial head fractures were treated according to a prospective protocol with two aims.

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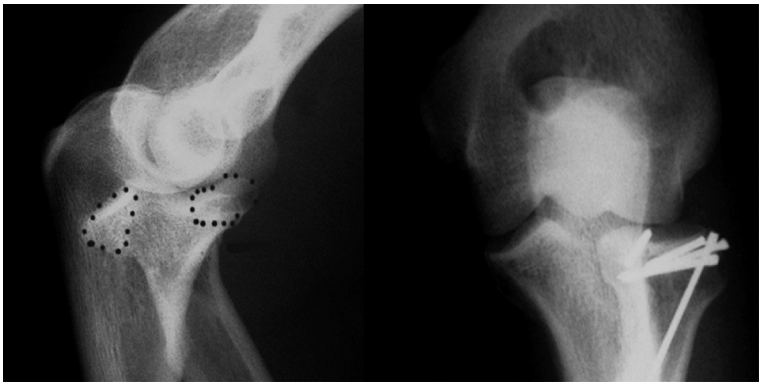
Figure 1. The elbow of a 43-year-old man with a comminuted radial head fracture (Mason type III).



A. The 2 main fragments are delineated by dotted lines. Additional fragments could not be seen in the preoperative radiographs.

B. The radial head was reconstructed using fine-threaded FFS implants. The radial head was separated from the shaft and fixed with 1 implant in an oblique direction from the head into the shaft. The postoperative clinical result was excellent with a free pro- and supination and a ROM of 0/0/140 degrees.

One aim was to avoid radial head resection and the second was to evaluate the clinical and radiological outcome after internal fixation with the FFS system (Orthofix, Bussolengo, Italy). The fractures were classified according to Mason (1954), as modified by Broberg and Morrey (1986). 65 patients had Mason type-II fractures, all of which were radial head fractures. Isolated radial neck fractures in the Mason type-II subgroup were excluded, because those were treated with ascending intramedullary bundle nailing. There were 14 Mason type-III fractures, 10 of which were radial head fractures. 4 patients had additional radial neck fractures with complete separation from the shaft. Among the type-III fractures, there were 2 concomitant olecranon fractures and 1 ulnar nerve lesion. All 11 Mason type-IV fractures were comminuted and 2 were additionally separated from the radial shaft. In all Mason type-IV fractures, a CT scan was performed to reveal any additional injuries and the degree of comminution and dislocation of the fragments. There were 2 olecranon fractures and 2 fractures of the coronoid process (Reagan/Morrey type II). In 7 cases of joint instability in Mason type-IV fractures, re-dislocation of the elbow joint occurred after reconstruction of the radial head when tested under an image intensifier in the operating room.

Following Kocher's approach, we used the FFS system (1.2 mm and 1.6 mm in diameter) for internal fixation after fracture reduction (Gausepohl et al. 2000, 2001). The implants are self-drilling and self-cutting, and are inserted directly into the fragment with the drilling machine. No temporary K-wire fixation and no pre-drilling are necessary before implantation. A proximal shoulder of the implant is responsible for its autocompression. Chisel fractures were fixed with the implants in a transverse direction. If the head was separated from the shaft, FFS implants were inserted in an oblique direction from the head into the shaft (Figure 1). In cases with comminuted and dislocated fragments, the radial head was reconstructed first, even with (in 2 cases) an on-table procedure. Fixation of the head to the radial shaft then followed using the aforementioned technique. At the end of the procedure, all implants were cut flush at the cartilage level, implant removal was not intended. An above-elbow plaster cast was applied postoperatively for 6 days. In all patients, daily physiotherapy started on day 6 and 50 mg Indomethacin with gastric protection was given twice a day for 6 weeks.

Ligament injuries and any coronoid fractures were not approached according to the concept of using a joint-bridging elbow fixator with motion capacity (Orthofix) in acute fracture dislocations

Patient data and results (median values) of 23 patients with comminuted radial head fractures (of Mason types III and IV)

	Mason type III	Mason type IV	Overall
No. of cases	12	11	23
Median age (range)	38 (45–63)	61 (38–79)	51 (38–79)
Months of follow-up (range)	24 (12–43)	30 (18–51)	26 (12–51)
ROM [a] (range)	125 (90–130)	125 (80–130)	125 (80–130)
Flexion (range)	130 (120–140)	130 (115–140)	130 (115–140)
Loss of extension (range)	5 (0–30)	5 (0–30)	5 (0–30)
Pronation (range)	85 (70–90)	85 (30–90)	85 (30–90)
Supination (range)	85 (60–90)	70 (0–90)	85 (0–90)
Elbow score (range)	97 (84–100)	97 (58–100)	96 (58–100)

[a] ROM: degrees flexion–extension

of the elbow (Gausepohl et al. 1999, Ruch and Triepel 2001). In 7 patients with a Mason type IV-fracture, the elbow remained unstable after fixation of the radial head and the aforementioned external fixation was performed. In these cases, the elbows were mobilized after soft tissue swelling had abated after a mean of 6 days.

Functional results were evaluated according to Morrey (1993), with consideration of motion, strength, pain, stability and daily activities. Motion was measured with a standard goniometer. Radiographic results were evaluated according to the measurement of reduction, intraarticular step-off on AP, and lateral radiographs at the most recent follow-up examination using computer software (MorphometT; Mockenhaupt, Germany). Nonunion or arthritic changes were evaluated according to the criteria of Broberg and Morrey (1986) and categorized as grade 0 (absent; normal elbow), grade 1 (mild changes), grade 2 (moderate changes) and grade 3 (severe degenerative changes).

Results

23 of 25 patients with a Mason type-III or type-IV fracture were followed for a median of 2 (1–4) years after reconstruction of the radial head (Table). 2 patients with Mason type-III fractures were lost to follow-up. The measurements and the functional assessment were performed by TCK, who was not involved in the operations. Anatomical reduction was achieved in 22 of 25 patients. In the remaining 3 patients, a step-off of more than 1 mm was detected in the postoperative radiographs. There were no nonunions in any of the 23 patients followed, and no recurrent dislocations and no pin-tract infections during external fixation of the seven patients with remaining instability after ORIF. In 2 cases, a partial migration of one implant led to a partial hardware removal with an additional surgical procedure. In all cases, reconstruction of the radial head was performed and radial head resection was avoided. In Mason type-III fractures, there were mild arthritic changes in 4 patients (grade 1) and moderate arthritic changes in 2 patients (grade 2); in type-IV fractures, there were 3 mild and 2 moderate arthritic changes at the time of follow-up. There was no correlation between radiographic results and clinical outcome.

Excellent results were achieved in 8 Mason type-III fractures and good results in 4, according to the Morrey score (Figure 1; Table). In type-IV fractures, there were 5 excellent, 3 good, and 3 fair results (Figure 2; Table). 7 patients with external fixation after ORIF of their Mason type-IV fracture had 4 excellent, 2 good and 1 fair results. At the time of the final assessment, no joint instability and no deformity were observed.

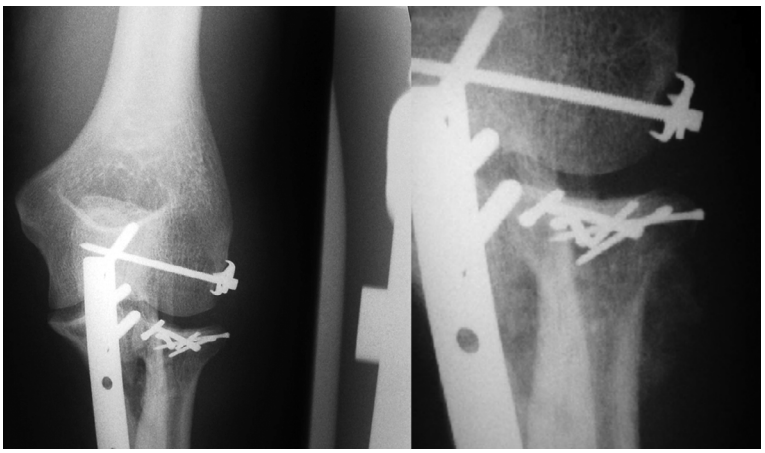
Discussion

Mason (1954) evaluated the results of 100 radial head fractures and his conclusion, “if in doubt, resect”, became widely accepted. In a recent paper, Herbertsson et al. (2004) reported good elbow motion after radial head resection without replace-

Figure 2. A 55-year-old man with a comminuted radial head fracture and olecranon fracture after elbow fracture dislocation.

Preoperative radiograph.

CT-scan showed a comminuted radial head fracture of Mason type IV.



Anatomical reconstruction of the radial head was performed. In addition to plating of the olecranon and refixation of an avulsed ulnar collateral ligament, an elbow fixator with motion capacity was used to control instability and alignment of the humeroulnar and humeroradial joint. Postoperative clinical outcome was good with a pro- and supination of 90/0/45 and a ROM of 0/20/130 degrees.

ment in Mason type-II, type-III, and type-IV fractures. Range of motion values were not given for the Mason type-III and type-IV subgroups, and the authors found severe pain in 4 of 12 patients with Mason type-IV fractures. Although clinically asymptomatic, they reported a large number of positive Tinel signs over the ulnar nerve and a larger number of ulna plus deformities after radial head resection. Interestingly, there was no difference in the outcome of primary versus delayed or secondary radial head resection (Herbertsson et al. 2004).

Others have increasingly recognized the radial head as an important stabilizer of the forearm and elbow (Ring et al. 2004). Resection of the radial head may lead to secondary problems including radial shortening with subsequent distal radioulnar pain, persistent instability in some type-IV injuries, loss of strength, cubitus valgus, and ulnar nerve neuritis (Mikic and Vukadinovic 1983, Hirvensalo et al. 1990, Ikeda et al. 2005). Thus, joint replacement or implantation of a radial head spacer is recommended, especially in cases of medial collateral

ligament injury where the radial head is important for prevention of valgus deformity (Hirvensalo et al. 1990, Frankle et al. 1999, King 2004). Reconstruction of the radial head is usually performed using a miniscrew or miniplate system (Mason 1954, Sanchez-Sotelo et al. 2000, Ring et al. 2002). More recently, absorbable pins have been developed (Hirvensalo et al. 1990, Esser et al. 1995, Rehm et al. 1997). These implants require a sequential procedure involving several steps (Ikeda et al. 2005), leading to the statement that fractures with more than 3 fragments are predictive of poor results with operative fixation (Ring 2004). The use of implants that are not suitable to address small fragments in comminuted radial head fractures leads to a high rate of radial head resection, followed by the problems described above (Ikeda et al. 2005).

Ikeda et al. (2003, 2005) were the first to demonstrate good clinical results after open reduction and internal fixation of comminuted radial head fractures, but they mentioned that reconstruction using miniplates is technically demanding and that not all radial heads are suitable for this type of internal fixation.

Although this study lacked a control group of patients with radial head resection or prosthetic replacement in complex radial head fractures, our results confirm that comminuted radial head fractures of Mason types III and IV can be treated with preservation of the radial head, and with excellent or good functional results. The grade of comminution and the pattern of concomitant lesions in our study are simular to those in the study of Ikeda et al. (2003). One explanation for the ability to reconstruct all comminuted radial head fractures in our study may be the versatility and holding power of the device used. The FFS system was designed as a one-step screw system (Gausepohl et al. 2001). The implant addresses even the small fragments, to reconstruct the radial head in conditions in which others implants seem too bulky. Even completely detached fragments of the radial head seem to revascularize when adequately fixed. We believe that the one-step technique of fragment fixation to address very small fragments is the key to our good results in radial head reconstruction. In cases of high comminution, the FFS system is still successful—even in situations where conventional implants fail.

As a consequence of our results, we no longer agree with the old dogma, "if in doubt, resect," even with comminuted fractures. Fracture-adapted internal fixation seems to be helpful in reconstruction of difficult radial head fractures. Primary resection of this important stabilizer should not be considered lightly.

Contributions of authors

TCK: performed the study. KM: helped with radiographic measurements and with preparation of the manuscript. TG and DP: operating surgeons, helped with preparation of the manuscript.

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