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Outcome following excision of the radial head in children with open physes for impaired elbow motion

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Background: Only few reports have described the outcome of pediatric patients following radial head resection. Therefore, the aim of the present study was to assess clinical and radiologic outcome of patients with open physes following resection of the radial head.
Materials and methods: Skeletally immature patients treated with resection of the radial head were included. Range of motion (ROM) of the elbow joint was compared with preoperative values. Grip strength, pronation and supination strength, and carrier angle were compared with the unaffected side. Radiographs were assessed for signs of arthrosis, radial migration, and perifocal ossification. Disabilities of the Arm, Shoulder and Hand and Mayo Elbow Performance scores were obtained.
Results: The study included 7 patients (mean age, 11 years), 5 with post-traumatic and 2 with congenitally impaired elbow joint motion. Mean follow-up was 47 months. Pronation/supination ROM improved significantly ($P = .018$). Extension/flexion ROM did not improve significantly ($P = .122$). Although grip strength ($P = .027$) and pronation strength ($P = .028$) of the affected side were significantly lower compared with the contralateral side, supination strength did not differ significantly ($P = .176$). The carrying angle was increased in 3 patients. Significant radial migration occurred (mean, 3 mm; standard deviation [SD], 3 mm; $P = .018$). Arthrosis was found in 3 patients. The mean Disabilities of the Arm, Shoulder and Hand score was 16.1 (range 8.8-30.8; SD, 10.1) and mean Mayo Elbow Performance Score was 88 (range, 70-100; SD, 12).
Conclusions: Radial head excision may be considered for selected patients with open physes in cases of severe impairment of pronation/supination. However, sequelae such as radial migration, arthrosis, and elevation of the carrying angle should be expected.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Pediatric; open physes; post-traumatic; congenital; impaired elbow joint motion; radial head excision

In children, limited motion of the radiocapitellar joint can exist due to developmental malformations, such as congenital radial head dislocation and radioulnar synostosis, or develop secondary to trauma.[8] In affected patients without

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limitations in activities of daily living, watchful waiting may be sufficient. However, resection of the radial head might be indicated in cases of severe impairment of range of motion (ROM) or pain if nonoperative or alternative operative methods have failed.[8] In adults, radial head excision is described as an effective treatment for comminuted radial head fractures without associated instability.[4,5] However, in patients with open physes, resection of the radial head has not been as commonly performed due to the rarity of malformations necessitating this operative procedure as well as concerns regarding sequelae such as regrowth of the radial head, cubitus valgus, early arthrosis, and potential derangement of the wrist following proximal radial migration.[11,14,16,17]

The currently existing reports describing functional outcomes of radial head resection have included heterogeneous groups of patients regarding concomitant instability and age.[1] Only a few reports have described the outcome of radial head resection of patients with open physes.[5,6,8] The present retrospective cohort study with prospective follow-up assessed the clinical and radiologic outcome of a series of children with open physes following resection of the radial head.

Materials and methods

All skeletally immature patients treated with resection of the radial head between 2005 and 2014 were included. Skeletal immaturity was defined as open physis of the proximal radius. Medical reports and radiographs were analyzed retrospectively. Information was obtained regarding the history of the patient and preoperative and postoperative ROM of the elbow joint, which were completely available for the retrospective review. All patients and their parents gave written consent for participation.

The operative procedure consisted of radial head resection and coverage of the bony defect with bone wax and an anconeus muscular flap to prevent periosteal calcification and radioulnar synostosis. Briefly, the anconeus muscle was freed from the ulna in a proximal direction, and the proximal attachment was left untouched. The muscle was then brought between the ulna and the radius, slung around the proximal radial stump, and reattached to the radial periosteum. At the end of the surgical procedure, the elbow joint was mobilized. No longitudinal instability was encountered, and neither valgus nor varus instabilities were found.

During inpatient care (mean, 7 days; standard deviation [SD] 2 days; range, 5-10 days) all patients received physical therapy with assisted active mobilization under regional anesthesia, which was maintained during the whole period of inpatient treatment. Subsequently, outpatient physical therapy was continued until no further improvement of ROM was recognized. A minimum of 2 cycles of physical therapy with 6 sessions each were performed. Postoperative ROM of the affected elbow joint was documented at the end of the outpatient rehabilitation phase.

All patients were invited to return for a follow-up clinical and radiologic examination. Pronation/supination and extension/flexion ROM of the affected side were measured, applying an inclinometer (Baseline Wrist Inclinometer; Fabrication Enterprises, Inc., Elmsford, NY, USA) and a goniometer and compared with preoperative and postoperative values. Grip strength of the affected and nonaffected sides was measured with a hand dynamometer (Baseline Hydraulic Hand Dynamometer; Fabrication Enterprises, Inc.). The carrying angle of both upper extremities was measured on the patient using a transparent goniometer by 2 examiners 3 times, and the mean of these measurements was calculated. Radiographs of the operated elbow joint in 2 planes and radiographs of both forearms (0° rotation view) were obtained and assessed for signs of arthrosis according to the Kellgren-Lawrence classification.[13]

For determination of radial migration, ulnar variance of both forearms was measured using the method of perpendiculars.[22] Briefly, a line is drawn through the ulnar border of the distal subchondral sclerotic radial line perpendicular to the radial shaft. A second line is drawn through the most distal portion of the ulnar head perpendicular to the ulnar shaft. Ulnar variance is measured as the distance between the 2 lines.

The Disabilities of the Arm, Shoulder and Hand (DASH) score[9] and Mayo Elbow Performance Score[18] were evaluated. Presence of pain caused by forced ulnar abduction of the wrist joint was documented. Valgus and varus stress tests were performed as described previously.[23] The elbow was placed in 15° flexion and maximal possible pronation for the varus stress test and in 15° flexion and maximal possible supination for the valgus test. Pain and instability were documented.

Statistical analysis

Data are reported as medians or means with the range and SD. Comparison of the preoperative, postoperative, and follow-up values for ROM of pronation/supination and extension/flexion of the elbow joint were performed with the Friedman test. Post hoc analysis with Wilcoxon signed rank tests was conducted with a Bonferroni correction applied. The remaining comparisons were performed with the Wilcoxon test. A P value of $<.05$ was considered statistically significant.

Results

Between 2005 and 2014, 7 children (4 girls, 3 boys) with open physes, with a median age of 11 years (range, 8-13 years) underwent resection of the radial head. The underlying reasons were post-traumatic dislocation in 3 patients, post-traumatic synostosis in 2, and congenital radial head dislocation in 2. One patient underwent reoperation due to radial head regrowth associated with painful elbow motion (patient 1). Time from index surgery to radial head resection was 6, 8, and 15 months for the patients with post-traumatic dislocations and 14 and 15 months for patients with post-traumatic synostosis. The nondominant side was operated on in 5 of the 7 patients.

Mean follow-up was 47.9 months (range, 24-76 months). All physes were closed at follow-up. The preoperative, postoperative, and follow-up pronation/supination and extension/flexion ROM results of the operated elbow joint are reported in Table I. Radial head resection led to a significant increase of pronation/supination ROM when preoperative and postoperative values were compared ($P = .012$), which was maintained at follow-up ($P = .018$; Fig. 1). However, the improvement of extension/flexion ROM was not statistically significant ($P = .122$).

Table I Individual preoperative, postoperative and follow-up ranges of motion for pronation/supination and extension/flexion of the affected elbow joint of 7 patients following radial head resection

Patient	Pronation/supination (°)			Extension/flexion (°)		
	Preoperative	Postoperative	Follow-up	Preoperative	Postoperative	Follow-up
1*	15/0/0	70/0/40	30/0/40	0/30/150	0/0/150	0/15/150
2*	90/20/0	70/0/90	80/0/90	0/0/90	0/5/140	0/25/120
3†	110/110/0	80/0/5	110/40/0	0/0/130	0/5/120	0/10/125
4†	5/0/5	70/0/85	40/0/60	5/0/100	0/0/140	20/0/130
5†	20/0/30	70/0/60	80/0/85	0/60/130	0/30/130	5/0/140
6†	10/0/0	60/0/85	45/0/120	0/10/110	0/0/130	10/0/115
7†	60/0/70	70/0/85	117/0/100	0/60/130	0/10/130	0/15/115

* Congenital radial head luxation.
† Secondary to trauma.

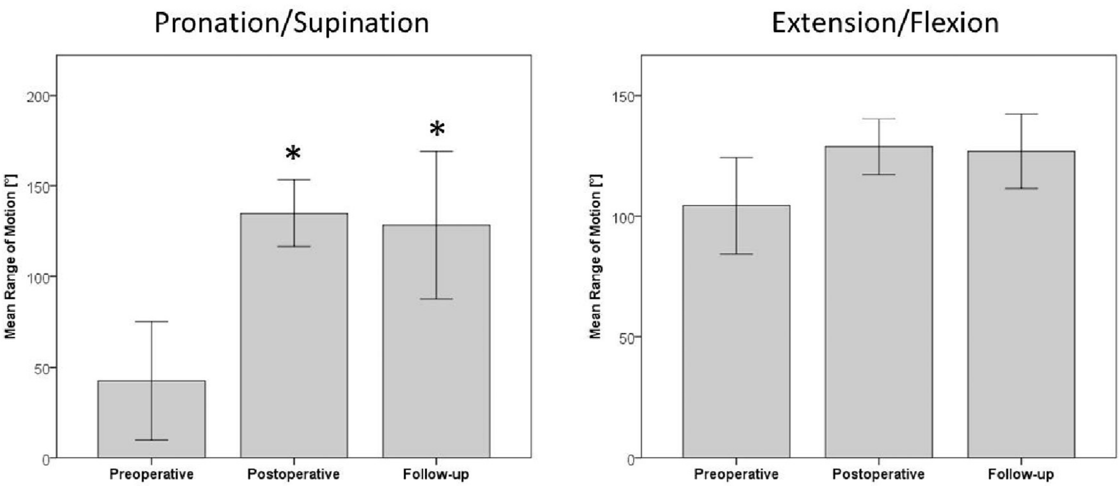

Figure 1 Mean preoperative, postoperative, and follow-up range of motion for (Left) pronation/supination and (Right) extension/flexion. **P* < .05 vs. preoperative.

The grip strength was significantly lower on the affected side than on the unaffected side ($P = .027$), and there was a significant ulnar variance comparing affected and unaffected side ($P = .018$; Table II). The strength of pronation was significantly lower on the operated side compared with the nonoperated side (mean, 51 kg [range, 16-83 kg; SD, 24 kg] vs. mean, 60 kg [range, 27-92 kg; SD, 24 kg]; $P = .028$). The strength of supination, however, did not significantly differ

Table II Individual grip strength and ulnar variance of the operated and nonoperated side of the 7 patients following radial head resection

Patient	Grip strength (kg)		*P*	Ulnar variance (mm)		*P*
	Operated side	Nonoperated side		Operated side	Nonoperated side	
1	39	39		3.8	−2.1	
2	21	24		3.5	−2.2	
3	27	53		4.8	−0.5	
4	12	18		3.1	0	
5	25	37		0	−5.9	
6	35	38		4.6	−3	
7	29	34		1.5	0	
Mean ± SD	27 ± 9	35 ± 11	.027	3 ± 1.7	−1.9 ± 2	.018

SD, standard deviation.

comparing the operated side (mean, 57 kg; range, 20-100 kg; SD, 33 kg) vs. the nonoperated side (mean, 67 kg; range, 23-102 kg; SD, 30; $P = .176$).

Three patients showed valgus deformity of the elbow with differences of the carrying angle on the operated/nonoperated side of 15°/5°, 35°/15°, and 20°/10°, respectively. None of the elbows were unstable to varus or valgus stress.

There was 1 grade 1 and 1 grade 2 arthrosis of the elbow joint, and 1 patient with radial migration of 5.3 mm showed grade 1 arthrosis of the wrist joint. Only this patient complained about pain in forced ulnar abduction of the wrist joint.

The mean DASH score was 16.1 (range, 5.8-30.8; SD, 10.1) and the mean Mayo Elbow Performance Score was 88 (range, 70-100; SD, 12).

Discussion

The most important finding of the study was that excision of the radial head in pediatric patients with open physes was associated with a significant postoperative improvement of pronation/supination ROM that could be maintained at a mean follow-up of 4 years. However, extension/flexion ROM did not improve, and proximal radial migration, as demonstrated by difference of ulnar variance to the unaffected side, was significant.

Limited ROM of the radiocapitellar joint in children and adolescents can occur following proximal radial neck fractures due to congenital dislocation and in some neurologic conditions.[10] Radial neck fractures account for 5% to 10% of all elbow fractures in children.[24] The growth plate of the proximal radius contributes only 20% to 30% to the growth of the radius.[21] Thus, there is limited remodeling potential in cases of post-traumatic subluxation, and severe impairment of range of motion can occur after both operative and nonoperative treatment. Radial head luxation is a rare congenital condition and can also occur following missed Monteggia fractures.[16] However, severe limitation of ROM might be the result in both cases.

Treatment of patients with open physes and limited elbow motion due to developmental or acquired deformity of the radiocapitellar joint is challenging. Open reduction of the radial head combined with osteotomy of the ulna represents an option, but outcome might be poor in cases of osseous dysplasia, radioulnar ossifications, and synostoses.[3,25] Ulnar posterior angulation may improve ROM in the sagittal plane but has been shown to decrease rotation capabilities of the forearm by causing secondary tightness of the interosseous membrane.[25]

In adult patients, excision arthroplasty of the radial head has been described as an effective treatment option following comminuted radial head fractures without associated instability.[1,6] However, concerns remain regarding complications such as valgus instability, stiffness, or proximal migration of the radius with sequelae to the wrist joint.[11] Traditionally, the radial head has been considered as an important stabilizer to valgus load, and experimental research has focused on valgus stability.[15] Studies have shown that the radial head is a secondary restraint to valgus stability, whereas the medial collateral ligament acts as the primary valgus stabilizer.[7,19] Several biomechanical studies have demonstrated that radial head excision alters the kinematics of the elbow joint, creating increased varus-valgus laxity even when the ligaments were intact.[2,7,12] This is consistent with our observation in 3 patients with increased cubitus valgus at follow-up despite intact ulnar collateral ligaments. These patients, however, did not display any ulnar nerve impairment or pain in the elbow joint at follow-up. Nevertheless, we still cannot rule out that such complications occur over time.

Excision of the radial head remains an uncommonly performed procedure in pediatric patients. Case reports and small series reporting radial head excision in children emphasize the tendency of subsequent perifocal ossification and recurrent synostosis in patients with open physes.[8,14,16,20] Hresko et al[8] reported 3 post-traumatic radial head excisions in children with open physes who all needed repeated revision surgery for postoperative perifocal ossification and synostosis. One patient in our series required revision surgery for radial head regrowth (patient 1 in Table I) after radial head excision at the age of 8 years due to congenital radial head luxation. None of the remaining patients showed signs of synostosis or perifocal ossification. We believe that a meticulous technique with both sealing the osteotomy with bone wax and interposition of an anconeus flap contributes to limit the risk of postoperative reossification.

Grip strength and strength of pronation at follow-up were both lower in the operated side compared with the nonoperated side. Because 5 of the 7 procedures were performed on the nondominant side, we cannot differentiate whether this finding was caused by the dominancy effect or the operation per se. However, grip strength loss following radial head excision was also observed by Hresko et al.[8] The differences of the ulnar variance between the operated and nonoperated side of the present series are also consistent with the results of Hresko et al,[8] who observed a mean ulnar variance of 4.4 mm in a small subgroup with open physes compared with a mean 4.1 mm in patients with closed physes following radial head excision. These differences indicate a higher risk for radial migration in patients with open physes compared with patients with closed physes following radial head excision. One of our patients with radial migration of 5.3 mm showed grade 1 arthrosis of the wrist and complained about pain in forced ulnar abduction, hinting at possible long-term sequelae due to radial migration.

Impaired forearm rotation was the main indication for radial head excision in our patients, and supination/pronation ROM was improved significantly. An unrestricted ROM could not be achieved in all patients, which was not surprising. Nevertheless, elbow scores at follow-up showed still satisfactory results. Pronation and supination beyond the neutral forearm position is pivotal to master the challenges of daily life activity.

Limitations of the study include its retrospective character and the heterogenous etiology of the radiocapitellar joint stiffness. The reported series of 7 patients is small, but this condition is very rare. Presenting this small series of patients with open physes is therefore still necessary, given that only a very limited number of reports have covered this topic. Moreover, with a mean follow-up of 4 years, we still cannot rule out that degenerative changes may progress over time and lead to further complications and function loss. Therefore, our findings have to be interpreted with caution, and longer follow-up times are necessary.

Conclusion

Radial head excision may be considered for selected patients with open physes in cases of severe impairment of ROM resulting from post-traumatic malalignment or from congenital luxation. ROM for pronation and supination can be significantly improved with satisfying DASH and Mayo Elbow Performance scores at midterm follow-up. However, the patient should be aware of the potential need for revision surgery and expectations for full ROM after the procedure should be tempered beforehand. In addition, sequelae, such as radial migration, cubitus valgus, and loss of grip strength and pronation strength, should be expected.

Disclaimer

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