

Arthroscopic treatment of radial neck fractures in children: a technical note

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Pediatric radial neck fractures should be treated by noninvasive methods such as closed reduction whenever possible. However, in cases of failed closed reduction or of instances where closed reduction is not an option because of severe angulation, open reduction and internal fixation may be required. But the use of such invasive procedures to treat children can cause complications such as developmental disabilities. When closed reduction fails in pediatric patients with radial neck fractures, arthroscopic reduction and percutaneous Kirschner wire (K-wire) fixation, rather than open reduction, can achieve accurate reduction through direct intraarticular visualization and reduce complications. Therefore, arthroscopic reduction and percutaneous K-wire fixation should be considered as alternative, minimally invasive treatment modalities.

Keywords: Radius fracture; Children; Arthroscopy; Arthroscopic surgery

INTRODUCTION

Various methods are available for treating pediatric patients with radial neck fractures that is dependent on the angulation of the fracture, and amongst them arthroscopic reduction offers the advantages of allowing reduction to be performed directly on the radial head, minimizing soft tissue damage, allowing direct visual confirmation of whether the radial notch has been reduced properly, and reducing the use of intraoperative fluoroscopy.

Of pediatric fractures, radial neck fractures account for 5% to 10% of all traumatic elbow injuries and approximately 1% of all pediatric fractures [1]. Radial neck fractures occur when pressure is applied through the forearm while the elbow is extended and the forearm is abducted [2]. If left untreated, it can lead to complications such as reduced range of motion (ROM), premature physeal closure, cubitus valgus, overgrowth of the radial head, and

avascular necrosis of the radial head [3]. Therefore, the fracture should be treated using noninvasive methods, such as closed reduction, as early as possible. However, in cases of failed closed reduction or instances where closed reduction is not an option because of severe angulation, open reduction and internal fixation may be required. But the use of invasive procedures to treat children can cause complications such as developmental disabilities; therefore, arthroscopic reduction and percutaneous Kirschner wire (K-wire) fixation may be considered as alternative, minimally invasive treatment modalities [4]. Accordingly, the authors of the present study investigated the radiological and clinical outcomes of arthroscopic reduction and percutaneous K-wire fixation in pediatric patients with recalcitrant radial neck fractures from failed closed reduction. We hypothesized that the arthroscopic reduction technique may achieve accurate reduction and good clinical outcomes.

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TECHNIQUE

We enrolled patients aged ≤ 14 years who were diagnosed as having a radial neck fracture between March 2013 and July 2016. Seven patients who had unsatisfactory reduction due to failed closed reduction were treated with arthroscopic reduction and percutaneous K-wire fixation.

Subjects

The mean patient age at the time of the procedure was 8.4 years (range, 4–13 years), and the mean follow-up period was 5.4 months (range, 2–20 months). Six cases involved boys and one case involved a girl. The inclusion criteria consisted of pediatric patients; those with a single fracture with no accompanying fractures; those who were able to participate in at least 2 months of outpatient follow-up; and those who had underwent closed reduction under intravenous anesthesia but had unsuccessful outcomes because they failed to achieve an angulation of $\leq 20^\circ$ (Fig. 1). Meanwhile, patients with open fractures or with accompanying nerve or vascular injuries were excluded. All surgical procedures were performed by a single orthopedic surgeon skilled in arthroscopic technique, and preoperative angulation was classified according to the Judet classification (Type I, nondisplaced; Type II, $< 30^\circ$; Type III, $< 30^\circ$ – 60° ; Type IVa, 60° – 80° ; and Type IVb, $> 80^\circ$). All patients had an open growth plate. All surgical procedures were performed within 3 days of the injury, and all the patients were fitted with a plaster splint during the emergency department visit, which was retained until the surgery.



Fig. 1. Preoperative anteroposterior and lateral radiographs of the elbow showing angulation of the radial neck.

Surgical technique

In adults, arthroscopic elbow surgery is commonly performed in the lateral decubitus position, but in children, the surgery is performed in the prone position with the elbow flexed at 90° , without using a fluid pump. The joint was inflated using an 18 G spinal needle filled with 10 mL of saline through the soft spot portal (located laterally and at the center of the olecranon, the lateral epicondyle, and the radial head) to distend the capsule and to avoid neurovascular injury. The proximal anteromedial portal was made 2 cm proximal and 1 cm anterior to the medial epicondyle to avoid injury to the ulnar nerve. We incised the skin carefully and bluntly dissected the soft tissues down to the level of the capsule. A 4.5 mm 30° arthroscope was inserted through this portal, and another portal was made under direct vision. We generally used a 4.5 mm arthroscope, but depending on the physique of the patients we occasionally used a 2.7 mm small joint arthroscope. The proximal anteromedial portal was mainly used as the viewing portal, while the soft spot portal was used as the working portal. After checking the status of the radius in the medial aspect of the joint through manual pronation and supination manipulation (Fig. 2A), we attempted the reduction of the radial head by inserting a probe, using the soft spot portal as our viewing portal (Fig. 2B). The reduction of the radial head was performed so that it would be inserted accurately in the radial notch (Fig. 2C). After the reduction, a 1.1-mm K-wire was inserted percutaneously for fixation from the radial head to the bone shaft, with proper placement assessed arthroscopically (Fig. 2D).

Postoperative evaluation

We measured the radiological and clinical parameters during the 3 postoperative outpatient follow-ups (the 2-week, the 4-week, and the final follow-ups). Radiological parameters were measured using plain film imaging, and our parameters of clinical outcome were the Mayo Clinic Performance Score (MCPS) and ROM. Radiological observations were made at every follow-up; at the last follow-up, we classified the radiological findings by applying the Métaizeau classification. Clinical parameters were measured at the last follow-up. Rehabilitation exercises for the recovery of ROM was initiated after the metal was removed on the 4th postoperative week. With respect to the assessment of ROM, complete functional recovery with no impaired movement in any direction was determined as “excellent”, while impaired movement

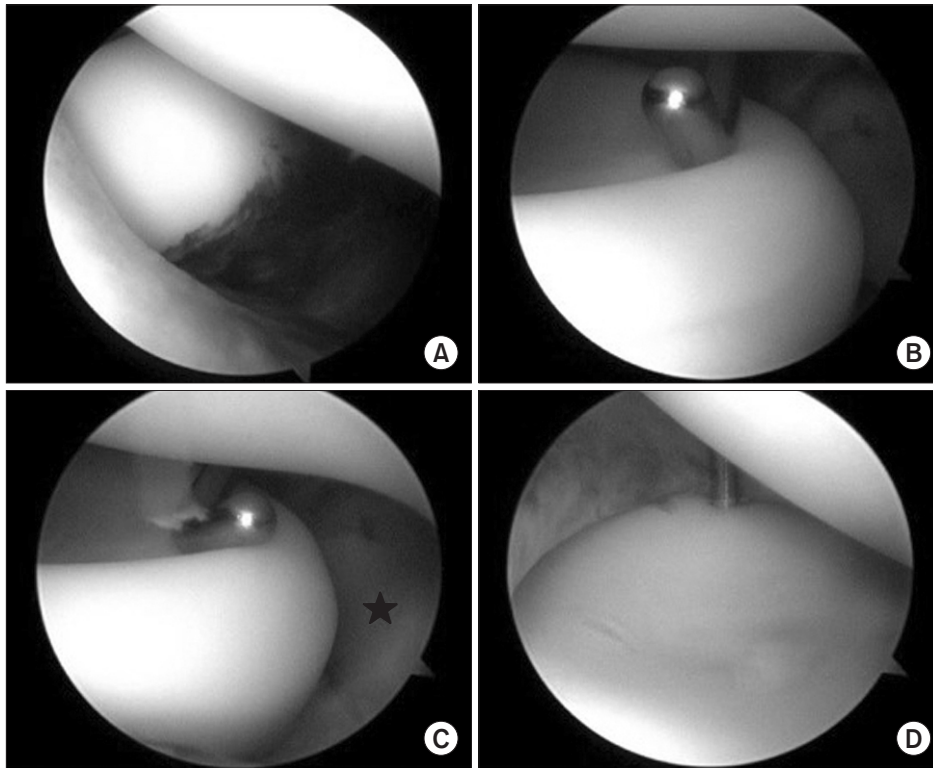


Fig. 2. (A) Arthroscopic view through the proximal anteromedial portal before the reduction. (B, C) Arthroscopic view through the soft spot portal. A probe was used to confirm that an appropriate height was maintained by reduction of the radial head into the radial notch (asterisk). (D) Radial head fixation using a 1.1-mm Kirschner wire after reduction.



Fig. 3. (A, B) Postoperative anteroposterior and lateral radiographs of the elbow showing reduction of the radial neck. (C, D) Last follow-up (20 months after surgery) anteroposterior and lateral radiographs of the elbow showing remodeling of the radial neck.

of $< 20^\circ$ in any direction was deemed “fair” and of $\geq 20^\circ$ was deemed “poor”.

The mean preoperative angulation was $48.86^\circ \pm 16.51^\circ$. With respect to the Judet classification, all the patients were classified as having a fracture grade of III or higher: 6 patients were classified as having grade III fractures and 1 patient, a grade IVb fracture. The mean postoperative angulation was 2° (Fig. 3A, B), and the mean angulation at the final follow-up session was 1.57° (Fig. 3C, D). According to the Métaizeau classification, the results were rated as “excellent” for 6 patients and as “good” for 1 patient. Likewise, 6 patients showed an “excellent” MCPS score and 1 patient, a “good” MCPS score. According to the ROM, the results were rated as “excellent” for 6 patients and as “fair” for 1 patient (Table 1). The patient identified as having a “fair” ROM did so 2-month postoperatively and appeared to show further improvement over time. All patients showed indications of bone union without any complications such as infections, iatrogenic nerve injury, re-fractures, nonunion, and osteonecrosis.

DISCUSSION

This technical report describes a clinical technique that can overcome the shortcomings of open reduction in pa-

Table 1. Results of arthroscopic reduction and fixation for radial neck fractures in children

Patient no.	Age (yr)	Sex	Angulation preop (°)	Judet classification	f/u (mo)	Angulation postop (°)	Angulation last f/u (°)	Métaizeau classification	ROM (°) (F/E/S/P)	Mayo elbow
1	10	Male	54	III	2	0	9	Good	125/5/65/60	Good
2	10	Male	39	III	3	0	0	Excellent	140/0/80/80	Excellent
3	10	Male	37	III	20	3	0	Excellent	145/0/85/80	Excellent
4	13	Male	53	III	6	4	0	Excellent	140/0/80/80	Excellent
5	6	Male	31	III	2	0	0	Excellent	140/0/85/85	Excellent
6	4	Female	47	III	3	4	2	Excellent	140/0/80/85	Excellent
7	6	Male	81	IVb	2	3	0	Excellent	140/0/85/85	Excellent

Métaizeau classification: Excellent, anatomic reduction; Good, < 20°; Fair, 20°–40°; Poor, > 40°.

preop, preoperative; postop, postoperative; f/u, follow-up; ROM, range of motion; F, flexion; E, extension; S, supination; P, pronation.

tients who require surgical treatment for severe angulation.

Kaufman et al. [5] indicated that an angulation of < 30° can be treated by simple fixation; an angulation of 30°–60°, by closed reduction and by revision open reduction if the closed reduction fails; and an angulation of ≥ 60°, by open reduction. However, the treatment modalities for pediatric radial neck fractures with 30° to 80° of angulation, which corresponds to Judet classification grades III and IV, are still controversial [6–8]. The reason for the controversy is because open reduction procedures are associated with a high risk of postoperative complications [4,9]. Therefore, the “treatment of choice” for pediatric radial neck fractures is still yet to be established.

Some fractures may require open reduction because capsular involvement or soft tissue such as the annular ligament between the radial head and neck may disfavor closed reduction. However, open reduction is associated with a high risk of serious complications such as premature closure of the growth plate, enlargement of the radial head, intraarticular ossification, and avascular necrosis [4,6,7,9–14]. Arthroscopic reduction technique should also be used with caution because these complications can occur during the manipulation of probes or during repeated percutaneous pinning. Poor outcomes of arthroscopic open reduction have been attributed to factors such as displaced angles, combined injuries, open treatment, and residual tilting. Factors such as displaced angles and severity of injury have also been associated with the energy of impact; a high-energy injury not only affects soft tissue and vascular supply but also increases the risk of avascular necrosis in the radial head.

Steinberg et al. [9] performed closed reduction in 42 patients and plaster immobilization in 28 of these patients, which included patients with severe displacement (60°–90°). They explained that satisfactory reduction was

achieved at first treatment in 22 patients despite plaster fixation. Although the majority of patients achieved excellent reduction at the time of surgery, Steinberg et al. [9] recommended against this treatment modality because of postoperative complications such as scarring from surgery, ossification near the joint, avascular necrosis, and enlargement of the radial head. Taking their advice, we investigated the effectiveness of a less invasive treatment modality than open reduction for arthroscopic reduction.

Compared with other techniques, arthroscopy can not only control the reduction of joint fractures more accurately but also yield better outcomes concerning combined injuries. Moreover, this method, which needs a smaller incision than open reduction, leaves a smaller scar and reduces the incidence of complications through early joint movement. Percutaneous reduction using the lever technique shares these advantages and also yields excellent clinical outcomes [6–8,11–14]. Although this technique is easier and simpler technically than the arthroscopic technique, the latter can obviate the need for intraoperative fluoroscopy through direct visualization of the intraarticular reduction, thereby minimizing radiation exposure to patients and surgeons.

In order to perform a safe and effective arthroscopic surgery on acute lesions of the radial neck of children, we attempted to identify clear landmarks of the elbow in all patients [15] and to reduce the radial head accurately into the ulnar radial notch. In the present study, only one patient's radiological and clinical outcomes at the final follow-up session were rated as “good.” We believed that since this patient was examined with a short follow-up period of only 2 months the long-term follow-up would show better outcomes in terms of bone regeneration. Moreover, no complications were observed in any of the cases, and excluding the case with a short follow-up period, all radiological and clinical outcomes were rated

“excellent.” At the final follow-up, satisfactory outcomes were achieved with respect to the Métaizeau classification, MCPS, and ROM.

However, the present study has a few limitations. First, the number of cases ($n = 7$) was small, which limits the statistical analysis of our findings. Second, because the study was a technical note and no control group was included, the mean or median values could not be statistically compared or analyzed. As such, we cannot definitively claim that this method is superior to invasive surgical methods. Third, the overall follow-up period of the pediatric patients was short. Additional studies are needed in the future that includes a greater number of ar-

throscopic treatment cases and a longer follow-up period and makes a comparative analysis involving different types of invasive surgical procedures.

In sum, on the basis of our findings, we recommend the use of arthroscopic reduction and percutaneous K-wire fixation as an alternative, minimally invasive treatment to open reduction when closed reduction fails in pediatric patients with radial neck fractures.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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