Annular ligament reconstruction by suture anchor for treatment of radial head dislocation in children

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Abstract

Background: We investigated the efficacy of annular ligament reconstruction by suture anchor in the treatment of radial head dislocation (RHD) in children.

Method: A total of 20 RHD children underwent annular ligament reconstruction surgery using suture anchor. Preoperative and postoperative elbow functions were evaluated according to Broberg and Morrey 100-point scale. Recovery of radial nerve function was assessed using the Chinese Medical Association of Hand Surgery Branch of Upper Limb Functional Assessment Standard. All statistical analyses were performed using SPSS version 17.0 software.

Results: All 20 RHD children who underwent the procedure were followed up for a median duration of 24 months. At the last follow-up, the average Broberg-Morrey score was 94.3, with 12 children (60.0 %) showing excellent outcomes (score range, 95 to 100), 7 children (35.0 %) showing good outcomes (score range, 80 to 94), 1 child (5.0 %) displaying a fair outcome (score range, 60 to 79), and 0 (0 %) poor outcome. A significant difference in the excellent-good rate was observed when the elbow function before surgery was compared to after surgery ($\chi^2 = 5.559, P = 0.018$). The radial nerve function of the 13 RHD children with radial nerve injury also recovered to normal. Among these 13 RHD children, nine exhibited excellent outcomes, 3 showed good outcomes, 1 displayed a fair outcome, and no patient showed a poor outcome. A significant difference in the excellent-good rate of radial nerve function was also observed when before surgery was compared to after surgery in these RHD children ($\chi^2 = 4.887, P = 0.027$).

Conclusion: Our results strongly indicated that suture anchor is highly effective for reconstruction of the annular ligament and to promote full functional recovery in RHD children, demonstrating that the procedure is an excellent treatment choice in RHD children.

Keywords: Radial head dislocation, Suture anchor, Annular ligament reconstruction, Broberg and Morrey 100-point scale, Radial nerve function, Functional recovery
RHD, some medical professionals suggest taking no surgical measures, while others recommend using splints after manual reduction. However, if the manipulative reduction fails, redislocation occurs or, in case of chronic RHD, the annular ligament must be reconstructed after surgical reduction [11, 12]. Chronic RHD in children is caused by progressive deformity and an unacceptable loss of motion, requiring timely intervention (fixation and reduction), as symptoms rapidly deteriorate [13]. Chronic RHD treatment is controversial. Conservative treatment of chronic RHD is prone to failure and radial head resection is inevitable for correcting the dysfunction, therefore early diagnosis and timely intervention is critical for effective treatment of chronic RHD [14, 15]. Open reduction and corrective ulnar osteotomy have been the main methods in treatment of chronic RHD, but annular ligament reconstruction has received significant attention as a viable treatment alternative [16, 17].

Annular ligament stabilizes the elbow joint and is a strong band of fibers that encircles the head of the radius and holds it in contact with the radial notch of the ulna [18]. Annular ligament prevents dislocation of the radial head and limits its forward, backward and lateral displacement [19, 20]. A variety of methods, such as palmaris longus tendon graft and suture anchor, have recently been developed for construction of the annular ligament to treat RHD [21, 22]. Suture anchor is a bioabsorbable tiny implant used for osteosynthesis and is an excellent fixation device for reattaching soft tissues, such as tendons and ligaments, to the bone [23]. However, various complications are associated with inserting suture anchors, such as stiffness, avascular necrosis, bone nonunion or malunion, and persistent pain [24–26]. Notably, population-based studies on the performance of suture anchors to reattach the ligaments in elbow dislocations linked with radial head showed poor clinical outcomes [27–29]. The efficacy of suture anchor in children is unclear and very few studies report its use in chronic RHD children, with inconclusive results. Therefore, we performed this present study to investigate the clinical outcome of suture anchor to reconstruct annular ligament for treatment of RHD in children.

Subjects
Between January 2011 and January 2013, 20 children with RHD were recruited at the Department of Orthopedics, Second Xiangya Hospital, Central South University. The diagnosis of RHD was based on the assessment by an experienced physician after examining the X-ray results: the central capitulum humeri was offset from the axis of the radial neck and the radial head was displaced out of the joint capsule from the lateral or anterolateral, but the radial head and capitulum humeri were normally developed. For chronic RHD, the diagnosis was based on patient history and X-ray examinations to avoid misdiagnosis. According to Bado’s classification, the fractures can be divided into four types: Type I refers to ulnar fracture accompanied by anterior dislocation of the radial head; Type II refers to ulnar fracture accompanied by posterior dislocation of the radial head; Type III refers to ulnar fracture accompanied by lateral dislocation of the radial head; and Type IV refers to RHD combined with fractures of the ulna and radius [30].

Surgical procedure
Fresh traumatic dislocation of radial head should be managed immediately by timely intervention, such as fixation and reduction, to achieve closed reduction of injury. If closed reduction in patients cannot be achieved, or in patients with an unstable diastasis and chronic RHD, or incarceration of annular ligament, open reduction and reconstruction of annular ligament is needed. This study contained 14 patients with chronic RHD and 6 fresh fracture patients with unstable closed reduction. All 20 patients received annular ligament reconstruction by suture anchor. Patients were placed in supine position under intravenous anesthesia or brachial plexus anesthesia. Antibiotics were administered prophylactically 30 min before tourniquet was applied to the arm. The injured limb was positioned on the surgery table with elbow flexion ranging from 30° to 60° and forearm pronated to expose radial head, humeroradial joint and proximal radioulnar joint. The average incision length was 3.5 cm and reached the joint directly. Hematoma in the joint of acute injury cases were evaluated. For old/acute injury, dense fibrous tissue were found in the elbow joint and scar tissue or fibrous tissue metaplasia into cartilage were found in 5 cases. These were resected for easier reduction of radial head. An optimal site at the junction of the joint surface and the bone in ulna was selected as an anchor. The anchor was in the middle of the inferior edge of the radial notch, a cartilage facet at the lateral-upper side of the ulna, which is located by the annular surface of radial head. A small ulnar incision was created and 3.0 mm suture anchor (Smith & Nephew) was inserted. The loaded suture anchor and its attached suture were placed into the shaped hole in the bone for suturing the grafted tendon. The

Methods
Ethics statement
This study was approved by the Medical and Health Research Ethics Regional Committees of Second Xiangya Hospital, Central South University. All study participants signed informed consent documents under the guidance of their parents or legal guardians. The research was conducted according to the principles of the Declaration of Helsinki declaration.
palmaris longus tendon of 4 cm average length was achieved by a small incision in the forearm to wrap the radial collar for reduction of radial head. Finally, the loaded suture anchor and its attached suture were fixed to the ulna. In order to ensure annular ligament reconstruction, flex-extension and pronate-supinate motion were applied to adjust the tendon tension. The remaining anchor suture was used to suture both ends of the tendon.

Evaluation
Broberg and Morrey is a 100-point rating system and was used to evaluate the elbow function in patients before and after surgery [31]. The evaluation consisted of four sections, with 40 points for motion, 20 points for strength, 5 points for stability and 35 points for pain. The categorical rating was: excellent outcomes range from 95 to 100 points; good outcomes range from 80 to 94 points; fair outcomes range from 60 to 79 points; and poor outcomes are below 60 points. The good or excellent outcome was considered as satisfactory, while fair or poor outcome was unsatisfactory.

Recovery of radial nerve function was assessed by the Chinese Medical Association of Hand Surgery Branch of Upper Limb Functional Assessment Standard (http://lib.gdyqs.cn/UpLoadFiles/Article/2013-10/2013100809473899703.pdf). The categorical rating system was: 13–16 points indicates an excellent outcome; 9–12 points, a good outcome; 5–8 points, a fair outcome; equal or below 4 points, a poor outcome.

Postsurgical management and follow-up
All the patients were immobilized in plaster at 70° to 90° flexion and rotation of neutral forearm for an average 5 weeks (range, 4 to 6 weeks). Heterotopic ossification was not prevented. Once the plasters were removed, assisted exercises were performed, with the supervision of a professional therapist, to improve the elbow function. Shoulder abduction was avoided to reduce elbow stress when the patients were treated with active flexion. All patients were followed up once a month after the surgery for the first six months and then once every six months. In follow up, the elbow function was assessed using the Broberg and Morrey score system. The range of motion was measured by a therapist with a goniometer and plain radiograph was performed to assess joint congruency.

Statistical analysis
The nonparametric Mann–Whitney (Wilcoxon) 2-sample rank sum test was applied for comparison between the preoperative and postoperative groups. Data were expressed as mean ± standard deviation. All statistical analyses were conducted using SPSS 17.0 software (SPSS Inc, Chicago, Illinois, USA). A value of \( P < 0.05 \) was considered as significant.

Results
Patient demographics
As shown in Table 1, this study enrolled 13 males and 7 females, with an average age of 6.7 and the ages ranging from 2 to 13 years. All injuries of the patients were unilateral, including 14 right elbow and 6 left elbow. There were 13 RDH children with radial nerve injury and 7 patients without radial nerve injury. Ten patients were Bado type I injuries, 6 patients with type II, 3 patients were type III, and only one patient showed type IV. Open fracture was found in 9 patients and close fracture was observed in 11 patients. A total of 9 fractures were located in the proximal third of the ulna, 7 in the middle third, and 4 in the distal third. The average time from injury to surgery was 8.1 weeks (1–14 months). All patients were followed up for a median of 24 months (range, 9 to 36 months).

Improvement of elbow function
Table 2 shows Broberg-Morrey score of RHD patients before and after surgery. At the last follow-up, the average Broberg-Morrey score was 94.3, with scores ranging between 82 and 100, and 12 patients (60.0 %) showed excellent outcomes (score range, 95 to 100), 7 patients (35.0 %) showed good outcomes (score range, 80 to 94), 1 patient (5.0 %) displayed a fair outcome (score range, 60 to 79), with 0 (0 %) poor outcome (as shown in Table 3). In the excellent-good score range, there was a significant difference between before surgery and after surgery \( (\chi^2 = 5.559, P = 0.018) \). All patients underwent post-operative radiographic evaluation. Range of motion was measured with flexion, extension, pronation, and supination. The average flexion and extension were 134.2 ± 3.5° and 8.3 ± 1.4° at the last follow-up, and the average pronation and supination were 85.8 ± 5.3 and 86.4 ± 4.0°, respectively. The postoperative flexion, extension, pronation and supination increased by 12.6°, 2.5°, 16.6°, 24.3°, respectively (Table 4). Follow-up X-ray examinations demonstrated excellent congruity of both the radio capitellar joints and the humeroulnar. X-ray examinations also showed no change in the position of suture anchors and good congruency of the elbow articulation (Fig. 1). All the surgical wounds were healing by first intention. Radial palsy occurred in 1 patient post-operatively, but reverted spontaneously after 3 months. We observed no cases of compartment syndrome, infection, myositis ossificans, posterior interosseous nerve injury, and radial neck fracture.

Improvement of radial nerve function
The radial nerve function of 13 RHD patients with radial nerve injury recovered to normal. Based on the Chinese Medical Association of Hand Surgery Branch of Upper Limb Functional Assessment Standard, the average
radial nerve function score was 14 (range, 10 to 16 score) at the last follow-up. As shown in Table 5, nine patients exhibited excellent outcomes, 3 patients with good outcomes, 1 patient with fair outcome, and no patient showed poor outcome. A significant difference in the excellent-good rate was also observed between before surgery and after surgery ($\chi^2 = 4.887, P = 0.027$).

Table 1 Clinical characteristics of twenty children with radial head dislocation

| No. | Gender | Age (years) | Affected limb | Causes of injury | Bado type | Radial nerve injury | Fracture type | Fracture site | TIS duration (weeks) | Follow-up (months) |
|-----|--------|-------------|---------------|-----------------|-----------|---------------------|--------------|---------------|---------------------|--------------------|
| 1   | M      | 6           | R             | Fall            | I         | Y                   | Open         | Middle 1/3    | 1                   | 21                 |
| 2   | F      | 8           | L             | Collision       | II        | N                   | Close Distal 1/3 | 4             | 33                  |
| 3   | M      | 7           | R             | Traffic accident| III       | Y                   | Open         | Proximal 1/3  | 3                   | 36                 |
| 4   | M      | 5           | L             | Fall            | IV        | Y                   | Close Distal 1/3 | 6             | 28                  |
| 5   | F      | 7           | R             | Collision       | II        | N                   | Close Proximal 1/3 | 5             | 40                  |
| 6   | M      | 6           | R             | Collision       | I         | Y                   | Close Proximal 1/3 | 7             | 32                  |
| 7   | F      | 9           | R             | Collision       | III       | N                   | Open         | Middle 1/3    | 8                   | 29                 |
| 8   | F      | 8           | R             | Fall            | I         | Y                   | Close Proximal 1/3 | 9             | 21                  |
| 9   | M      | 10          | L             | Fall            | II        | Y                   | Close Distal 1/3 | 10            | 18                  |
| 10  | M      | 12          | R             | Fall            | III       | N                   | Open         | Middle 1/3    | 7                   | 9                  |
| 11  | M      | 4           | R             | Fall            | I         | Y                   | Close Proximal 1/3 | 12            | 12                  |
| 12  | F      | 3           | R             | Traffic accident| I         | N                   | Open         | Proximal 1/3  | 11                  | 16                  |
| 13  | M      | 13          | L             | Fall            | I         | Y                   | Close Distal 1/3 | 14            | 10                  |
| 14  | M      | 4           | R             | Collision       | II        | Y                   | Open         | Middle 1/3    | 10                  | 32                  |
| 15  | M      | 5           | R             | Fall            | II        | Y                   | Close Proximal 1/3 | 7             | 30                  |
| 16  | M      | 7           | R             | Fall            | I         | Y                   | Close Proximal 1/3 | 8             | 25                  |
| 17  | F      | 6           | L             | Collision       | I         | N                   | Close Distal 1/3 | 11            | 23                  |
| 18  | M      | 5           | R             | Fall            | I         | Y                   | Open         | Middle 1/3    | 12                  | 21                  |
| 19  | M      | 7           | L             | Collision       | I         | N                   | Open         | Proximal 1/3  | 9                   | 35                  |
| 20  | F      | 2           | R             | Collision       | II        | Y                   | Open         | Proximal 1/3  | 8                   | 19                  |

M, male; F, female; R, right; L, left; Y, yes; N, no; TIS duration represents the duration from the injury to the surgery

Table 2 The Broberg-Morrey score of elbow function of children with radial head dislocation before and after the annular ligament reconstruction by suture anchor

| Time point | Broberg-Morrey score | Strength | Pain | Stability | Motion | Total |
|------------|----------------------|----------|------|-----------|--------|-------|
| Preoperative |                      | 11.8 ± 2.1 | 21.4 ± 3.6 | 2.2 ± 0.8 | 28.7 ± 3.9 | 64.3 ± 7.6 |
| Postoperative |                    | 14.5 ± 3.2 | 25.6 ± 2.0 | 3.5 ± 1.1 | 31.9 ± 3.4 | 81.2 ± 5.8 |
| 1st month    |                      | 15.7 ± 2.6 | 26.8 ± 3.4 | 3.9 ± 0.8 | 33.2 ± 5.0 | 86.9 ± 4.4 |
| 3rd month    |                      | 16.4 ± 1.8 | 27.3 ± 2.7 | 4.1 ± 0.6 | 34.5 ± 4.2 | 88.8 ± 3.2 |
| 6th month    |                      | 17.3 ± 1.5 | 28.4 ± 1.8 | 4.3 ± 0.2 | 36.1 ± 2.9 | 90.3 ± 1.6 |
| 12th month   |                      | 18.5 ± 0.9 | 28.9 ± 0.3 | 4.5 ± 0.1 | 37.2 ± 1.3 | 91.2 ± 2.1 |
| 24th month   |                      | 19.1 ± 0.4 | 29.2 ± 0.3 | 4.6 ± 0.3 | 38.1 ± 0.4 | 94.3 ± 2.1 |

Discussion

RHD can occur under various conditions and RHD in children requires prompt intervention. The main approaches used in children include closed reduction with casting and open reduction and internal fixation. Delayed or inadequate treatment in children may lead to complications such as pain, nonunion, loss of full range of motion or enlargement of the proximal end of the radius [32]. In patients with annular ligament contraction into the joint space or those who suffered re-dislocation caused by an external force, stretching the ligament by manipulative reduction or other non-operative management is very difficult. In this study, chronic RHD children that failed closed reduction via manipulative reduction were enrolled to receive annular ligament reconstruction by suture anchor. Such studies in children are very few and more data is required to understand the best approaches for treatment in children. Therefore, we studied the clinical efficacy of suture anchor for reconstruction of annular ligament in children with RHD. Our study results showed that all patient showed excellent recovery with respect to pain and elbow function, suggesting that suture anchors for reconstruction of annular ligament may be highly effective in the treatment of children with chronic RHD or in children who failed closed reduction.
reduction via manipulative reduction. Earlier studies reported that the material for construction is mostly palmaris longus tendon and triceps aponeurosis, and the procedure is accomplished by drilling tunnels in the ulna, bypassing around the radial neck after threading the construction materials through the bone tunnel [32, 33]. Notably, reconstruction of annular ligament can also be achieved by palmaris longus tendon autograft, which is passed around the radial neck first and then through a bony tunnel to be sutured to itself [17]. However, this surgical method is too complicated and requires ensuring that the longer graft can pass through the narrow ulnar tunnel, which could lead to ulna fracture [34]. In this study, we used suture anchors to reconstruct annular ligament in children with RHD. A significant advantage of our approach is that the annular ligament reconstruction by suture anchor minimizes the risk of overcorrection of ulna in radial head [35]. In addition, the small surgical incision of this technique may reduce stripping of the surrounding tissue and limit surgical trauma, resulting in better recovery of the ligament and wound (http://d.wanfangdata.com.cn/Periodical_xdkf201009024.aspx). The anchors, with two long and absorbable sutures, weave the tendon around the ligament to strengthen the repair of the ligament, preventing re-dislocation of radial head [36]. Previous studies suggested that the use of suture anchors save surgical time and minimize the size of surgical incision, compared to the tendon palmaris longus approach [37, 38]. In addition, the fixation is highly effective in preventing re-dislocation of radial head, with fewer related complications [39, 40]. Consistent with this, our study also demonstrates fewer post-operative complications. The radial head can remain in its original position to allow the growth of fibrous tissue around the sutures, even if the tendon graft fails. Additionally, the sutures cannot prevent the growth of radial head since they are absorbable [25].

On the other hand, repeated dislocation and subluxation can have a huge impact on the articular surface and joint capsule, causing severe complications [41]. Our results indicate that reconstruction of annular ligament is critical for

| Table 4 | The functional range of motion (°) of the affected elbow before and after the annular ligament reconstruction by suture anchor |
|---------|---------------------------------------------------------------|
| Time point | Range of motion (°)                                      |
|          | Flexion | Extension | Pronation | Supination |
| Before surgery | 121.6 ± 2.7 | 5.8 ± 0.9 | 69.2 ± 4.6 | 62.1 ± 7.2 |
| Last follow-up | 134.2 ± 3.5 | 8.3 ± 1.4 | 85.8 ± 5.3 | 86.4 ± 4.0 |

| Table 5 | Radial nerve function of 13 radial head dislocation patients with radial nerve injury before and after the annular ligament reconstruction by suture anchor |
|---------|-----------------------------------------------|
| Time point | Elbow function grade | Excellent | Good | Fair | Poor |
| Before surgery | 0 | 7 | 5 | 1 |
| Last follow-up | 9 | 3 | 1 | 0 |
the stability and maintenance of the reduction of radial head because annular ligament was accessed at the incision safely, with shorter operative time, and annular ligament is thick and sturdy with tough internal fixation and low-risk of re-dislocation [6]. Due to the unique function of annular ligament in preventing RHD during rotation of forearms, radius spins inside the annular ligament against the ulna and allows axis rotation [16]. Additionally, without the involvement of annular ligament when spinning, radial head will carry the translational motion, which is associated with the risk of leaving the proximal radio ulnar joint and anterolateral dislocation [42]. Metallic anchors are associated with loosening, migration and chondral injury, and orthopedic surgeons are increasingly using bioabsorbable anchors to solve this issue [25]. Bioabsorbable suture anchors are safe and mechanically stable implants, allowing arthroscopic surgeons to secure soft tissue to the bone in and around the shoulder [25].

The current study has several limitations. First, the small sample size may limit statistical accuracy and universal application. In this study, only 20 children with RHD were recruited and the clinical efficacy of annular ligament reconstruction by suture anchor on RHD might be influenced by random variation. Second, the midterm follow-up and the potential lack of power to detect the complication rates may also influence the short-term and long-term clinical efficacy of annular ligament reconstruction by suture anchor on RHD. Thus, prospective studies and long-term follow-up is needed to further confirm whether suture anchor represents the optimal treatment for isolated old radial head dislocation.

Conclusion

In conclusion, our study presents preliminary evidence that suture anchors may be effective in reconstructing annular ligament and promote functional recovery in RHD patients. The procedure has the advantage of being a simple operation and is less prone to fracture or re-dislocation. Thus, suture anchors may be an effective and reliable approach for the treatment of children with chronic RHD or in patients with failed closed reduction via manipulative reduction.

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References

1. Smit AJ, Giannakopoulos GF, Zuidema WP. Long-term results and treatment modalities of conservatively treated Broberg-Morrey type 1 radial head fractures. Injury 2014;45(10):1564–8.
2. Lapner M, King GJ. Radial head fractures. Instr Course Lect. 2014;63:13–13.
3. Hartlzer RJ, Morrey BF, Steinmann SP, Iusa-Perez M, Sanchez-Sotelo J. Radial head reconstruction in elbow fracture-dislocation: monopolar or bipolar prosthesis? Clin Orthop Relat Res. 2014;472(7):2144–50.
4. Celli A, Modena F, Celli L. The acute bipolar radial head replacement for isolated unconstructable fractures of the radial head. Musculoskelet Surg. 2010;94 Suppl 1:135–39.
5. Rosenbaum AJ, Leonard GR, Uhl RL, Mulligan M, Bagchi K. Radiologic case study. Diagnostic congenital posterior dislocation of the radial head. Orthopedics. 2014;37(11):1. 62–3.
6. Li Z, He Y, Zhong G, Huang F. Research progress in repair and reconstruction of isolated traumatic radial head dislocation with annular ligament injury in children. Chin J Reconstructive Surg. 2011;25(10):1266–8.
7. Takase K, Maizuchi J. Irradiable dislocation of the radial head with undisplaced olecranon fracture in a child: a case report. J Pediatr Orthop B. 2011;20(5):345–8.
8. El Ibrahimi A, Shimi M, Daoudi A, Elmirini A. Isolated, traumatic posterior dislocation of the radial head in an adult: A new case treated conservatively. J Emerg Trauma Shock. 2010(3):422–4.
9. Wang MN, Chang WN. Chronic posttraumatic anterior dislocation of the radial head in children: Thirteen cases treated by open reduction, ulnar osteotomy, and annular ligament reconstruction through a boyd incision. J Orthop Trauma. 2006;20(1):1–5.
10. Pike JM, Athwal GS, Faber KJ, King GJ. Radial head fractures—an update. J Hand Surg Am. 2009;33(3):557–65.
11. Strum PP, Levine J, Sedlin ED, Ulin RI. Isolated dislocation of the radial head. Mt Sinai J Med. 1989;56(4):304–8.
12. Kluh M, van der Woudten JC, van Suijlekom-Smit LW, Koes BW. Manipulative interventions for reducing pulled elbow in young children. Cochrane Database Syst Rev. 2012;1(907)(3):CD007759.
13. Kim HT, Park BG, Suh JT, Yoo CI. Chronic radial head dislocation in children, part 2: Results of open treatment and factors affecting final outcome. J Pediatr Orthop. 2010;22(3):591–7.
14. Illingworth KD, Thompson K, Lovell M, McGinty J. Spontaneous reduction of a chronic radial head subluxation after open reduction and percutaneous pin fixation of a radial neck fracture: a case report and review of the literature. Iowa Orthop J. 2013;33:221–4.
15. Xiao SW, Xiao HL, Yan JH, Qin SH. Surgical treatment for chronic radial head dislocation. China J Orthopaedics Traumatol. 2013;26:1530–2.
16. Eamsobhana P, Kaewpornsawan K. Chronic Monteggia lesions: treatment with open reduction and Z-lengthening technique with annular ligament reconstruction. J Med Assoc Thai. 2012;95 Suppl 9:547–53.
17. Iadera E, Ueno K. Recurrent anterior instability of the radial head: case report. J Hand Surg Am. 2014;39(2):206–8.
18. Nwokol CE, Patel PP, Richard MJ, Leversedge FJ. Annular ligament reconstruction using the distal tendon of the superficial head of the brachialis muscle: an anatomical feasibility study. J Hand Surg Am. 2013;38(7):1315–9.
19. Zhang X, Gan RZ. Dynamic properties of human stapedial annular ligament measured with frequency-temperature superposition. J Biomech Eng. 2014;136(8): doi: 10.1115/1.4027688.
20. Parakselas GK. Human ligaments classification: a new proposal. Folia Morphol (Warsz). 2011;70(2):61–7.
21. Jones KL, Dodson CC, Osbahr DC, Parisien RL, Weiland AJ, Altschek DW, et al. The docking technique for lateral ulnar collateral ligament reconstruction: surgical technique and clinical outcomes. J Shoulder Elbow Surg. 2012;21(3):389–95.
22. Liu YP, Du Y, Wang MM, Li M, Liu SY, Liu W. Small longitudinal S incision and page turning style of annular ligament partial resection to treat...
stenosing tenosynovitis of thumb flexor tendon. Med Sci Monit. 2014;20:683–7.

23. Nho SJ, Frank RM, Van Thiel GS, Wang FC, Wang VM, Provencher MT, et al. A biomechanical analysis of anterior Bankart repair using suture anchors. Am J Sports Med. 2010;38(7):1405–12.

24. Rosenblatt Y, Athwal GS, Faber KJ. Current recommendations for the treatment of radial head fractures. Orthop Clin North Am. 2008;39(2):173–85.

25. Dhawan A, Ghodadra N, Karas V, Salata MJ, Cole BJ. Complications of bioabsorbable suture anchors in the shoulder. Am J Sports Med. 2012;40(6):1424–30.

26. Randelli P, Spennacchio P, Ragone V, Amigonii P, Casella A, Cabitza P. Complications associated with anthropic rotator cuff repair: a literature review. Musculoskelet Surg. 2012;96(1):10–16.

27. Siebenlist S, Fischer SC, Sandmann GH, Ahrens P, Wolf P, Stockle U, et al. The functional outcome of forty-nine single-incision suture anchor repairs for distal biceps tendon ruptures at the elbow. Int Orthop. 2014;38(4):873–9.

28. Rodriguez-Martín J, Pretell-Mazzini J, Andres-Esteban EM, Lamainzar-Garajo R. Outcomes after terrible triads of the elbow treated with the current surgical protocols: A review. Int. Orthop. 2011;35(6):851–60.

29. McKee MD, Pugh DM, Wild LM, Schmitz EH, King GJ. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. Surgical technique. J Bone Joint Surg Am. 2005;87(Suppl 1 Pt 1):e2–32.

30. Tan JW, Mu MZ, Liao GJ, Li JM. Pathology of the annular ligament in paediatric monteggia fractures. Injury. 2008;39(4):451–5.

31. Longo UG, Franceschi F, Loppini M, Maffulli N, Denaro V. Rating systems for evaluation of the elbow. Br Med Bull. 2008;87:131–61.

32. Wegmann K, Burkhart KJ, Bingel AS, Ries C, Neiss WF, Muller LP. Anatomical relations between the lateral collateral ligament and the radial head: implications for arthroscopic resection of the synovial fold of the elbow. Knee Surg Sports Traumatol Arthrosc. 2014 Jun 11. [Epub ahead of print]

33. Park U, Kim HM, Lee SU, Lee JY, Jeong C, Opponensplasty using palmaris longus tendon and flexor retinaculum pulley in patients with severe carpal tunnel syndrome. Arch Orthop Trauma Surg. 2010;130(7):829–34.

34. Lee MC, Lee DW, Rah DK, Lee WJ. Reconstruction of a total soft palatal defect using a folded radial forearm free flap and palmaris longus tendon sling. Arch Facial Surg. 2012;39(1):25–30.

35. Miyake J, Oka K, Moritomo H, Sugamoto K, Yoshikawa H, Murase T. Open reduction and 3-dimensional ulnar osteotomy for chronic radial head dislocation using a computer-generated template: case report. J Hand Surg Am. 2012;37(3):517–22.

36. Wang W, Jiang SC, Liu S, Ruan HJ, Fan CY. Stability of severely stiff elbows after complete open release: treatment by ligament repair with suture anchors and hinged external fixator. J Shoulder Elbow Surg. 2014;23(10):1537–44.

37. Huang YJ, Chen WL, Zhang L, Peng MX, Cai CY, Yang GJ. [Suture anchor for acute injuries of medial collateral ligament of knee at degree III]. Zhongguo Gu Shang. 2014;27(2):137–9.

38. Gasparella A, Katusic D, Perissinotto A, Miti A. Repair of distal biceps tendon acute ruptures with two suture anchors and anterior mini-open single incision technique: clinical follow-up and isokinetic evaluation. Musculoskelet Surg. 2014;99(1):19–25.

39. Song SY, Kim IS, Chang HG, Shin JH, Kim HJ, Seo YJ. Anatomic medial patellofemoral ligament reconstruction using patellar suture anchor fixation for recurrent patellar instability. Knee Surg Sports Traumatol Arthrosc. 2013;21(10):2431–7.

40. Maniar RN, Nayak RM, Vatchha S, Singhi T. Periarticular patellar fracture fixation using suture anchors. Orthopedics. 2013;36(11):e1470–3.

41. Little KJ. Elbow fractures and dislocations. Orthop Clin North Am. 2014;45(3):327–40.

42. Winter M, Chouinard C, Cikes A, Pelegrin C, Bonsard N, de Peretti F. Surgical management of elbow dislocation associated with non-reparable fractures of the radial head. Chir Main. 2009;28(3):158–67.