Observational Study
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Clinical and radiographic outcomes of treatment of comminuted Mason type II radial head fractures with a new implant

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Abstract

This study aims to evaluate the clinical and radiographic treatment outcomes of comminuted Mason type II radial head fractures, which underwent open reduction and internal fixation (ORIF) using a new implant (mother-child screw, MCS).

This study included 16 patients (7 male and 9 female patients; mean age: 40.9 years, age range: 19–68 years), who were treated with ORIF, followed by MCS fixation for comminuted type II radial head fractures. The clinical results were evaluated using the Mayo Elbow Performance Score (MEPS). Radiographs, which included the quality of fracture reduction, stability, osteoarthritis, and heterotopic ossification of the elbow, were investigated. The mean follow-up period was 23.4 months.

Anatomical reduction and bone union were achieved in all patients treated with MCS, and mean union time was 6.2 weeks. The average flexion-extension arc of elbow motion was 135.6° (range: 125°–150°), and the average arc of forearm rotation was 155.3° (range: 145°–170°). Furthermore, MEPS was 94.1 (range: 85–100), and the rate of excellent and good was 100%. All patients returned to preinjury work within a mean period of 11.7 weeks. No heterotopic ossification and joint stiffness of the elbow were encountered. Two patients had mild arthritic changes (grade I), but none of these patients complained of pain.

The use of MCS fixation for comminuted type II radial head fractures resulted in good clinical and radiographic outcomes.

Abbreviations: MCS = mother-child screw, MEPS = Mayo Elbow Performance Score, ORIF = open reduction and internal fixation.

Keywords: bone screws, open reduction and internal fixation, radial head fracture

1. Introduction

Radial head fractures account for approximately 30% of all elbow fractures and 1.7% to 5.4% of all adult fractures.[1,2] There are different treatment concepts for comminuted Mason type II radial head fractures, such as conservation, radial head excision, arthroplasty, and open reduction and internal fixation (ORIF). Conservative treatment or excision of the radial head with arthroplasty is not recommended for type II radial head fractures, since this may lead to many complications.[3–8] ORIF with plate or screws is currently the preferred method of treatment.[1,4,9–11] However, the fixation with plate may lead to revision surgery for hardware removal, resection of the radial head, or arthroplasty due to pain or limitation of forearm rotation.[12,13] Fixation with common screws has drawbacks of greater cartilage damage and higher risk of breaking small fragments into pieces. Hence, ORIF for comminuted type II radial head fracture remains as a challenge.

The present study aims to evaluate the clinical and radiographic outcomes of comminuted Mason type II radial head fractures treated with ORIF using a new fixation implant (mother-child screw, MCS; Fig. 1).

2. Introduction of devices

MCS is a 2-part system that consists of 2 connected pieces: mother screw (Fig. 1A) and child screw (Fig. 1C). The child screw, which threads as a cortex screw, has a small diameter (1.5 mm), while the mother screw has a hollow design (3.5 mm outside diameter, 1.5 mm inside diameter), which has an external thread as a cancellous lag screw and an inside thread. The child screw can be screwed into the mother screw and combined with each other. The gasket (Fig. 1B) is seldom used.

Advantages of MCS: first, the mother screw, which has a cancellous thread, can achieve a reliable fixation that allows for the early mobilization of the elbow; second, the child screw, which has a small diameter (1.5 mm), can prevent small fragments from breaking and reduce bone loss; finally, MCS is a low-profile implant that does not need to be inserted in the safe zone, and it can diminish scarring and hardware impingement of the lateral ligamentous complex and annular ligament.

Editor: Johannes Mayr.

The authors report no conflicts of interest.

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Medicine (2018) 97:13(e0086)

Received: 30 September 2017 / Received in final form: 13 February 2018 / Accepted: 14 February 2018

http://dx.doi.org/10.1097/MD.0000000000010086

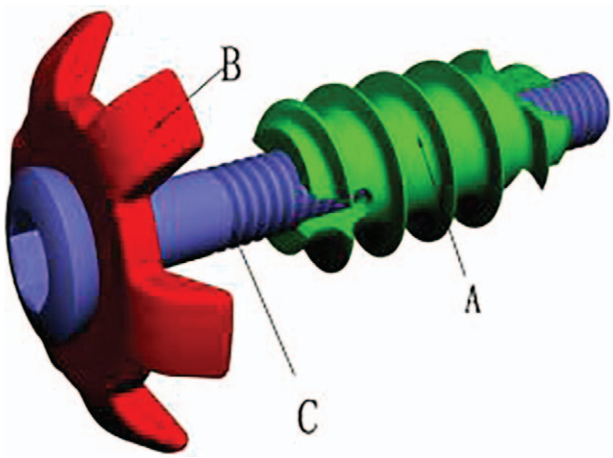

Figure 1. The mother-child screw (MCS) consists of 2 connected pieces: mother screw (A) and child screw (C). The gasket (B) is seldom used.

3. Materials and methods

This study was conducted in accordance with the principles of the Helsinki Declaration, and approved by the Ethics Committee of our Hospital. A written informed consent was obtained from all participants.

3.1. Subjects

Between October 2010 and March 2014, 16 consecutive patients (7 males and 9 females; mean age: 40.9 years, age range: 19–68 years) with comminuted Mason type II radial head fractures (2 or more separate fragments) were enrolled into the present study. Radiographic examination of the elbow consisted of the anteroposterior and lateral views. A CT scan was performed to reveal additional injuries and the degree of comminution and displacement of the fragments. According to the Mason classification system (Mason's original description, all partial articular fractures, both simple and comminuted, were classified as type II),[12] all patients had Mason type II radial head fractures and underwent treatment with ORIF using MCS.

Eight injuries were the result of falling from standing height, 2 injuries were due to falling from a greater height, 2 injuries were due to falling during sports activities, 1 injury was due to a motor-vehicle accident, and 3 injuries were due bicycle accidents. These fractures were on the right in 6 patients and on the left in 10 patients.

Ten fractures of the radial head had isolated radial head fractures, 5 patients were associated with fracture-dislocation of the elbow (3 patients had coronoid process fractures, 1 had an olecranon fracture, and 1 had both olecranon and coronoid process fractures), and 1 patient was associated with Monteggia fracture. Furthermore, 7 patients were associated with medial collateral ligament injury, in which 2 patients were associated with lateral collateral ligament injury.

MCSs were used to fixate all radial head fractures. None of the patients needed ancillary fixation. Furthermore, MCSs were also used for the ORIF of coronoid fractures. Two olecranon fractures were fixed with a plate or tension band wiring, respectively. One ulnar shaft fracture of the Monteggia fracture was fixed with plate. On completion of the associated fracture repair, the stability of the elbow was examined. The elbows, which remained unstable, may require collateral ligament reconstruction using a suture or anchor. In the present cases, lateral collateral ligament was repaired in 1 patient, medial collateral ligament was repaired in 3 patients, and both ligaments were repaired in 1 patient.

Postoperatively, 15 patients wore a sling for 3 weeks with the elbow at 90°. Elbow flexion-extension and forearm rotation commenced on the first day after surgery under the supervision of a physical therapist. A cast was performed in 1 patient (who had a "terrible triad" injury) for 3 weeks. Indomethacin or irradiation was not used as prophylaxis against heterotopic ossification after the operation.

3.2. Surgical technique

Patients were placed in the supine position under general anesthesia. The arm was positioned on a radiolucent hand table, and a tourniquet was applied to improve visualization. The Kocher approach was used for access to the radial head fracture.[14] After anatomic reduction of the radial head fracture, K-wires, which had the same diameter as the child-screw (1.5 mm), were selected as a guide pin, and inserted through the fragment to the intact part of the radial head (Fig. 2B). After moving the fragments aside, the mother screw was first inserted into the intact part of the radial head through the positioning hole (Fig. 2C). Then, a child-screw was placed into 1 or 2 fragments along the positioning hole and screwed into the mother-screw (Fig. 2D–E).

3.3. Evaluation

Two orthopedic surgeons, who were not involved in the operations, reviewed all the patients. The evaluation included a clinical examination and a radiographic evaluation. Clinical outcomes were evaluated according to the Mayo Elbow Performance Score (MEPS).[2,15] The radiographs of each elbow, including the anteroposterior and lateral views, were reviewed. The evaluation of the radiographic results included the quality of fracture reduction, stability and arthritis of the elbow joint. The radiographic signs of post-traumatic arthritis were rated according to the criteria of Broberg and Morrey, which was categorized as follows: grade 0 (absent; normal elbow), grade 1 (mild changes), grade 2 (moderate changes), and grade 3 (severe degenerative changes).[15]

4. Results

Table 1 summarizes the characteristics of the study group. All patients were followed-up, and the mean duration of follow-up was 23.4 months (range: 13–37 months). Anatomical reduction of the radial head fracture was achieved in all patients. All fractures consolidated, and the mean time needed was 6.2 weeks (range: 5–9 weeks). All affected elbows were evaluated to be stable and without recurrent dislocations. Furthermore, no hardware was removed and no loss of fixation occurred. There were mild arthritic changes in 2 patients (grade 1), but no patient complained of pain of the elbow. Complications such as neuropathy, infection, heterotopic ossification and joint stiffness of the elbow were not encountered. All patients returned to preinjury work within a mean period of 11.7 weeks.

According to MEPS, the results were excellent in 11 patients and good in 5 patients, with the mean score of 94.1 (range: 85–100). The rate of excellent and good was 100%. The average flexion-extension arc of elbow motion was 135.6° (range: 125°–150°), and the average arc of forearm rotation was 155.3° (range: 145°–170°). Furthermore, the mean pronation arc was 75.0°

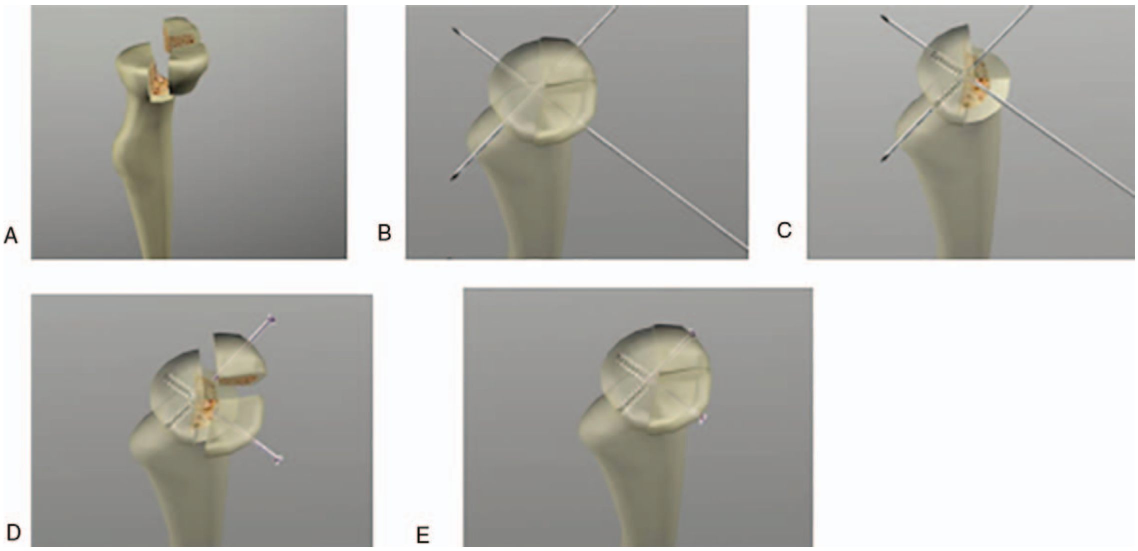

Figure 2. The surgical process of reduction and internal fixation using the Mother-Child screw is shown. (A) Comminuted type II radial head fracture with 2 separate fragments. (B) Anatomic reduction was secured. K-wires (1.5 mm in diameter) were selected and inserted as a guide pin. (C) The fragments were moved aside to allow the mother screws to be inserted directly into the intact part of the radial head over the guide pin. (D) Along the positioning hole of the fragments, the child screws were inserted into the fragments. (E) The child screws were screwed into the mother screws to obtain compression and stable fixation.

(range: 70°–80°), and mean supination was 80.1° (range: 75°–90°).

5. Discussion

The radial head is recognized as an important stabilizer of elbow and forearm articulations.[3,16–19] There are different treatments for comminuted Mason type II fractures such as excision, arthroplasty and ORIF. Excision may lead to many complications such as instability, ulnar nerve neuritis and cubitus valgus.[3,4] Arthroplasty is also not free from complications, and its long-term effects are unknown.[5–8,20] ORIF has been recommended as the preferred method of choice in type II fractures.[21–23]

However, ORIF of comminuted Mason type II radial head fracture remains a challenge for orthopedic surgeons, and may result in nonunion, loss of fixation and restriction of forearm rotation.[1,4,24,25] Furthermore, ORIF of partial radial head fractures with greater than 3 fragments have been reported to be less reliable, and replacement is recommended.[1] Mason reported that type II fractures with 2 or more fragments are difficult to fixate, and resection of the radial head is recommended.[26] Although plates afford greater biomechanical stability, it has been shown to be more likely to cause stiffness of the elbow and have high rates of hardware removal.[12,27,28] Headless compressed screw was applied, because it can be buried under the cartilage, and is commonly used for radial head fractures. However, sometimes headless compressed screws are

Table 1

demographic characteristics and postoperative result of patients.

Patient data			Associate injury			Range of movtion (degrees)		Complication			
Case number	Sex	Age, y	Dislocation	Ligment injury	Fracture	Flexion contracture/ flexion	Pronation/ supination / rotation	HO	Degenration change (grade)	MEPS (points)	Overall result
1	M	44	Yes	–	Coronoid	5/145	80/85	No	No	100	Excellent
2	F	34	No	–	–	5/135	75/75	No	No	100	Excellent
3	M	19	Yes	L+M	Coronoid	10/135	75/75	No	No	85	Good
4	F	27	No	–	–	0/145	80/80	No	No	100	Excellent
5	F	30	No	M	–	0/150	80/90	No	No	100	Excellent
6	M	41	Yes	L+M	Coronoid +olecranon	5/130	70/75	No	No	85	Good
7	F	52	No	–	–	5/130	75/75	No	1	100	Excellent
8	M	49	No	–	–	0/145	75/90	No	No	100	Excellent
9	M	22	No	M	–	0/145	75/85	No	No	95	Excellent
10	F	50	No	–	Olecranon	5/135	75/80	No	1	95	Excellent
11	F	68	Yes	M	Monteggia	5/145	75/85	No	No	95	Excellent
12	M	35	No	–	–	5/130	70/80	No	No	85	Good
13	F	51	No	M	–	5/135	75/75	No	No	95	Excellent
14	M	30	No	–	–	0/135	70/75	No	No	85	Good
15	F	62	Yes	M	Coronoid	10/135	75/75	No	No	85	Good
16	F	41	No	–	–	0/150	75/85	No	No	100	Excellent

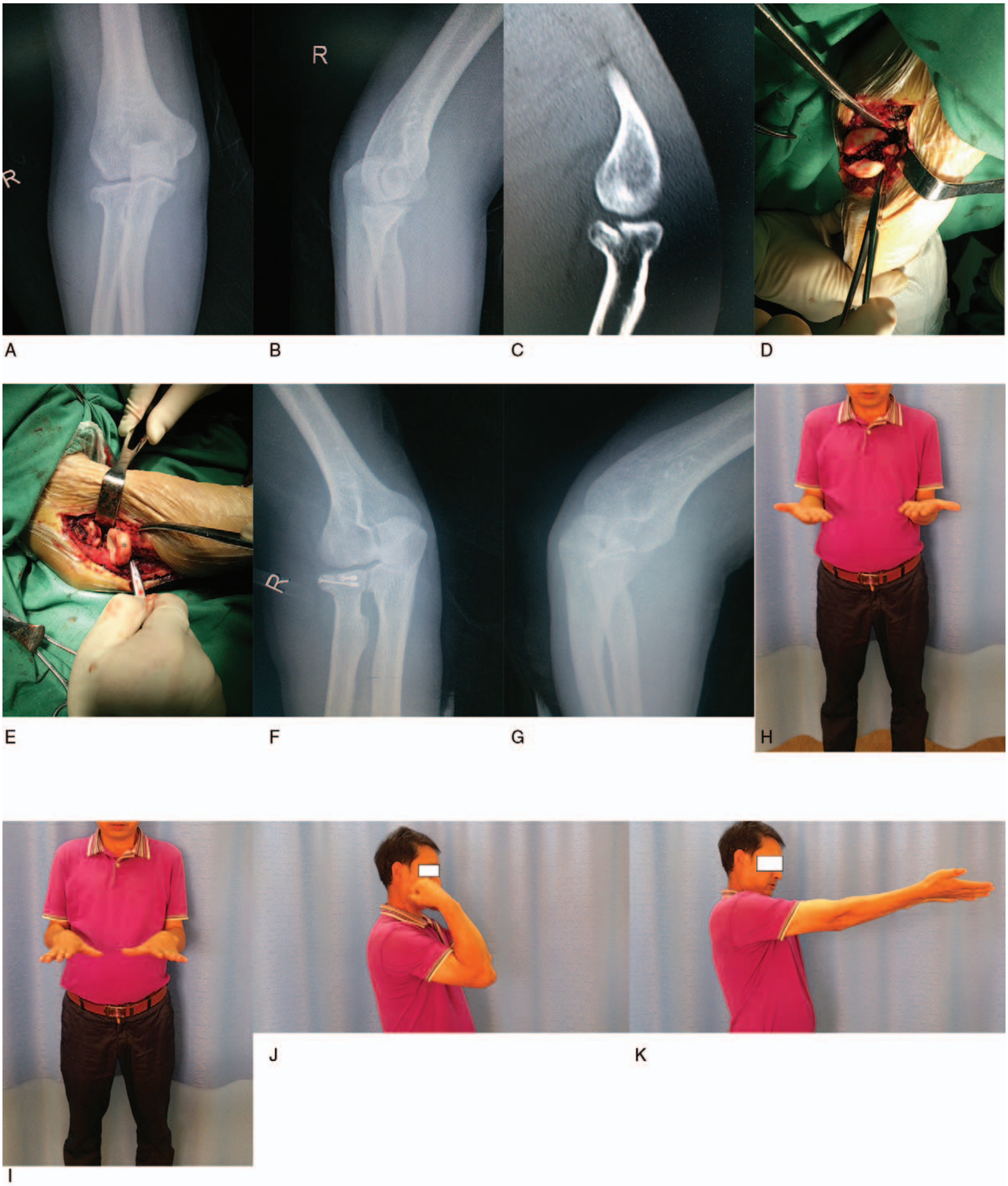

Figure 3. Internal fixation of a comminuted radial head fracture with 2 mother-child screws is shown. (A–C) Preoperative radiographs demonstrating a comminuted Mason type-II fracture. (D–E) Intraoperative photographs showing the radial head fracture, consisting of 2 fragments. (F–G) Postoperative radiographs showing that the fragments were reduced and fixed with 2 mother-child screws. (H–K) Elbow range of motion at 6 months of follow-up.

bulkier for fixing small fragments due to its relatively large end (Fig. 3D), which may break small fragments into pieces and result in failure of fixation. The child-screw of MCS has a small diameter (1.5 mm), and it should only be inserted through the fragment, effectively avoiding fragment breakage. Hence, MCS can address even these small radial head fragments in conditions where conventional implants appear excessively bulky (Fig. 3D). In the present study, all comminuted radial head fractures were successfully fixed with MCS. No fragment broke into pieces and no auxiliary fixation was needed.

The primary goal of the treatment with ORIF of the radial head fracture was to achieve early mobilization with stable fixation.[29] Evidence has demonstrated the superiority of early mobilization *vs*. prolonged immobilization in the post-injury management of radial head fractures.[25,26] Broberg and Morrey demonstrated an inverse relationship between final pain, function and range of movement with the duration of immobilization.[30] The mother-screw of MCS, which has the same thread as cancellous bone screws, has a strong anti-pull force. Hence, the comminuted radial head fractures treated with MCS may achieve stability and permit the early mobilization of the elbow. All patients, except the patient who had a "terrible triad" injury, wore a sling for 3 weeks, and elbow exercise began on the first day, postoperative. No loss of fixation and no stiffness were encountered. Furthermore, none of the patients required revision surgery and complained of pain in the elbow. All patients achieved good or excellent results according to MEPS. The stable fixation of the fragment with MCS was the key to these good clinical results.

The safe zone of the radial head is an important concept when considering plate or screw fixation.[31] Plates or screws inserted outside the safe zone result in compression in the proximal radioulnar joint.[32] In particular, the insertion of plates adjacent to the lateral ligamentous complex and annular ligament may lead to material compression, resulting in the restriction of forearm rotation and scar development.[27,33] MCS was a low-profile device, because only the small end of the child-screw was out of the radial head (Fig. 3E). In most cases, the end of the child-screw could almost be placed under the articular surface to avoid hardware impingement in the articulations. In the present patients, the MCS was inserted in any zone of the radial head, and none of the patients was asked to remove this hardware due to restriction of forearm rotation or pain of impingement. The average flexion-extension arc of elbow motion was 135.6°, and the mean pronation and supination arc was 75.0° and 80.1°, respectively.

The present data suggests that Mason type II radial head fractures can be treated with MCS and obtain excellent or good functional results. The use of MCS gives the surgeon another option for this type of fractures. However, the present study has limitations, such as the small number of patients and the lack of control groups of patients.

Author contributions

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Writing – review & editing: C-J. Yun, C. Qian, G-F. Wang, J. Zhang, J-Y. Sun, K. Mei.

References

[1] Ring D, Quintero J, Jupiter JB. Open reduction and internal fixation of fractures of the radial head. J Bone Joint Surg Am 2002;84-A:1811–5.
[2] Morrey BF, Kai-Nan A. Morrey BF. Functional evaluation of the elbow. The elbow and its disorders 3rd ed.W.B. Saunders, Philadelphia:2000;74–83.
[3] Khalfayan EE, Culp RW, Alexander AH. Mason type II radial head fractures: operative versus nonoperative treatment. J Orthop Trauma 1992;6:283–9.
[4] Ikeda M, Sugiyama K, Kang C, et al. Comminuted fractures of the radial head. Comparison of resection and internal fixation. J Bone Joint Surg Am 2005;87:76–84.
[5] Acevedo DC, Paxton ES, Kukelyansky I, et al. Radial head arthroplasty: state of the art. JAmAcad Orthop Surg 2014;22:633–42.
[6] Kachooei AR, Claessen FM, Chase SM, et al. Factors associated with removal of a radial head prosthesis placed for acute trauma. Injury 2016;47:1253–7.
[7] van Riet RP, Sanchez-Sotelo J, Morrey BF. Failure of metal radial head replacement. J Bone Joint Surg Br 2010;92:661–7.
[8] Flinkkilä T, Kaisto T, Sirniö K, et al. Short- to mid-term results of metallic press-fit radial head arthroplasty in unstable injuries of the elbow. J Bone Joint Surg Br 2012;94:805–10.
[9] Pugh DM, Wild LM, Schemitsch EH, et al. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. J Bone Joint Surg Am 2004;86-A:1122–30.
[10] Iacobellis C, Visentin A, Aldegheri R. Open reduction and internal fixation of radial head fractures. Musculoskelet Surg 2012;96(Suppl 1): S81–6.
[11] Rolla PR, Surace MF, Bini A, Pilato G. Arthroscopic treatment of fractures of the radial head. Arthroscopy 2006;22:233.e1–6.
[12] Koslowsky TC, Schliwa S, Koebke J. Presentation of the microscopic vascular architecture of the radial head using a sequential plastination technique. Clin Anat 2011;24:721–32.
[13] Ring D. Displaced, unstable fractures of the radial head: fixation vs. replacement—what is the evidence? Injury 2008;39:1329–37.
[14] Kocher T. Textbook of operative surgery. Stiles HJ, Paul CB, translators. 3rd ed. London: Adam and Charles Black; 1911.
[15] Broberg MA, Morrey BF. Results of delayed excision of the radial head after fracture. J Bone Joint Surg Am 1986;68:669–74.
[16] Gupta GG, Lucas G, Hahn DL. Biomechanical and computer analysis of radial head prostheses. J Shoulder Elbow Surg 1997;6:37–48.
[17] Knight DJ, Rymaszewski LA, Amis AA, et al. Primary replacement of the fractured radial head with a metal prosthesis. J Bone Joint Surg Br 1993;75:572–6.
[18] Morrey BF, An KN. Articular and ligamentous contributions to the stability of the elbow joint. Am J Sports Med 1983;11:315–9.
[19] Morrey BF, Tanaka S, An KN. Valgus stability of the elbow. A definition of primary and secondary constraints. Clin Orthop Relat Res 1991;187–95.
[20] Moro JK, Werier J, MacDermid JC, et al. Arthroplasty with a metal radial head for unreconstructable fractures of the radial head. J Bone Joint Surg Am 2001;83-A:1201–11.
[21] Carrigan RB, Bozentka DJ, Beredjiklian PK. Open reduction and internal fixation of radial head fractures. Tech Shoulder Elbow Surg 2002;3:195–201.
[22] Ring D. Fractures and dislocations of the elbow. In: Bucholz, RW, Heckman, JD, Court-Brown, CM, et al., editors. Rockwood and Green's fractures in adults. Vol. 1, 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2005. p. 1011–20.
[23] Ikeda M, Sugiyama K, Kang C, et al. Comminuted fractures of the radial head: comparison of resection and internal fixation. J Bone Joint Surg Am 2006;88(Suppl 1 Pt 1):11–23.
[24] Heim U. Surgical treatment of radial head fracture [in German]. Z Unfallchir Versicherungsmed 1992;85:3–11.
[25] Heim U. Surgical treatment of radial head fracture. Z Unfallchir Versicherungsmed 1992;85:3–11. [Article in German].
[26] Mason ML. Some observations on fractures of the head of the radius with a review of one hundred cases. Br J Surg 1954;42:123–32.
[27] Smith AM, Morrey BF, Steinmann SP. Low profile fixation of radial head and neck fractures: surgical technique and clinical experience. J Orthop Trauma 2007;21:718–24.
[28] Neumann M, Nyffeler R, Beck M. Comminuted fractures of the radial head and neck: is fixation to the shaft necessary? J Bone Joint Surg Br 2011;93:223–8.
[29] Morrey BF. Current concepts in the treatment of fractures of the radial head, the olecranon, and the coronoid. Instr Course Lect 1995;44:175–85.
[30] Morrey BF. Current concepts in the treatment of fractures of the radial head, the olecranon, and thecoronoid. Instr Course Lect 1995;44:175–85.
[31] Smith GR, Hotchkiss RN. Radial head and neck fractures: anatomicguidelines for proper placement of internal fixation. J Shoulder Elbow Surg 1996;5:113–7.
[32] Capo JT, Dziadosz D. Operative fixation of radial head fractures. Tech Shoulder Elbow Surg 2007;8:89–97.
[33] Gupta A, Kamineni S, Patten DK, et al. Displaced operable radial head fractures. Functional outcome correlations. Eur J Trauma Emerg Surg 2008;34:378–84.