



History of radial head prosthesis in traumatology

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A review of the literature was performed to survey the history of the radial head prosthesis in traumatology. Radial head resection was the treatment of choice before Speed first reconstructed the radial head with a metal prosthesis.

Over the years, the indication for the use of a radial head prosthesis changed from the prevention of heterotopic ossification to the prevention of proximal migration of the radius and instability of the elbow. Currently, the optimal indication for the use of radial head prostheses is a non-reconstructible radial head fracture with associated injuries that would leave the elbow, or forearm unstable if the radial head were resected.

Keywords : radial head ; fracture ; prosthesis.

INTRODUCTION

Radial head prostheses are mainly used in the treatment of non-reconstructible radial head fractures (fig 1). Current designs are relatively new. Short and medium term follow-up studies have shown promising results (29, 63, 70, 87), but only one long-term follow-up study has been published so far (29). Older designs are no longer used due to reports of poor results and numerous complications (9, 10, 47, 56, 64, 76, 99). The goal of this study is to describe the history of the radial head prosthesis in traumatology and its clinical and biomechanical evolution.

MATERIALS AND METHODS

Pubmed™, Medline™ and OldMedline™ searches were done to identify literature relating to the history of radial head prostheses. Literature was limited to those papers describing the use of radial head prostheses. Due to the limited historical timeframe that can be searched via these search engines, references from the existing literature were also searched (55).

The literature was organised using Endnote Software (ISI, Research Soft, Berkeley California, USA). Results are discussed as a chronological review of the relevant literature.

DISCUSSION OF THE LITERATURE

In the early twentieth century, radial head resection became the treatment of choice for displaced radial head fractures (41, 74, 75). In 1924, Speed (74) even stated that: *“In adults, unless the lesion is only a mere crack, there is no doubt that removal of the head is primarily indicated”*. Others reserved

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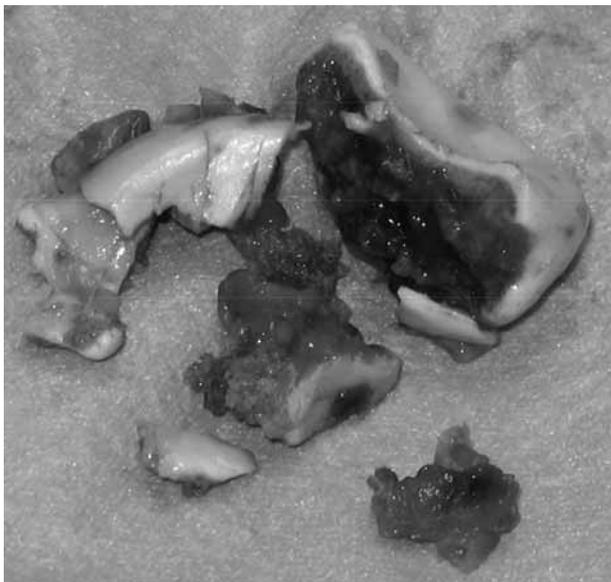


Fig. 1. — Resected fragments of a comminuted radial head fracture. The fracture was complicated by a medial collateral ligament injury and it was judged that this fracture was not amenable to reconstruction. The radial head was replaced with a metal prosthesis.

resection for cases where the radial head fracture caused a functional impairment that was not likely to improve with conservative treatment (17) or when open reduction and internal fixation was not possible (40, 41, 69). Currently, open reduction and internal fixation has become the treatment of choice for displaced radial head fractures (34, 55, 58, 65, 87).

Regrowth of bone at the proximal radius was one of the most feared complications after resection (41, 43, 57, 77). Interposition of soft tissue (43, 67, 75, 77) or bone grafting (77) was therefore suggested and in 1941, Speed (73) was the first to describe the use of a ferrule cap that could be placed over the radial neck, in order to prevent heterotopic bone formation. Interestingly, the caps were made from casts of resected normal heads of the radius, and thus were in essence, 'anatomic' radial head prostheses (73).

Indications slowly changed and ten years later, Carr *et al* (14) were the first to comment that the prosthesis increased elbow stability, when com-

pared to radial head resection. Also in 1951, Essex-Lopresti (22) described two cases where the radial head fractures were associated with a distal radio-ulnar dislocation. Although he did not use a prosthesis in either of these cases, he suggested the temporary use of a radial head prosthesis, until the forearm had healed and became stable (22).

In 1953, Cherry (16) described a second type of radial head prosthesis made of an acrylic resin, to prevent proximal translation of the radius and consequent strain on the distal radio-ulnar joint and to maintain the normal carrying angle of the elbow and prevent cubitus valgus. The use of a radial head prostheses was however still quite rare at that time (1, 18).

The first time the use of a radial head prosthesis was compared to resection of the radial head was in a retrospective study in 1960. Despite a broken stem in one, patients that were treated with prosthetic replacement of the radial head were more satisfied with the procedure, had greater mobility, less pain, and none had wrist symptoms, compared to three patients with wrist pain in the resection group (20).

Prevention of distal radio-ulnar joint subluxation became an accepted indication for radial head replacement (83).

Long-term results of the Speed prosthesis published in 1964 were shown to be similar to those of patients treated with radial head resection, with decreased pronation and supination in the prosthesis group (3).

In 1969, the Swanson Silastic® radial head prosthesis became available (Dow Corning Corporation, USA) (78, 79). Unfortunately the prosthesis did not prevent proximal migration of the radius (5, 48) and a large degree of distortion was found during movement of the elbow (72).

Timing of the prosthetic replacement was first discussed in 1974. Early replacement of the radial head showed better functional results, but good pain relief was still achieved in the late group (72).

The first structural complications with the Swanson prosthesis were reported in 1979. In a series of eighteen patients, the prosthesis had broken in three, subluxed in one and tilted in six (48) (fig 2).

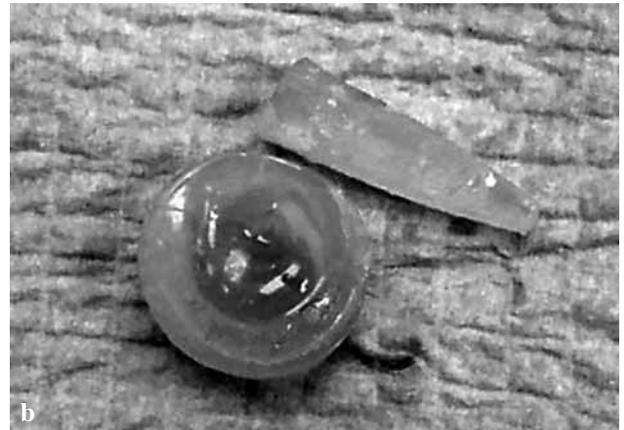


Fig. 2. — a) AP radiograph of a right elbow showing a fractured silastic radial head replacement ; b) Resected silastic radial head replacement showing the intact prosthetic head and the fractured stem.

Besides breakage of the prosthesis (7, 9, 47, 49, 76, 85, 86), giant cell synovitis from silastic particles were shown to be a problem (27, 85, 95, 99). Results of clinical reports were mixed with some showing the silastic prosthesis to yield improved results over radial head resection (7, 21, 42, 80, 86), others showing no difference (23, 96, 97) or poor results following the use of the silastic prosthesis (24, 50, 56, 66, 76). Biomechanical studies showed that radial head replacements could restore some of the stability of the elbow (28, 33, 45, 64), and longitudinal stability of the forearm (13, 28, 32, 68), but that a stiffer implant would be necessary. Due to the abundance of objective data against the Swanson radial head prosthesis, new types of prostheses were developed (30, 38, 39, 46, 52, 53) and indications were again adjusted (56). Morrey *et al* (56) limited the indications for the use of a radial head implant to insta-

bility following radial head resection and acute dissociation of the distal radio-ulnar joint.

The development and clinical trial of a vitallium prosthesis (Howmedica, London, UK), were described by Knight *et al* (46) in 1993. Loosening of the prosthesis was described in two patients and the authors commented that replacement was not clearly better than resection for simple radial head fractures (46).

Judet *et al* (38, 39) introduced a bipolar prosthesis in the literature in 1994 with promising results. The 'floating' radial head prosthesis (Tornier SA, Saint-Ismier, France) is made of cobalt-chrome, has a collared stem with a 15° neck shaft angle and consists of 2 parts connected by a spherical joint allowing 35° of uniplanar motion in any direction (38) (fig 3).

In 1996, Charnley *et al* (15) used the floating radial head prosthesis after release of the elbow for heterotopic ossification following head injury. No recurrence of the heterotopic ossification was found at a follow-up of 3.5 years (15). Interestingly, prevention of heterotopic ossification was the main indication for Speed to use a radial head prosthesis (73).

Allograft replacement of the radial head was published in 1997 (54, 82). One of the allografts dislocated three weeks following surgery, while the



Fig. 3. — Lateral postoperative radiograph of a complex elbow reconstruction following trauma. The radial head was replaced with a 'floating radial head prosthesis' (Tornier SA, Saint-Ismier, France).

arm was still in a long arm cast. Another concern was degeneration and collapse of the graft that was found in follow-up radiographs (82). No long-term results were published.

In contrast to the results of radial head prostheses, excellent long-term (average follow-up of 17 years) results of resection of the radial head, were published in 1997 (98).

In 1999, Beredjikian *et al* (6) reported on another problem with metal radial head replacements. Anatomic data were compared with commercially available titanium radial head implants. In 39% (18 of 46) of the cases, even the smallest prosthetic stem would not fit into the radial intramedullary canal. The length of the radius could not be restored in any of the cases in which a prosthesis could be fitted (6).

In 2000 'safe and effective' short-term results were found with a new type of metal radial head prosthesis used for non-reconstructible radial head fractures (52, 53). Short-term results of the floating radial head prosthesis were also promising and the prosthesis was found to restore clinical stability (63, 70). However, degenerative changes of the elbow were found in approximately 50%, while the prosthesis had to be removed in a patient due to pain and functional impairment at the elbow (70).



Fig. 4. — a) Modular radial head replacement (Evolve, Wright Medical Technology Inc., Arlington, TN, USA). Head and stem sizes can be determined individually and prosthetic components are interchangeable to accommodate the anatomy ; b) Evolve radial head prosthesis 'in situ'.

The first long-term results of a 'monoblock' metal radial head prosthesis (Smith & Nephew, Inc., Memphis, TN, USA) were published in 2001. The authors advocated the use of a metal prosthesis if the elbow was shown to be unstable following radial head resection, and concluded that radial head resection was still a valid treatment option in the otherwise stable elbow (29).

Further anatomical studies defined the dimensions of the proximal radius (19, 62, 81, 94). The radial head and neck relationship was found to be variable (93) and a modular type of radial head prosthesis was recommended (44) (fig 4). The anatomic radial head was found to be elliptical in shape (94)

and although this has so far not had any implications in prosthesis design, biomechanical testing showed altered ulnohumeral kinematics due to the fact that prostheses do not duplicate the elliptical shape of the anatomic radial head (92).

Biomechanical studies found that metal radial head prostheses could improve stability (37, 45), but could not completely restore normal valgus stability of the medial collateral ligament (36, 60). This was also concluded in a retrospective clinical review of patients (31). Others showed radial head prosthetic replacement to improve longitudinal forearm stability (84), and decrease proximal migration of the radius (59), but not to restore stability to normal, in experimentally induced Essex-Lopresti lesions.

Despite these somewhat disappointing biomechanical results, radial head prostheses have gained widespread acceptance. The radial head has been shown to be particularly important in non-reconstructible fractures that are complicated by ligamentous injury or other associated fractures, such as in the so-called "terrible triad fractures", with radial head and coronoid fractures and an associated lesion of the medial collateral ligament (51, 65). These associated injuries have recently been shown to be extremely common in radial head fractures (35, 91). Short- to midterm clinical results in this complex group of patients have been shown to be good to excellent in the majority of patients in mostly small patient series (2, 4, 11, 25, 61). Secondary radial head replacement has also been shown to yield good short-term results in a small group of patients in the treatment of sequelae of radial head fractures (11).

Although the designs and materials of modern radial head replacements have improved dramatically in recent years, the surgical technique has largely remained unchanged. Failure of the prosthesis is rare but reports of complications have been presented recently. These include loosening and dislocation of the prosthesis (26) but the main problem is mismatch in sizing the prosthesis with the native radial head. Ulnohumeral kinematics and load transfer have been shown to be adversely affected if radial neck length is not restored within 2.5 mm of the native radial head length (88, 89). This

has clinically been shown to lead to decreased range of motion and elbow pain necessitating removal of the prosthesis in some cases (8, 11, 100). Erosion of the capitellum has been shown in patients following removal of the prosthesis (8, 11) and has also been described radiographically with associated pain in the elbow (90).

CONCLUSION

Radial head prostheses have found a definite place in the treatment of complex radial head fractures. Materials and designs have improved and even the indication has changed since Speed implanted his first prosthesis (73), from prevention of bone formation to prevention of instability of the elbow (65). Biomechanical research has shown that there remains room for improvement (60) and results of the use of a radial head prosthesis have thus far not been shown to be superior to radial head resection in simple fractures.

Radial head prostheses should however be used when a radial head resection would likely cause detrimental effects to the elbow or wrist, and the majority of patients with an non-reconstructible radial head fracture has been shown to have associated lesions to the elbow (35, 91). Pre- and intraoperative assessment of elbow and forearm stability (4, 12, 71) should be included in the treatment protocol to definitely determine the indication. Certain complications described can be prevented if the radial head is replaced using anatomic guidelines (19, 88, 89).

After a thorough review of the literature we believe that the use of current radial head prostheses can be advantageous to the patient. Newer designs and surgical techniques will have to prove their merit and this could potentially broaden the indications and improve future results.

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