Full length article

Partial humeral replacement for peri-prosthetic fractures of the humerus

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ABSTRACT

Introduction: Treating peri-prosthetic fractures of the humerus can be very challenging, especially when there is poor bone stock and in the presence of adjacent joint prostheses. We discuss the option of a partial humeral replacement as a salvage procedure for such cases with some technical comments.

Methods: This paper presents a technique which utilises a custom- made cemented connector to incorporate the existing well functioning elbow or shoulder replacement with a commercially available partial humeral replacement (PHR) or to an existing prosthetic humeral stem.

Results: Our series involves 6 patients with severe rheumatoid arthritis, all female, with a mean age of 62.5 years. Their surgeries were performed over a span of 10 years, with an average follow up of 49 months. All had a well functioning implant at final follow-up, with a mean Mayo Elbow Performance score of 65. There were no cases of infection, nerve injury or dislocation in our patients. There were 2 deaths in our series, from unrelated medical causes at 2 and 4 years following their surgery.

Conclusion: Although a partial humeral replacement connected to a well functioning implant is a rare procedure for salvage of a humeral peri-prosthetic fracture, it can be a viable option in certain patient populations. Every attempt should be made to maintain the secondary shoulder stabilisers at the proximal humerus as a functioning unit.

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1. Introduction

Peri-prosthetic fractures of the humerus can be managed in a number of ways if the implants are stable; many eventually unite if treated conservatively. Open reduction and internal fixation with plates and screws can be performed if there is good bone stock available for apposition and screw purchase. Fixation can be augmented with bone allograft, or an allograft prosthetic composite can be used if the bone quality is inadequate.^{1–4} If the elbow or shoulder implant is short stemmed it could be removed and the fracture bridged with a longer stem. However in some end- stage cases, the biology of healing fails or there are problems with the joint above. Managing peri-prosthetic fractures in rheumatoid arthritis (RA) patients can be very challenging, because of their poor bone stock and the presence of adjacent joint prostheses. Systemic inflammation, loose implants and poor bone

health, as in RA patients can increase fracture healing time and the rate of complications, including non-unions.⁵

We present a technique which utilises a custom- made cemented connector to incorporate the existing total elbow humeral component with commercially available proximal humeral replacements (PHRs) or the existing shoulder replacements. The use of proximal femoral, distal femoral and even total femoral replacements in complex fracture management has been described in the literature previously⁶ and the use of cement tubes to attach to femoral implants has also been reported.^{7–9} To our knowledge, this is the first paper reporting the use of PHRs for the management of peri-prosthetic fractures involving total elbow replacements in the literature.

2. Methods

We report this technique in RA patients with total elbow replacements, who subsequently sustained peri-prosthetic humeral fractures. We will also discuss some patients with ipsilateral shoulder hemi arthroplasties and total elbow replacements, who had their fractures treated in a similar fashion with custom made cemented tubes to connect the two adjacent implants.

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Pre-operatively, the length of the custom made extension piece and the level of the bony resection at the distal fracture end is determined so that it fits with the humeral segments/shoulder hemiarthroplasty stems and restores the native humeral length (Fig. 1). The custom designed piece is essentially a hollow tube that is cemented over the humeral stem of the native total elbow replacement. This tube is fashioned to either combine with the proximal PHR segments or be cemented over the existing humeral stems to bypass the fracture and restore upper limb function. The cavity in the extension piece has an irregular cross sectional area to allow for macro fixation of the cement, and there are also small proximal holes into it, to allow for cement escape when the stem is being inserted into the cement mantle. Figs. 2 and 3 show the design schematics for extension pieces created for various total elbow humeral stems previously.

2.1. Surgical technique

General anaesthesia with an inter-scalene block was utilised, with prophylactic antibiotics given on induction. Patients are positioned in a beach chair position, with all their pressure areas padded and calf pumps for deep vein thrombosis prophylaxis.

An extended Henry's approach to the humerus¹⁰ is utilised to address the fracture with meticulous haemostasis along the way. The interval between pectoralis major and the deltoid insertion is identified and this forms the plain for longitudinally splitting the proximal humerus with an oscillating saw. The pre-determined amount of bone and loose proximal cement is removed off the arthroplasty humeral stem. Humeral head resection is then made and then the medullary content of the proximal humerus is removed with a large bone nibbler. An identical routine is carried out at the distal humerus if the prosthesis is to be cemented onto an existing humeral component.

Fig. 1. Pre-operative templating of the custom made extension piece and the level of the distal bony resection for Patient A.

Fig. 2. Axial cross section view of an extension piece created for Patient A, who had a Coonrad-Morrey stem in situ. Note the irregular cross sectional shape of the cavity to ensure macro fixation of the cement.

Fig. 3. Sagittal cross section view of an extension piece created for Patient B, who had a Souter-Strathclyde revision humeral stem in situ. Note the necessary minimum 6 cm overlap and the small proximal holes into the cavity to allow cement escape when the stem is inserted into the cement mantle.

Trial reduction with the definitive implants is then attempted. Once successful, they are removed and strong transosseous sutures are placed proximally in the inter-tuberosity region and circumferentially distally as well. This is in preparation for eventual closure of the humeral bone 'shell' over the definitive implants. The custom made sleeve is then filled with cement and docked on to humeral stem of the total elbow arthroplasty. The PHR is then fitted onto this in approximately 30° of retro version.

Once reduced, the greater and lesser tuberosities are reduced and secured through bone and over the implant. The distal circumferential sutures and the lateral aspect of the rotator interval are also secured. This will result in a satisfactory reduction of the humerus, which is stable through range of motion on the table and with good restoration of the soft tissue tension. The wound is copiously washed and closed in layers. Patients are allowed gentle active range of motion physiotherapy and are usually discharged on the second post-operative day.

3. Results

Our series has 6 RA patients whose peri-prosthetic fractures involving total elbow replacements were treated using custom made cemented tube extension pieces. These were performed over a span of 10 years, from 2006 to 2016. The patients were all female

with severe progressive RA despite aggressive medical management, with a mean age of 62.5 years (range 41–73). The average follow up period was 49 months (range 3–127). 3 cases involved the dominant right side, and 3 cases involved the non-dominant left side. 2 patients had the custom made pieces fitted onto PHRs (Fig. 4) and the other 4 patients had customised cemented tubes to connect their existing shoulder hemiarthroplasty and total elbow humeral stems (Fig. 5). 3 of the patients had already sustained previous peri-prosthetic fractures, requiring revision of their total elbow humeral components to long stemmed components. 1 patient suffered from aspiration pneumonia in her early post-operative period, requiring intensive care unit admission, and had a rocky, prolonged hospital stay from respiratory complications, before eventually making a full recovery. In the very first patient in our series, no attempt was made to re-attach bone and soft tissues to the construct. Understandably, she went on to have a poor active shoulder range of movement and clinical outcome. Following this, the subsequent patients all had their proximal humeral bone and its soft tissue attachments preserved and reattached to the final construct, with satisfactory clinical and subjective outcomes. There were no incidences of infection, nerve injuries or dislocations in our patients. There were 2 deaths in our series, from unrelated medical causes at 2 and 4 years following their surgeries. Both had a well functioning implant in place at their time of death. At final follow-up, the remaining 4 patients had a mean Mayo Elbow Performance score (MEPS) of 65 (range 60–70, which all qualify as 'fair' results). All the patients expressed subjective improvement following their salvage surgeries.

4. Discussion

The use of PHRs has been well documented in the literature in dealing with massive bony defects following tumour excision.^{11–}

¹⁷ There has only been 1 series which included endoprosthesis replacements in their management of total shoulder peri-prosthetic fractures.¹⁸ Complications previously described with PHRs in tumour surgery include deep infections, implant loosening, radial nerve palsy (both transient and permanent), technical difficulties with implant insertion, haematoma formation and a globally reduced active range of motion (ROM) at the shoulder. A glenohumeral instability rate of 11–31% has been described after PHR, and this likely due to the sacrificed rotator cuff in tumour scenarios.^{15–17} Many studies consistently report limited active ROM of the shoulder with good passive ROM post-operatively; the patients report functional limitations with activities involving pulling, pushing and lifting above shoulder level.^{12,14,16,17} However, all these patients still have a stable platform for their elbow and hand function, which is maintained. It is this return to pre-injury functional levels which we aim to achieve in our series of RA patients, who generally have poor shoulder function prior to their fractures anyway. While muscle function around the elbow can be preserved by careful surgical approach, shoulder function in these cases depended on the secondary humeral stabilisers, which is why the problem of instability in the first case was avoided subsequently by preserving the osseous tube proximally and reforming it around the implant. All our patients had 'fair' Mayo Elbow Performance scores (MEPS) post-operatively with a mean score of 65, which is comparable to the results with other treatment options for this problem. Previously reported mean post-operative MEPS values at final follow-up are 79 (range 40–100) for revision fixation with strut allografts, and 67 (range 15–100) for allograft-prosthesis composites; these qualify as 'good' and 'fair' outcomes respectively.^{1,2}

Unlike in tumour surgery, the humeral bone and soft tissues can be preserved in fracture scenarios, for presumably better function post-operatively. However, it has been noted that soft tissue

Fig. 4. Pre- and post-operative films for Patient A. This patient had a previous distal humerus periprosthetic fracture treated with revision to a long stemmed humeral implant after an attempted internal fixation and bone grafting had failed. She then suffered a new fall, with a more proximal fracture, with the problems of insufficient proximal bone for fixation and a stiff shoulder secondary to RA.

Fig. 5. Post-operative films of two different patients who had their humeral peri-prosthetic fractures involving ipsilateral shoulder hemiarthroplasties and total elbow arthroplasties treated with a custom cemented tube to combine the two humeral stems.

reconstructions with reattachment of the rotator cuff tendons did not improve the ROM results after proximal and total humeral replacements in tumour patient studies.¹⁴ The 10 year and 20 year PHR implant survival rates have been reported at 90% and 86.5% respectively, in patients who had survived their tumours.^{14,16} More studies are required to evaluate the long term implant survival and clinical outcomes when used in fracture management, in both normal and rheumatoid patient populations.

This approach was utilised by the senior author, such that the existing well-functioning total elbow (or shoulder) replacements could be preserved and patients could be returned to their pre-injury, often limited, functional status. In 1987, when reporting on their series of PHRs for tumours, Ross et al. had concluded that, “prosthetic replacement should be considered in traumatic or benign lesions where destruction of the humerus is so severe that reconstruction by conventional means is impossible . . .”.¹⁷ There are now comprehensive segmental revision systems available which allow for anatomic and reverse total shoulder systems and total elbow systems to be compatible, thus addressing such complex fracture or revision cases through proximal, distal or complete humeral replacements. While this remains a rare indication for salvage of peri-prosthetic humeral fractures, because of the increasing numbers of patients undergoing upper limb arthroplasties, subsequently presenting with peri-prosthetic fractures, and the associated complications of their surgical management, a greater number of such salvage procedures may be performed in future. However the routine revision of both shoulder and elbow implants is a major undertaking for the patient and the surgeon.

The use of a custom cemented tube to connect to a well-functioning implant above or below has previously been reported to be successful in the femur.^{7–9} In the complex humeral cases reported here the aim of surgery was to interfere as little as possible with well functioning (though possibly loose) implants while obtaining enough stability to allow immediate mobilisation

and a return to a pre-injury functional state. By avoiding the complications of revision joint surgery potentially the complications will reduce.

5. Conclusion

The management of peri-prosthetic fractures in rheumatoid patients remains very challenging. Although partial humeral replacements connected to a well functioning implant is a rare indication for salvage of a humeral peri-prosthetic fracture, it can be a viable option in certain patient populations, such as RA patients with poor bone stock and health and joint disease in adjacent joints. The use of partial humeral replacements has been limited mainly to tumour surgery; more research is needed to evaluate their outcomes and survival when used in fracture management though each case is likely to be unique and the functional outcome predicated by pre-existing disease and disability elsewhere. Every attempt should be made to maintain the secondary shoulder stabilisers at the proximal humerus as a functioning unit.

Conflict of interest

The authors have none to declare.

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Informed consent

Informed consent was obtained from all individual participants included in the study.

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