Enhancing soft-tissue reattachment in proximal humeral endoprosthetic reconstruction

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ABSTRACT

Purpose. To report on the use of the Ligament Advanced Reinforcement System (LARS) to enhance joint stability and functional outcome in proximal humeral endoprosthesis reconstruction.

Methods. Two men and 5 women aged 16 to 66 (mean, 28) years underwent wide resection of tumour and endoprosthesis reconstruction of the proximal humerus using the LARS, as the rotator cuff and/or deltoid muscle could be preserved. The preserved muscles were reattached to anatomic positions to regain function. Shoulder range of motion and Musculoskeletal Tumour Society scores were evaluated.

Results. The mean follow-up was 26 (range, 14–36) months. All the 7 patients were alive without disease. The mean active abduction was 77º (range, 60º–100º), and the mean active flexion was 74º (range, 50º–100º). The mean Musculoskeletal Tumour Society score was 86% (range, 80–93%). One patient had instability of the glenohumeral joint at one year.

Conclusion. The LARS may enhance soft-tissue reattachment and improve shoulder stability after proximal humeral endoprosthetic reconstruction.

Key words: humerus; joint instability; ligaments; limb salvage

INTRODUCTION

Salvage of the proximal humerus following tumour resection is a preferred treatment.1 The complication rate after endoprosthetic reconstruction is lower than that after reconstruction using allografts or allograft-prosthetic composites.2,3 However, metal prostheses lack an interface for soft-tissue reattachment. The shoulder joint has 6º of freedom; its function and stability is provided by surrounding soft-tissue attachments.4 Direct soft-tissue ingrowth into metal prostheses cannot provide adequate strength.5 Theoretically, prostheses coated with biocompatible scaffolds for soft-tissue ingrowth may improve function and stability. The use of a synthetic ligament combines the benefits of soft-tissue reattachment
in a biological reconstruction with the benefits of endoprosthesis reconstruction. The Ligament Advanced Reinforcement System (LARS), a type of synthetic ligament, has been used for reconstruction of the anterior cruciate ligament, rotator cuff, and Achilles tendon. We report the use of LARS to enhance joint stability and functional outcome by increasing soft-tissue reattachment in proximal humeral endoprosthesis reconstruction.

MATERIALS AND METHODS

Between March 2009 and March 2011, 2 men and 5 women aged 16 to 66 (mean, 28) years underwent endoprosthesis reconstruction of the proximal humerus using the LARS (40 cm long and 6 cm wide) following tumour resection. The tumour histologies were osteosarcoma (n=4), chondrosarcoma (n=1), fibrosarcoma (n=1), and malignancy in a giant cell tumour (n=1). The LARS was used as the rotator cuff and/or deltoid muscle could be preserved.

Wide resection of the tumour was made through an extended deltopectoral approach. The tuberosity was not preserved. If the deltoid was preserved, its tendon was cut 1 cm from its insertion. If the tumour involved the glenohumeral joint, extra-articular resection was performed, the capsule was kept intact, and the glenoid was osteotomised medially to the scapular attachments, where the rotator cuff muscles were cut. Care was taken to preserve axillary and radial nerves. After transection of the biceps, the latissimus dorsi and teres major were identified and cut. The capsule was then released completely around the humeral neck. The infraspinatus, supraspinatus, and teres minor tendons were cut and tagged. The deltoid was then dissected from the humeral shaft, and the osteotomy performed.

A proximal humeral endoprosthesis (Link; Hamburg, Germany) was used to reconstruct the bone defect. It is made up of a metal stem covered by polyethylene and is lighter than the all-metal design. The endoprosthesis was cemented into the distal host bone at 35° of retroversion with respect to the forearm. One end of the LARS was sutured circumferentially along the remaining capsule or the glenoid (Fig. 1). The prosthetic humeral head was reduced into the artificial capsule. The other end of the LARS was secured to the prosthesis by purse string sutures while wrapping it around the shaft of the endoprosthesis spirally. The rotator cuff and remaining deltoid tendon, latissimus dorsi, pectoralis major, and longer head of biceps tendon were anatomically reattached to their corresponding positions on the prosthesis wrapped with the LARS.

Postoperatively, a shoulder immobiliser was worn for 3 weeks, and pendulum exercises were allowed. After 3 weeks, a sling was used and supine active-assisted range-of-motion exercises were started. Active motion was started after 6 weeks. The shoulder range of motion and the Musculoskeletal Tumour Society score were evaluated.

RESULTS

The mean follow-up was 26 (range, 14–36) months (Table). All 7 patients were alive without disease. The mean active abduction was 77° (range, 60°–100°), and the mean active flexion was 74° (range, 50°–100°). The scapula was stabilised while measuring the range of motion. The mean Musculoskeletal Tumour Society score was 86% (range, 80–93%). One patient had instability of the glenohumeral joint at one year (Fig. 2). One other patient had a wound dehiscence that was managed conservatively.
Limb salvage has become a preferred reconstructive option, because of component modularity, improved design and fixation, and quicker return to function. However, the use of endoprosthesis after tumour resection is associated with substantial soft-tissue loss and functional deficits. Metallic proximal humeral endoprostheses usually act as a spacer and do not allow a stable reconstruction with a hemiarthroplasty. In contrast, glenohumeral instability is less frequent in patients with a more biological reconstruction. Shoulder arthrodesis with vascularised free fibular grafts can provide a strong and stable shoulder girdle. However, such a construction is contraindicated when the deltoid and rotator cuff can be preserved. Vascularised free fibular grafting is also associated with donor-site morbidity.

The main advantage of a biological reconstruction (using osteoarticular allografts or allograft-prosthesis composites) over a prosthetic reconstruction is the feasibility of periarticular attachments for the host’s remnant soft tissues, and the lower chance of instability caused by rotator cuff dysfunction. However, the problems of infection and non-union after allograft reconstruction remain. The complication rate after endoprosthesis reconstruction is lower than after reconstructions using allografts or allograft-prosthesis composites. Using an artificial ligament as a sleeve anchored to the endoprosthesis may enhance joint stability and function by providing a biocompatible scaffold for musculotendinous reattachment. Polyethylene terephthalate tubes, synthetic aortograft meshes, and collagen membranes can enhance biological incorporation of soft tissues and implant while maintaining joint mobility. Growth of the surrounding fibrous tissue into the polyethylene terephthalate has been reported.

The functional outcome of our patients was comparable to those having biological reconstructions. In 36 patients with proximal humeral reconstruction using allograft-prosthesis composites, the periarticular soft tissue was reconstructed to stabilise the glenohumeral joint and improve functional outcome. The mean active abduction and flexion in patients with an intact deltoid was 72° and 70°, respectively, and the mean Musculoskeletal Tumour Society score was 83.

### DISCUSSION

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### Table

<table>
<thead>
<tr>
<th>No.</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Diagnosis</th>
<th>Range of motion (degrees)</th>
<th>Follow-up (months)</th>
<th>Status</th>
<th>Musculoskeletal Tumour Society score (%)</th>
<th>Complication</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>16</td>
<td>Osteosarcoma</td>
<td>Flexion 70, Extension 20, Abduction 10, Adduction 80, Internal rotation 40, External rotation 20</td>
<td>36</td>
<td>NED</td>
<td>83</td>
<td>-</td>
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<tr>
<td>2</td>
<td>F</td>
<td>19</td>
<td>Osteosarcoma</td>
<td>Flexion 100, Extension 30, Abduction 20, Adduction 90, Internal rotation 80, External rotation 60</td>
<td>34</td>
<td>NED</td>
<td>87</td>
<td>Glenohumeral instability</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>21</td>
<td>Osteosarcoma</td>
<td>Flexion 90, Extension 30, Abduction 20, Adduction 90, Internal rotation 50, External rotation 30</td>
<td>29</td>
<td>NED</td>
<td>84</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>66</td>
<td>Chondrosarcoma</td>
<td>Flexion 60, Extension 20, Abduction 20, Adduction 60, Internal rotation 30, External rotation 20</td>
<td>29</td>
<td>NED</td>
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<td>Wound dehiscence</td>
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<td>5</td>
<td>M</td>
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<td>Flexion 120, Extension 30, Abduction 20, Adduction 100, Internal rotation 40, External rotation 50</td>
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<td>93</td>
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<tr>
<td>6</td>
<td>F</td>
<td>25</td>
<td>Fibrosarcoma</td>
<td>Flexion 100, Extension 15, Abduction 25, Adduction 60, Internal rotation 30, External rotation 30</td>
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<td>NED</td>
<td>87</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>28</td>
<td>Malignancy in giant cell tumour</td>
<td>Flexion 90, Extension 20, Adduction 60</td>
<td>14</td>
<td>NED</td>
<td>83</td>
<td>-</td>
</tr>
</tbody>
</table>

* NED denotes no evidence of disease
Society score was 87%, which is comparable to 83% noted in our study. The rate of glenohumeral instability after endoprosthesis reconstruction is about 11 to 31%. The tendon and scapular reconstructions using allografts result in superior function and joint stability. The ligament can provide scaffolding for reattachment of the surrounding musculotendinous structures. In our study, only one patient had instability at one year, which was due to minimal excentration of the humeral head migrating superiorly secondary to rotator cuff insufficiency.

The use of the LARS together with endoprosthesis can achieve better joint stability and functional outcome, owing to capsular reconstruction and better surrounding muscle reattachment.

The main limitation of this study was lack of comparison between patients using and not using LARS. Further long-term, controlled trials are required to determine the efficacy of LARS in proximal humeral reconstruction. These studies should include assessment of costs and benefits compared to other techniques in terms of donor-site morbidity, rehabilitation, and operating time.

REFERENCES