The Use of Ligament Advanced Reinforcement System (LARS) in Limb Salvage Surgery: A Pilot Clinical Study

Tao Ji MD, Xiaodong Tang MD, Wei Guo MD, PhD
Musculoskeletal Tumor Center, People’s Hospital, Peking University, Beijing, China

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ABSTRACT

The aims of this study were to analyze the preliminary clinical outcome of limb salvage using Ligament Advanced Reinforcement System (LARS). It is hypothesized that LARS ligament is a safe and effective choice to enhance prosthetic reconstructions, providing good muscles reattachment and improving joint stability. From March 2009 to March 2010, 7 patients received megaprosthetic reconstruction following tumor resection in combination with soft tissue reconstruction using LARS. Reconstructions were four around the knee and three in proximal femur. The average MSTS 93 score was 81.0% at a mean follow-up of 27.0 months. No infection was observed. The results show that LARS appears to be an effective device for limb salvage surgery providing good muscles reattachment, improving joint stability.

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Limb salvage surgery is widely used as a preferred treatment for patients with primary malignant bone and soft tissue sarcomas [1]. A wide resection of the tumor usually results in a large segmental defect. Different procedures, mainly endoprosthetic reconstruction and allograft reconstruction, are well established and have been described in the literature. Nonetheless, different reconstructions result in problems for soft-tissue reattachment, host-implant integration, and stability of unconstrained endoprosthesis [2–4]. Current preparations of metal prostheses have demonstrated limited soft tissue in growth and limited interconnectivity [5]. Textile implants have been introduced for soft-tissue reconstruction following megaprosthetic reconstruction [3, 4]. The Ligament Advanced Reinforcement System (LARS), a kind of synthetic ligament, has been successfully used for ACL repair, rotator cuff and Achilles tendon reconstruction [6]. Dominkus et al [3] first reported application of the LARS ligament in tumor surgery for extensor apparatus reconstruction. In order to avoid dislocation, enhance soft-tissue reattachment, the LARS ligament band (R06×400/S), 40 cm long and 6 cm wide, has been used since 2008. The aims of this study were to evaluate the application of LARS ligament in tumor endoprosthetic reconstruction in lower extremity. It is hypothesized that LARS ligament is a safe and effective choice to enhance prosthetic reconstruction, providing good soft-tissue reattachment, improving joint stability and optimizing function outcome.

Methods

From March 2009 to March 2010, 7 patients (5 males, 2 females) with a mean age of 28.0 years (range, 11–43 years) received a mega prosthetic reconstruction following tumor resection in combination with reconstruction using LARS (Arc sur Tille, France) (Table 1). The diagnosis was osteosarcoma in 3 cases, chondrosarcoma in 2 cases, fibrosarcoma and giant cell tumor in one case each. All the tumors were resected with wide margin and extra articular resection was performed in one patient diagnosed with osteosarcoma in proximal femur and had hip joint involved. All patients with an osteosarcoma received neoadjuvant and adjuvant chemotherapy.

For tumors in proximal femur, the patients were placed in a lateral position and lateral approach was used in all the three patients. In one patient, both preoperative MRI and bone scan showed no tumor involvement at lateral cortex of greater trochanters, and therefore, the trochanteric osteotomy was performed. Tumor was removed with normal tissue envelope. The essential point of the capsulotomy was to preserve as much as possible. After the prosthetic stem was cemented into the residual canal, the body of the prosthesis was then wrapped with LARS ligament. Nonabsorbable sutures were secured through artificial ligament and holes located on the trochanters. A purse-string suture was used to reconstruct the capsule. The abductors were then reattached to the prosthesis using wire cables if a segment of great trochanter remained. The remnant soft hip muscles such as pectineus,

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Reprint requests: Wei Guo, MD, PhD, Musculoskeletal Tumor Center, People’s Hospital, Peking University Beijing 100044, China.

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the external rotators, and psoas were then sutured to the reconstructed capsule. The gluteus tendon and other muscles were sewn with woven, nonabsorbable suture to the LARS sheath. Muscle reattachment was performed with the intent to recover primary muscle insertions. Postoperative mobilization and weightbearing as tolerated were continued for 6 weeks and standard hip precautions for 3 months.

When extra articular resection, which needs acetabulum to be resected, is indicated for proximal femur tumor resection, LARS ligament reconstruction is considered to avoid high risk of dislocation. Nonabsorbable sutures are used to fix the LARS ligament on acetabulum of the modular hemipelvic endoprosthesis [7] to form an artificial capsule encompassing the hip joint. It provides the initial mechanical support needed for healing and scarring. Also the proximal femur endoprosthesis is wrapped with LARS ligament, and the adjacent muscles, including gluteus medius, gluteus maximus, iliopsoas, pectineus and vastus lateralis, are secured to the ligament. Patients are allowed to commence protective weight bearing two weeks after surgery. Daily physical therapy for assistance with ambulation and range of motion exercise for the knee is recommended.

For distal femur and proximal tibia reconstruction, the endoprosthesis is wrapped with LARS ligament and attached to spared muscles and tendons. For one patient reconstructed with non-hinged endoprosthesis, the distal part of LARS ligament was splitted into two bundles and one was used to reconstructed medial collateral ligament with the intention to improve the stability of knee joint (Fig. 1).

The functional outcomes were evaluated according to the Musculoskeletal Tumor Society score [8] for the following six categories: pain, function, emotional acceptance, use of external support, walking ability, gait. Results are reported as a percentage of the full score.

Results

The mean follow-up was 27.0 month (range, 24–36 months). One patient diagnosed with osteosarcoma in proximal femur died of disease 24 months after extra articular resection. All the other ten patients are alive without disease. The average MSTS 93 score was 81.0% (range, 60%–93.3%).

The mean active flexion of the patients with proximal femur replacement was 80° (range, 60°–100°). Two of the three patients underwent both acetabulum and proximal femur resection and reconstruction. For active extension, the range of motion was 5° to 10°. Range of motion of abduction (average 28.3°) and adduction (average 16.7°) were satisfactory. The active internal rotation was on average 18.3° and external rotation was on average 26.7°. The mean MSTS 93 score was 78.9%. All the three patients did not use any external support and no Trendelenburg sign was observed.

For patients with reconstruction around the knee, two with proximal tibia replacement, one with distal femur replacement and one with extensor apparatus reconstruction, the active flexion was 90° (range, 60°–110°). The mean functional outcome was 82.5%.

No patient had infection or foreign body reaction. The surrounding soft tissue including LARS ligament was harvested in one patient who had revision for recurrent tumor. The histopathologic findings showed tissue ingrowth of surrounding fibrous tissue into the ligament and no foreign body granuloma or inflammatory (Fig. 2).

Discussion

Limb salvage surgery has become a favorable reconstructive option with component modularity, improved design and fixation, and quicker return to function in recent years [9]. However, the follow-up showed numerous complications such as aseptic loosening, infection, mechanical failures, and also dislocations. Repair of joint capsule, reconstruction of surrounding muscle can restore joint stability and avoid dislocation [4,10]. Osteochondral allografts provide mechanisms to preserve capsular tissue and reattach of surrounding muscles subsequently may be associated with lower rates of joint instability and better functional outcome [11–13], but the problems of infection and nonunion after allograft reconstruction remain unsolved. Allograft prosthesis composites have been used to enhance the soft tissue

Table 1

Demographic Data.

<table>
<thead>
<tr>
<th>No.</th>
<th>Sex/Age (Years)</th>
<th>Diagnosis</th>
<th>Localization</th>
<th>Procedure</th>
<th>Flexion (°)</th>
<th>Ext. (°)</th>
<th>Adduction (°)</th>
<th>Abduction (°)</th>
<th>Int. Rotation</th>
<th>Ext. Rotation</th>
<th>Follow-Up (Months)/Status</th>
<th>MSTS 93 Score (%)</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M/41</td>
<td>Chondrosarcoma</td>
<td>Periacetabulum + Proximal Femur</td>
<td>R+E</td>
<td>60</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>36/DOD</td>
<td>93.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>F/43</td>
<td>Chondrosarcoma</td>
<td>Patella</td>
<td>R</td>
<td>60</td>
<td>-10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>35/NED</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>M/24</td>
<td>Osteosarcoma</td>
<td>Proximal Tibia</td>
<td>R+E</td>
<td>100</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>35/NED</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>M/35</td>
<td>Osteosarcoma</td>
<td>Proximal Femur</td>
<td>R4+E</td>
<td>80</td>
<td>10</td>
<td>15</td>
<td>30</td>
<td>15</td>
<td>30</td>
<td>26/DOD</td>
<td>70.0</td>
<td>Local recurrence</td>
</tr>
<tr>
<td>5</td>
<td>M/11</td>
<td>Osteosarcoma</td>
<td>Distal Femur</td>
<td>R+E</td>
<td>110</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>27/NED</td>
<td>93.3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>F/19</td>
<td>Fibrosarcoma</td>
<td>Proximal Femur</td>
<td>R+E</td>
<td>100</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>30</td>
<td>30</td>
<td>26/NED</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M/23</td>
<td>Giant cell tumor</td>
<td>Proximal Tibia</td>
<td>R+E</td>
<td>90</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>24/NED</td>
<td>86.7</td>
<td></td>
</tr>
</tbody>
</table>

R+E: wide resection and endoprosthetic reconstruction; NED: Non evidence of disease; DOD: Died of disease.

a Extra articular resection.

b Non-hinged epiphysis preservation prosthesis.
reconstruction. The main advantage, comparing to resection mega-
prosthesis, is the effective reattachment of the tendons of the hip
abductors and iliopsoas muscles, thereby preventing dislocation
and allowing better function [12]. However, the biological characteris-
tics of the allograft bone lead some complications, including nonunion
at allograft-host bone junction, postoperative infection, periprosthetic
fracture, and aseptic loosening [14,15].

Over the last two decades new types of synthetic ligament have
been developed with promising clinical results [6,16,17]. Goshgeger
et al [4] ever reported use of a special trevira tube to avoid dislocation
of an unconstrained endoprosthesis. One of these synthetic ligaments,
the LARS, has recently gained popularity [3,6,17–20]. The LARS band
used in the current study was as a band of 40 cm long and 6 cm wide,
which not only offers joint stability but also allows for reattachment of
the surrounding muscles to the endoprostheses. Besides improve-
ment of joint stability, the reattachment of adjacent soft tissue can
decrease the possible dead space around the metallic implant after
extensive detachment and may possibly decrease the infection rate.

Dislocation is the most common complication after proximal
femur resection [10]. No dislocation occurred in the three patients
with proximal femur replacement. Two of them received complex
reconstruction involving both periacetabulum and proximal femur.
Without capsular preservation, joint stability was determined by the
muscle reconstruction and scar formation. Given the condition that an
extraarticular resection of hip joint is indicated, capsule reconstruction
becomes necessary to avoid high risk of dislocation. In the current
study, the patients reached good active abduction with an average of
28.3°. The range of motion of hip joint was comparable to those
reported before [4,10]. Henderson et al [21] recently reported a
 technique to enhance soft tissue ingrowth in proximal femoral
arthroplasty with aortograft sleeve. A synthetic mesh tube composed
of collagen-coated filamentous yarn was used to form an aortograft
sleeve wrapping the metal prosthesis.

For reconstructions around the knee, Dominkus et al [3] used LARS
ligament to reconstruct extensor apparatus and their results proved it
was promising for augmentation and complete reconstruction of
extensor apparatus after tumor resection. The mean degree of active
flexion of knee joint was 90°, which may be caused by inadequate
rehabilitations. In current study, LARS ligament was used to
reconstruct medial collateral ligament on immature patient

with non-hinged distal femur endoprosthesis reconstruction. Stable
knee joint was achieved postoperatively.

Trieb et al [20] analyzed the biopsies from LARS six months after
implantation and investigated by biochemistry showed a complete
cellular and connective tissue ingrowth. Also in an in vitro study, the
fibroblasts and osteoblast-like cells encapsulated the fibers by
building a cellular net around them. The same biocompatibility was
confirmed in the current study by pathology study.

The main limitation of the current study was lack of comparison
between the groups of patients who had LARS ligament reconstruc-
tion versus those who had not. Another limitation was the small
number of cases. Considering the good biocompatibility and favorable
functional outcome, more cases evaluation and long-term follow-up
are warranted to confirm the early results.

The early results show that LARS ligament is a safe and effective
alternative choice to facilitate soft tissue reconstruction in prosthetic
reconstructions after tumor resection, providing good muscles
reattachment and improving joint stability.

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Fig. 2. The tissue section shows scar tissue surrounding the LARS ligament (Stain,
haematoxylin and eosin; original magnification, ×100).