Reconstruction of lower end of radius using vascularized upper end of fibula

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ABSTRACT

Background: Giant cell tumor is a fairly common locally invasive tumor in young adults. The lower end of the radius is the second commonest site for this tumor. The most common treatment for this tumor is curettage with or without bone grafting but it carries a significant rate of recurrence. Excision is the treatment of choice, especially for cases in which the cortex has been breached. After excision of the distal end of the radius, different procedures have been described to reconstruct the defect of distal radius. These include partial arthrodesis and hemiarthroplasty using the upper end of the fibula. The upper end of the fibula has a morphological resemblance to the lower end of the radius and has been used to replace the latter. Traditionally it was used as a ‘free’ (non-vascularized) graft. More recently the upper end of the fibula has been transferred as a vascularized transfer for the same purpose. Though vascularized transfer should be expected to be more physiological, its superiority over the technically simpler non-vascularized transfer has not been conclusively proven. Materials and Methods: Two patients are presented who had giant cell tumor of distal radius. They underwent wide local excision and reconstruction with free vascularized upper end of the fibula. Result: Follow-up period was two and a half years and 12 months respectively. Both patients have returned to routine work. One patient has excellent functional result and the other has a good result. Conclusion: Vascularized upper end of fibula transfer is a reliable method of reconstruction for loss of the distal end of the radius that restores local anatomy and physiology.

KEY WORDS

Distal radius, free vascularized fibula, giant cell tumor

Giant cell tumor of the distal radius is a fairly common, locally aggressive tumor of young adults. While early tumors can be treated by curettage with or without bone grafting, recurrence rates are significant. Once the tumor has breached the cortex, wide local excision remains the only curative treatment. No traditional procedure can replace the wrist joint and completely restore normal morphology and function. Hemi-arthroplasty using the upper end of the fibula has been described as one of the procedures of choice because the upper end of the fibula has some similarity in shape to the distal radius.\(^1\) The upper end of the fibula has been described both as a vascularized as well as a non-vascularized transfer. This is a report of two cases we did, in which we were able to restore near normal functions of the hand, using vascularized transfer of the upper end of the fibula.
PROCEDURE

Preoperative planning
Cutaneous perforators from the anterior tibial artery (ATA) were marked over the upper antero-lateral leg with a portable Doppler. The length of the fibula required was marked from the radiograph after discussing the amount of excision needed with the orthopaedic surgeon.

Two-team approach
Both donor and recipient site dissections were carried out simultaneously, under tourniquet control.

The orthopaedic surgery team resected the lower end of the radius, performing a step-cut osteotomy in the radius.

The plastic surgery team dissected out the ipsilateral (as we feel that vascular anatomy would be more suitable) upper end of the fibula.

Operative details
An antero-lateral approach was used to isolate the proximal part of the fibula. Based on the previously marked perforators, an ellipse of skin (about 5.0 cm × 2.0 cm) was marked. This skin paddle helped in the final closure in the forearm that may be otherwise difficult due to edema and the bulk of additional transferred tissue. It is also useful for monitoring the flap postoperatively.

Dissection was carried out between the tibialis anterior and extensor digitorum longus muscles to explore anterior tibial vessels. Throughout the dissection, care was taken to identify and preserve at least one good cutaneous perforator from the anterior tibial artery, supplying the overlying skin paddle. The recurrent branch of the anterior tibial artery was identified and traced upwards towards the superior tibio-fibular joint. The common peroneal nerve was identified as it winds around the neck of the fibula. The origins of the extensor digitorum longus and peroneus longus were sharply dissected out from the fibula (origin) at the level of entry of the common peroneal nerve into the anterior compartment of the leg. The recurrent branch of the anterior tibial artery was skeletonized up to the level where it gives the fibular epiphyseal branch [Figure 1a] on which the flap would be based.

In the proximal part of the leg the common peroneal nerve branches cross the pedicle and often have a complicated relation with it. It is not always possible to preserve all of them and some nerve branches had to be cut. These branches were repaired immediately [Figure 1b] after separating the fibula. The fibula was then separated from the peroneal artery that is closely related to the middle and lower parts of the bone. The tibiofibular joint was opened carefully preserving the lateral collateral ligament of the knee joint and all the remaining ligamentous attachments of the fibula were divided. Finally, proximal dissection of the pedicle was carried out till the origin of the anterior tibial vessels. A short segment of the anterior tibial artery was harvested, to be used as the donor pedicle. The lateral collateral ligament and biceps femoris tendon were fixed to the lateral aspect of the tibial periostium with nonabsorbable sutures.

In both our cases the flap was based solely on the recurrent branch of the anterior tibial artery.

Reconstruction of distal radius
The distal end of the radius was fixed to the distal end of...
anastomosis good bleeding was observed through the medullary cavity of the fibula. Postoperatively the limb was splinted with a bulky dressing and an above elbow plaster of paris slab, with the elbow in 90-degree flexion and wrist in 20 degrees of extension in midprone position.

**Postoperative**

Immediate postoperative check X-ray was taken to confirm the position of the wrist. Unrestricted finger movements were started after a week postoperatively. K wires were removed at six weeks and the wrist was mobilized. Check X-rays were taken six-monthly up to one year to confirm bony union and yearly thereafter to check for any remoulding of articular surfaces.

**RESULTS**

The first patient (follow-up 2.5 years) got 25 degrees of extension and 50 degrees of flexion at the wrist, full range of pronation/supination and radial and ulnar deviation (Figure 4a-g). He was back at work six months after surgery doing the same job (photographer). There was no postoperative complication in the upper limb. He had a transient period of weakness of the extensor muscles of the donor leg that recovered completely in three months time [Figure 4 h].

The second patient was a young female (27 years) with multiple co-morbidities. These included poorly controlled insulin-dependent diabetes mellitus, depression and cardiomyopathy (discovered two months after the operation). She had a stormy postoperative period. She developed venous congestion in the skin paddle, which...
was debrided and the underlying viable bone was covered with free gracilis muscle flap and skin graft [Figure 5a, b]. Subsequently she developed a hematoma in the donor site producing compartment syndrome. It was released and was left open and allowed to heal secondarily [Figure 5c]. She also recovered extensor compartment muscle weakness of the leg in three months [Figure 5c, d].

She was bedridden for many months due to her medical problems and started full day-to-day activities only after about eight months of operation. The full range of radial and ulnar deviation, pronation/supination and 45/25 degree of flexion/extension were achieved in one year’s time.

Patient related information has been presented in Table 1, while the scoring awarded as per Ennekings system[21] is presented in Table 2.

Both patients showed good bony union [Figures 2 and 3 b] at four months postoperatively.

DISCUSSION

Giant cell tumor is not an uncommon tumor occurring in young adults. Over half of them occur around the knee but no bone is immune. Roentgenogram is characteristic. Magnetic resonance imaging helps to detect surrounding soft tissue

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age</th>
<th>Stage*</th>
<th>Fibula length</th>
<th>Skin paddle dimensions</th>
<th>Bone Union</th>
<th>Follow-up Period</th>
<th>Recurrence</th>
<th>Range of motion</th>
<th>Grip strength</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>24</td>
<td>2</td>
<td>9 cm</td>
<td>5 * 2 cm</td>
<td>14 wks</td>
<td>26 months</td>
<td>Nil</td>
<td>25/50</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>27</td>
<td>2</td>
<td>10 cm</td>
<td>6 * 2 cm</td>
<td>14 wks</td>
<td>8 months</td>
<td>Nil</td>
<td>25/45</td>
<td>75</td>
</tr>
</tbody>
</table>

*Stage according to Ennekings surgical staging system (5); Grip strength as compared to opposite hand; Wks = Weeks

Figure 4: 41/2 months postoperatively patient (Figure 2, 24/male) is having A) full range of finger flexion B) fingers extension. C) Thumb adduction, extension D) Thumb opposition. E) Pronation F) Supination G) radial/ulnar deviation H) Donor site with plantar flexion and dorsiflexion of foot and toes

Table 1: Summary of patients
involvement and a positive biopsy establishes the diagnosis. Three to ten per cent tumors may become malignant. Incidence of primary malignant tumor is around 1%.

Traditional treatment is curettage with or without bone grafting. Usually this is associated with high (15-60%) recurrence rate, which occurs within three years of primary surgery and is thought to be persistence of disease rather than recurrence. For the same reason this method is unacceptable in upper limbs and wide local excision with 2.5 cm margin is indicated. Secondly, due to small but definite risk of malignancy they should be regularly followed up.

Autogenous vascularized bone graft for long bone reconstruction after tumor resection was first described by McKee,[2] Ueba[3] and Taylor et al.[4] Free fibula subsequently has become more popular in limb-sparing after long bone tumor resection.

Because of its anatomical similarity to the distal radius,[1,5,6] the proximal part of the ipsilateral fibula/ contralateral fibula can be used. Though it has been documented that due to the plastic properties of fibular head some remoulding occurs with time, it is seen only in children whose fibula carries true physis and epiphysis, also in them it shows growth proportional to the radius;[1] the same is not applicable when the transfer is performed after epiphyseal fusion i.e., in adults. No remoulding was observed in any of our patients.

Transferring vascularized head of fibula is unlike the routine harvesting of fibula based on peroneal vessels.

<table>
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<th>Table 2: Functional results by Ennekings evaluation system[22]</th>
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<td><strong>Patient</strong></td>
</tr>
<tr>
<td>-------------</td>
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<tr>
<td>1</td>
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<td>2</td>
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Fibular head gets blood supply from three sources, namely peroneal, anterior tibial and inferior lateral genicular arteries. Different studies have underlined its importance and can guide one in decision-making in a particular situation. Wood et al. (1997) and Tsai et al. (1986) recommended harvesting graft with two pedicles; inferior lateral genicular artery or anterior tibial artery for the head and peroneal artery to supply the diaphyseal segment. Such a procedure was time-consuming and complex with increased risk of failure. According to the anatomical studies of Taylor et al and Bonnel et al the anterior tibial artery can supply both the epiphysis and diaphysis and there is no need to provide double pedicle to the graft. However, harvest of fibula must preserve the recurrent branch that originates at the level of entrance of the anterior tibial artery into the anterior compartment.

The fibula can also be harvested based on the inferior lateral genicular artery [Figure 1a], a branch of the popliteal artery, which also gives a constant branch to the fibular head which is also supplied by the proximal part of the anterior tibial artery. Ono et al, (1997) in their injection study have concluded that there are two vascular networks around the neck of the fibula. Subsequently they recommended that in defects larger than 10-12 cm, peroneal vessel should be used, but that in shorter defects the anterior recurrent tibial artery could be used as the sole source. Pho has described transfer of fibular head on peroneal vessels. We have based our flap on the ATA in both our cases.

The branches of the common peroneal nerve (mainly to the tibialis anterior) have an intimate relationship with the recurrent branch of the anterior tibial artery. It is important to try and preserve as many motor branches of the peroneal nerve as possible; those which need to be cut should be tagged and approximated with microsurgical technique, immediately after fibular harvest.

The distinct advantages of vascularized bone graft as illustrated by the experimental work of Ostrup et al and Weiland et al are faster bony union, low rate of graft fracture, earlier evidence of bony hypertrophy, greater mechanical strength, no resorption of graft and growth potential if used for children, with lowest rates of infection and nonunion. Non vascularised bone grafts lack these advantages and in our opinion they are inferior to vascularised grafts though Rtaimate et al. claim good results with it.

Minami et al, Zaristaski and Gao et al are in favor of partial wrist arthrodesis, they claim it gives good results and eliminates the problems of arthroplasty. Usai et al comment on problems of hemiarthroplasty like palmar shift of carpal bones, bony collapse of fibular head and X-ray changes like sclerosis and osteophytes which are said to be due to incongruity of the articular surfaces leading to osteoarthritis. Minami et al in his study (four cases) has concluded partial wrist arthrodesis to be far superior to hemiarthroplasty with Ennekings score 87 for those who underwent arthrodesis contrary to 47 in the other group. This procedure uses vascularized fibular shaft; this has the advantage of avoiding wrist joint with incongruent surfaces facing each other, avoiding dissecting out head (which has complex blood supply and prolongs operative time) and long-term problems of osteoarthritis, while having all the advantages of vascularized bone graft.

Though our follow-up is too small to comment about such long-term complications, we have not noted any such changes till now. The palmar subluxation of the wrist in our first patient seen in Figure 4 was present since operation and is due to mal-positioning of wrist at initial procedure as can be appreciated in postoperative X-ray picture [Figure 2 b, c].

Ono et al have concluded that wrist arthroplasty using vascularized fibular graft is the best procedure for a Stage 2 giant cell tumor of the distal end of the radius. In Stage 3 disease wrist arthrodesis using vascularized fibular shaft is indicated. And Ennekings surgical staging system should be the basis of what method of reconstruction is to be used.

Even though no soft tissue repair was performed in both our patients the wrist and distal radioulnar joints were stable.

Free fibular epiphyseal transfer is a reliable method of reconstruction that restores local anatomy and physiology and gives better functional outcome and ensures early rehabilitation. Though its usefulness is debatable when compared to partial wrist arthrodesis, it is definitely superior to curettage with or without bone graft or nonvascularized bone transfer.

Note:
During the last eight months when the paper was under revision, the second patient (16 m onths post surgery) had developed local recurrence which was re-excised. Histopathological diagnosis was soft tissue recurrence and margins were histologically clear of tumor.
Since a month after the second surgery patient is not under regular follow-up.

REFERENCES


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