The purpose of this study was to evaluate the surgical outcomes of reconstruction of chronic Achilles tendon ruptures using various methods, including Achilles tendon allograft. Between October 2003 and March 2010, twelve patients with chronic Achilles tendon ruptures and a defect gap of >4 cm underwent surgical reconstruction with V-Y advancement, gastrocnemius fascial turn-down flap, flexor hallucis longus tendon transfer, or Achilles tendon allograft. The study group comprised 11 men and 1 woman. At last follow-up, all patients were assessed with regard to postoperative complications, self-reported level of satisfaction, American Orthopaedic Foot and Ankle Society (AOFAS) ankle–hindfoot score, Achilles tendon Total Rupture Score, repetitive single-heel rises, single-leg hopping test, and ankle range of motion.

The AOFAS scores increased from an average of 68.7 (range, 50-87) preoperatively to 98.0 (range, 88-100) postoperatively. All patients were able to perform 10 repetitive single-heel raises and single-leg hops at last follow-up. No patient experienced wound complications or deep infection. Seven patients were rated as excellent, 4 as good, and 1 as fair.

Chronic Achilles tendon ruptures can be successfully treated by careful selection of the reconstruction method according to the length of defect gap and state of the remaining tissue. With an extensive defect, use of an Achilles tendon allograft can be a good option.
Acute rupture of the Achilles tendon can be easily diagnosed clinically by a physical examination, but incorrect early diagnosis can occur in 10% to 25% of acute rupture patients.\textsuperscript{1,2} If the diagnosis of acute rupture is missed, a conservative treatment fails, or the rupture turns into a chronic injury from severe degeneration, discomfort is caused by reduced plantarflexion,\textsuperscript{3,4} which can only be reversed by surgical treatment.\textsuperscript{5,6} Chronic Achilles tendon ruptures are defined as those with a time period >4 to 6 weeks between injury and surgical management.\textsuperscript{7} Patients with neglected Achilles tendon ruptures may recall a specific injury without prodromal symptoms such as pain or swelling, thus delaying diagnosis.

Various surgical reconstruction methods have been introduced depending on the defect gap and the state of the remaining tendon, but a more difficult surgery and a longer recovery time than those for an acute ruptures are the challenges to the surgeon and patient, respectively.\textsuperscript{8}

This article describes the outcomes of surgery performed on patients with chronic Achilles tendon ruptures by applying various reconstruction methods depending on the length of defect after thorough debridement of the degenerative tissue at the time of index surgery. This included Achilles tendon allografts that were performed in 2 patients where reconstruction with the patient’s own tissue was not feasible due to an extensive defect gap.

**MATERIALS AND METHODS**

This retrospective study was conducted with 14 consecutive patients with chronic Achilles tendon rupture who underwent surgery at our institution by single surgeon (K.S.S.) between October 2003 and March 2010. Twelve of 14 patients were followed-up for >12 months. All patients were diagnosed by physical examination and either ultrasonic imaging or magnetic resonance imaging (MRI). For all patients, at least 4 weeks had passed since the primary injury (4 weeks to 12 months), and all patients reported limping during walking because of an absence of or decreased pushoff in their step. Neglected rupture refers to patients where no symptoms existed before injury, whereas chronic rupture refers to patients in which chronic pain at the Achilles tendon existed although the injury mechanism or external force was not distinctive.

The study group comprised 11 men and 1 woman ranging in age from 31 to 74 years (Table 1). The position of the rupture was 1 to 6 cm superior to the tendon insertion, and the ruptured gap was between 4 and 16 cm. The length of the defect gap was measured with the ankle plantarflexed up to 30°, following debridement of the scar and degenerative tissue between the ruptured tendons intraoperatively.

**SURGICAL TECHNIQUE**

After placing the patients in a prone position, the surgery was initiated by a midline incision. The ruptured part was reached without dissection of the subcutaneous tissue. After identifying the ruptured site, the scar tissue formed in between the ruptured tendons and the remaining degenerative tendon tissue was debrided. Then, the ruptured defect gap was measured with the ankle plantarflexed up to 30°, and various surgical reconstruction methods were performed depending on the gap and the state of the proximal muscle and fascia.

The reconstruction methods were V-Y advancement in 1 patient, V-Y advancement with flexor hallucis longus tendon transfer in 1 patient, gastrocnemius fascial turn-down flap in 3 patients, gastrocnemius fascial turn-down flap simultaneously performed with flexor hallucis longus tendon transfer for 3 patients (Figure 1), and V-Y advancement simultaneously performed with flexor hallucis longus tendon transfer and Achilles tendon allograft in 2 patients.

### Table 1

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Symptom Duration, mo</th>
<th>Follow-up, mo</th>
<th>Defect Size, cm</th>
<th>Reconstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/67</td>
<td>10</td>
<td>94</td>
<td>12</td>
<td>Allograft + FHL transfer (2-incision)</td>
</tr>
<tr>
<td>2/M/31</td>
<td>2</td>
<td>55</td>
<td>7</td>
<td>Turn-down</td>
</tr>
<tr>
<td>3/M/74</td>
<td>6</td>
<td>46</td>
<td>7</td>
<td>Turn-down</td>
</tr>
<tr>
<td>4/M/53</td>
<td>12</td>
<td>39</td>
<td>7</td>
<td>Turn-down</td>
</tr>
<tr>
<td>5/M/54</td>
<td>1</td>
<td>37</td>
<td>16</td>
<td>Allograft + FHL transfer (1-incision)</td>
</tr>
<tr>
<td>6/M/41</td>
<td>1</td>
<td>34</td>
<td>6</td>
<td>Turn-down + FHL transfer (1-incision)</td>
</tr>
<tr>
<td>7/M/31</td>
<td>2</td>
<td>34</td>
<td>9</td>
<td>V-Y +turn-down + FHL transfer (1-incision)</td>
</tr>
<tr>
<td>8/F/52</td>
<td>1</td>
<td>33</td>
<td>4</td>
<td>V-Y advancement</td>
</tr>
<tr>
<td>9/M/63</td>
<td>7</td>
<td>18</td>
<td>6</td>
<td>Turn-down + FHL transfer (1-incision)</td>
</tr>
<tr>
<td>10/M/36</td>
<td>2</td>
<td>17</td>
<td>8</td>
<td>Turn-down + FHL transfer (1-incision)</td>
</tr>
<tr>
<td>11/M/70</td>
<td>2.5</td>
<td>14</td>
<td>4</td>
<td>V-Y advancement</td>
</tr>
<tr>
<td>12/M/39</td>
<td>1</td>
<td>13</td>
<td>8</td>
<td>Turn-down + FHL transfer (1-incision)</td>
</tr>
</tbody>
</table>

Abbreviation: FHL, flexor hallucis longus tendon.
(Table 1). In cases of tendon defect gaps of 2 to 5 cm, V-Y advancement was performed, whereas for those with gaps of 5 to 10 cm, gastrocnemius fascial turn-down flaps were used. If the state of the remaining tendon was poor, concomitant flexor hallucis longus tendon transfer was performed.

Achilles tendon allograft was performed in the 2 patients where reconstruction with the patient’s own tissue was not possible because the defect gap was too large (>12 cm). In these patients, fresh frozen Achilles tendon allografts were used (Figure 2). If sufficient tendon was attached to the calcaneus, the calcaneal bone block of the graft was not used. In cases of insufficient tendinous stump, the calcaneal bone block was used to reconstruct Achilles tendon and fixed with screws.

Flexor hallucis longus tendon transfer was additionally performed in all patients who underwent tendon allograft. A single-incision technique was used for flexor hallucis longus tendon transfer in all patients, except for 1 in which an additional incision was performed to harvest enough flexor hallucis longus tendon to make a tendon weaving suture through the distal stump of the remaining Achilles tendon. With the single-incision technique, suture anchors were used to augment the repair site at the distal stump. The proper tension of surgical reconstruction was verified by the degree of ankle plantarflexion with the knee flexed up to 90° guided by the contralateral side, as well as the presence of springiness, which was determined by spring-back of the ankle joint to the resting plantarflexion position after a forceful dorsiflexion of the ankle joint up to neutral position (Figure 3).

Postoperatively, a short-leg splint was applied to the ankle joint with the plantarflexion at 20°. The cast was generally applied for 4 weeks, but it was used for up to 6 weeks in patients where the state of the remaining tendons was poor. Then, patients were placed in a walking boot (Platform boot; Medical Technology, Grand Prairie, Texas) with 2 hindfoot wedges for 2 months and were instructed to remove 1 wedge every 2 weeks. Patients were allowed to bear weight as tolerated with crutches. Active joint exercises were started from the time of wearing the boot, and other muscle-strengthening exercises, such as cycling, passive joint exercise, stretching and heel rises, were gradually performed as comfort allowed. Athletic activities such as sudden acceleration, cutting, and jumping were restricted for the first 6 months postoperatively.

Patient evaluation was performed with the pre- and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) ankle–hindfoot scores and visual analog scale (VAS) scores for pain and postoperative Achilles tendon Total Rupture Score (ATRS). The ATRS was used to evaluate postoperative symptoms and outcomes after treatment of chronic Achilles tendon rupture. Clinical evaluations included assessment of the ability to perform 10 repetitive single affected-side heel rises and single affected-side leg hopping, the ankle ROM and surgery-related complications.
AOFAS ankle–hindfoot scores and VAS remained unsolved. Pre- and postoperative daily living or severe complications that occurred. Mean AOFAS (range, 13-94 months), and no major complications, such as wound infection, deep infection, or sural nerve injury, occurred in any patient, and no re-rupture was reported at any follow-up.

No patient was able to perform a single affected-side heel rise preoperatively, but all patients were able to perform 10 repetitive single-leg heel rises 1 year postoperatively. Single affected-side leg hopping was also possible in all patients. Postoperative ankle ROM was equal to that of the opposite side in 9 patients, whereas in 3 patients, ankle dorsiflexion was smaller by <10° when compared with the opposite side. The plantarflexion power of the big toe was reduced to level 4 in 2 of 6 patients where flexor hallucis longus tendon transfer was performed; single incisions were performed in these patients. Subjective satisfaction was excellent in 7 patients, good in 4 patients, and fair in 1 patient. All patients stated that they would undergo the same treatment if they were in the same situation.

**DISCUSSION**

Patients in this study had a neglected rupture that was not initially properly diagnosed with an acute Achilles tendon rupture (n=5) or a chronic rupture by degeneration (n=7). Patients with neglected or chronic ruptures can be considered different groups because the tissue pathology before the rupture is different; however, because the scar tissue formed in between the ruptured tendons is similar, we considered them to be the same. Amyotrophy and contraction take place in the tendon, and in 10 days after acute rupture, the muscle shows similar pathological findings in both groups. Intraoperative macroscopic findings showed that degeneration and scar tissue at the distal and proximal regions of the ruptured tendons were similar, although the rupture gap and the denatured range were different. Thus, the study was conducted by combining the neglected rupture and chronic rupture groups into one. In addition, because the rupture defect gap, which was an important guideline in selecting surgical reconstruction methods, was measured after debridement of the scar and degenerative tissue, there was no reason to consider these 2 groups as different.

However, analysis of the 2 groups showed a significant difference in age and rupture gap size. Mean age of patients with neglected ruptures was 45.0 years, whereas mean age of patients with chronic ruptures was 59.2 years. The rupture gap was larger in the chronic rupture group due to a more severe degeneration: mean rupture gap was 6.8 cm in the neglected rupture group and 9.2 cm in the chronic rupture group. The reconstruction can be more difficult and a poorer result can be expected in the chronic rupture group based on these differences, but a significant difference was not seen because the number of patients in the study was small.

Many studies have reported reconstruction during neglected chronic rupture depending on the rupture gap between the remaining tendons after elimination of the scar tissue formed in between the ruptured tendons, but some studies reported successful ruptured gap reconstruction that was performed without removing the scar tissues. Thus, additional studies examining the necessity and range of the debride-
screws are used. The flexor hallucis longus tendon is frequently used to augment the ruptured gap for reconstruction of neglected chronic ruptures. The flexor hallucis longus is the plantar flexor and is stronger than the peroneus brevis and flexor digitorum longus. Its axis of contractile force more closely resembles that of the Achilles tendon, and it works in phase with the gastrocnemius–soleus complex. Because it also has the advantage of being transferred without neurovascular interference due to proximity with the Achilles tendon,17 the transfer can be implemented to fortify muscle strength with other reconstruction techniques. Moreover, the flexor hallucis longus muscle belly extends into the distal Achilles tendon reconstruction region, which is an avascular zone, and it allows recruitment of increased blood supply to the repaired tendon.8

In an MRI-based postoperative study, Hahn et al18 reported complete integration of the flexor hallucis longus tendon in 60% of patients, showing no degeneration of the flexor hallucis longus muscle belly, but rather a thickening in 85% of patients, thus proving the theoretical advantages of flexor hallucis longus tendon transfer. In the current study, flexor hallucis longus tendon transfer was performed in 6 patients as the auxiliary technique, and a single incision was applied to all but the first patient. Although the length of the tendon taken is shorter in the single-incision than the double-incision technique, the relatively short tendon length may be sufficient for fixation if suture anchor screws or interference screws are used.

Reduced flexor hallucis longus tendon strength is a known complication of tendon transfer. In our study, reduced strength of the flexor hallucis longus tendon was found in 2 of 7 patients in which the transfer was performed, and a single incision was performed in these 2 patients. Although it was expected that the strength of the flexor hallucis longus tendon could be better conserved with the single incision than double incision because the position crossed with flexor digitorum longus is retained, flexor hallucis muscle strength reduction was similar to the results of Elias et al.19 In their study, flexor hallucis longus tendon transfer by a single incision was performed, and they noted that 11 of 15 patients were not able to perform active flexion of the hallucal interphalangeal joint.10 However, Wegrzyn et al19 performed flexor hallucis longus tendon transfer using a double-incision technique and reported that the active flexion of the hallucal interphalangeal joint was lost in all patients, but this did not affect exercise or activities of daily living.

In our series, gastrocnemius fascial turn-down flap was performed in 3 patients with a similar rupture gap (7 cm for all), but tendon transfer was not performed because intraoperative findings showed that the state of the remaining tendon and the fascia was good.19,20 Moreover, because good results were seen in these patients, further study may need to be conducted determining the necessity of flexor hallucis longus tendon transfer in neglected chronic rupture. Currently, we are performing flexor hallucis longus tendon transfer depending on the state of the remaining tendon, fascia, and muscle after debridement, then providing information to the patients who will undergo Achilles tendon reconstruction about the possibility of augmentation with flexor hallucis longus tendon transfer and the resulting weakening of the strength of the flexor hallucis longus tendon.

Synthetic materials11,12,21 and tendon allograft have been used to reconstruct the Achilles tendon with neglected chronic rupture. These procedures do not require additional surgical procedures for tendon harvest and do not result in longer surgical times. Furthermore, additional functional deficits and donor site complications such as sural nerve damage. However, synthetic materials like Marlex mesh (C.R. Bard, Inc, Murray Hill, New Jersey)24 Dacron (DuPont, Wilmington, Delaware) vascular graft,25 collagen tendon prosthesis,26 polyglycol threads,27 and polymer carbon fiber28 are not absorbed and remodeled, potentially leading to inflammatory responses.22,29,30 Their durability against fatigue failure has also not been proven.3

Although only a few reports exist on reconstruction using Achilles tendon allograft, all of them demonstrate good results. The introduction of an Achilles tendon allograft is based on the success of anterior cruciate ligament reconstruction of the knee. The advantages of Achilles tendon allograft are that fixation and suture can be done by various methods because the tendon length is sufficiently long and an ideal outcome can be anticipated after final healing because the shape and thickness are the same with those of the original tissue. However, concern exists about rejection of the allograft, spread of infectious diseases, and deep infection. Furthermore, the period for thick and long allografts to be replaced by self-tissue can be long, and a tendon rupture can occur if the allograft is not properly replaced by self-tissue.31

We performed Achilles tendon allograft with fresh frozen tendons, as well as flexor hallucis longus tendon transfer for 2 patients for whom the reconstruction was impossible with the remaining gastrocnemius fascia. All patients underwent the same postoperative rehabilitation process and showed benefits in muscle strength evaluation, AOFAS ankle–hindfoot scores, and subjective satisfaction at last follow-up. Recovery occurred using rehabilitation treatments similar to other construction methods because healing of the transferred allograft was enhanced due to parallel transfer with the flexor hallucis longus tendon.

CONCLUSION

Good outcomes were observed in surgeries performed for neglected chronic ruptures of Achilles tendons using various reconstruction methods depending on the rupture gap and the state of the remaining
tissue. The use of Achilles tendon allografts for primary reconstruction of neglected chronic Achilles tendon ruptures can be a good surgical reconstruction method when reconstruction with one’s own tissue is impossible because the rupture gap is too large. Therefore, surgical treatment is recommended for patients with neglected chronic Achilles tendon ruptures who have discomfort in activities of daily living.

REFERENCES


30. Kissel CG, Blacklidge DK, Crowley DL. Revision anterior cruciate ligament reconstruction. *ORTHOSuperSite.com*