On the surgical treatment of chronic anterolateral ankle instability

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Chapter VIII

SPORTS ACTIVITY LEVEL AFTER SURGICAL TREATMENT OF CHRONIC ANTEROLATERAL ANKLE INSTABILITY: A MULTICENTRE STUDY

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Abstract

After an inversion injury to the ankle, approximately 10-20% of athletes suffer from persistent laxity of the lateral ankle ligaments. When conservative treatment fails, surgical treatment is indicated. Surgical treatment can be divided into two main categories; anatomical reconstruction and tenodesis. The objective of this retrospective multicentre study was to see which method produces better results in terms of maintenance of sports activity level, restoration of laxity, degenerative changes and patient satisfaction.

Five European centres participated in the study. Only athletes with a preinjury of Tegner activity level ≥ 7 were included. At follow-up, pre- and postoperative data, the present Tegner activity level, the functional Karlsson score and the subjective result according to the rating system developed by Good et al. were assessed. Standard and stress radiographs of both ankles were taken. The study population was divided into anatomical reconstructions (AR) and tenodeses (TE). A total of 41 anatomical reconstructions and 36 tenodeses were included. There were no significant differences in baseline characteristics between the two groups. The median preinjury Tegner activity level for both groups was 9 (range 7-10). At the follow-up, 2-10 years after the operation, the median Tegner activity level for both groups was 8 (range 4-10). However, 17 patients in the TE group had a lower Tegner activity level than before the operation due to the current status of their operated ankle. The corresponding number in the AR group was four patients (p<0.001). Significantly more patients in the TE group (n=15) had limited ankle dorsiflexion than in the AR group (n=3, p<0.001). At radiographic examination, 11 patients in the TE group displayed medially located osteophytes compared with two patients in the AR group (p=0.02). The stress radiographic examination revealed that more patients in the AR group (n=38) had normal laxity values than in the TE group (n=28, p=0.06). According to the rating system developed by Good et al., 36 patients in the AR group had a good or excellent result versus 21 patients in the TE group (p=0.003).

We conclude that a tenodesis leads to a reduction in activity level due to the loss of ankle function, increased mechanical laxity and degenerative changes in the medial compartment of the ankle joint. Anatomical reconstruction was found to be superior to tenodesis in all the above mentioned outcome measures and should therefore be the surgical treatment of choice for chronic ankle instability in athletes with a high activity level.
Introduction

Approximately 50-60% of all inversion injuries occur in sports.\textsuperscript{1,16,18,23,33,39,51} Although non-surgical treatment is successful in many athletes, approximately 20% will continue to sustain recurrent inversion sprains during their activities.\textsuperscript{7,9,13,25,27} In these patients, surgical treatment is indicated, if supervised rehabilitation does not produce normal functional stability.

A variety of surgical methods have been described for the treatment of chronic anterolateral instability of the ankle joint. They can be divided into two main categories; non-anatomical reconstructions using tenodesis or anatomical reconstruction using the direct repair or imbrication of the lateral ankle ligaments.\textsuperscript{7,25,27} In the case of a non-anatomical reconstruction, the anterior talo-fibular ligament and the calcaneo-fibular ligament are reconstructed by means of an autologous graft, usually involving one of the peroneal tendons.\textsuperscript{1,8,14,15,17,40,44-46,56}

In an anatomical reconstruction, the ends of the ruptured or elongated remnants of the lateral ankle ligaments are utilized.\textsuperscript{5-7,25,27,30,37,42}

In some studies, the results of tenodesis procedures have been less successful than anatomical reconstruction procedures, with only 50% excellent or good at the long-term follow-up and a deterioration noted during follow-up.\textsuperscript{26,50} Recently, we reported superior results for anatomical reconstruction in terms of patient satisfaction, mechanical laxity and degenerative changes in a series of 219 patients.\textsuperscript{32} Moreover, Hennrikus et al. and Wallenböck et al. have reported superior functional results for anatomical reconstruction.\textsuperscript{21,55} The tenodesis procedure has the disadvantage of reducing the strength of the peroneus brevis and decreasing the range of ankle motion.\textsuperscript{26,50} Most studies that report on the outcome of anatomical reconstruction or tenodesis are based on a mixed population. For the outcome of the treatment, the patient activity level is, however, of great importance. The functional demands imposed on the ankle joint of athletic individuals are substantially higher when compared with non-athletic patients. The aim of the present study was, therefore, to compare the outcome of anatomical reconstruction and tenodesis in an athletic population. The principal outcome measures were; maintenance of activity level, mechanical laxity, degenerative changes in the ankle joint and functional stability. Our hypothesis was that, in an athletic population, tenodesis produces inferior results in terms of function and the restoration of laxity.
Patients and Methods

Assessment and analysis of the results in the present study were performed according to the protocol of a large multicentre trial comparing anatomical reconstruction and tenodesis in a general population. \(^{32}\) Five European centres participated in this multicentre study. Patients who underwent anatomical reconstruction or tenodesis between 1987 and 1995 were eligible for inclusion.

All the patients underwent rehabilitation with range of motion and proprioceptive training for a period of at least six months before a surgical procedure was considered. The indication to perform anatomical reconstruction or tenodesis was surgeon-dependent and independent of the type of instability or other patient characteristics.

For this study, the following inclusion criteria were employed; 1) preinjury Tegner activity level \(\geq 7\); 2) age at operation between 14 and 40 years; 3) an uninjured contralateral ankle; 4) no history of previous fractures of the affected ankle; 5) no prior surgery other than an anatomical reconstruction, tenodesis or revision of the affected ankle; 6) no prior surgery on the contralateral ankle; 7) no history of bilateral hyperlaxity; 8) no history of subtalar instability; 9) no generalized neuromuscular disorder.

At follow-up, 2–10 years after the operation, the following data were recorded; age, gender, profession, affected side and the preinjury Tegner activity level. \(^{48}\) The follow-up protocol consisted of an assessment of the present Tegner activity level, postoperative complications and the number of reoperations. A reduction in the Tegner activity level in comparison with the preinjury level was carefully evaluated to determine whether the patient related this reduction to the current status of the operated ankle or other reasons. Functional outcome was graded using two ankle scores; the Karlsson score and the scoring scale developed by Good et al. \(^{19, 28}\)

At physical examination, the range of ankle motion was determined by measuring dorsiflexion and plantarflexion, inversion and eversion to the nearest five degrees, using a goniometer. A reduction of more than five degrees compared with the contralateral ankle was considered to be a limited range of ankle motion. In addition, the presence of swelling and pain on palpation was determined.

Ankle joint laxity was tested using the anterior drawer test with the ankle in 15 degrees of plantarflexion. This test was regarded as positive when there was a difference of more than 5 mm compared with the contralateral ankle. At all the centres, standardized radiographic examinations consisting of AP and lateral radiographs of both ankles, as well as stress radiographs, including measurements of both talar tilt (TT) and anterior talar translation...
(ATT) with the ankle in 15 degrees of plantarflexion, were performed as at follow-up. These radiographs were performed pre-operatively and at follow-up. Measurements were assessed according to the criteria established by Lindstrand et al. TT was regarded as positive when the tibio-talar angle was more than 10° or when the difference between both ankles was more than 6°. ATT was regarded as positive when the anterior displacement of the talus relative to the distal tibia was more than 4 mm, or the difference between both ankles was more than 3 mm. The standard load was 150 Newtons using Telos® apparatus. The development of degenerative changes was graded according to the scale introduced by van Dijk et al. All the standard and stress radiographs were graded by one independent observer (RK). Differences in baseline characteristics and final results between the centres and groups were analysed (Table I).
**Statistical analysis**

Differences in baseline characteristics and final results were calculated using the Multi Analysis of Variance (MANOVA) for a comparison of mean values, the Mann Whitney U-test for the comparison of median values and the chi-square test for proportions between the centres. Differences in baseline characteristics and final results between the two groups were calculated using the Analysis of Variance (ANOVA) for a comparison of mean values, the Mann Whitney U-test for the comparison of median values and the chi-square test for proportions. A p-value of <0.05 was considered statistically significant.
Results

Selection of patients

Between 1987 and 1995, a total of 324 reconstructions for chronic anterolateral instability of the ankle were performed at five centres. One hundred and fifty-one patients underwent anatomical reconstruction and 173 underwent tenodesis. A total of 102 patients had a preinjury Tegner activity level of ≥ 7 and were thus eligible for inclusion. Of this subpopulation, 21 patients were lost to follow-up, eight anatomical reconstructions and 13 tenodeses, 13 patients were untraceable, three patients did not wish to participate and five had emigrated to another city or country. With regard to the number of patients that were lost to follow-up, there were no significant differences between the centres. After further analysis, four patients had to be excluded; three patients did not meet the inclusion criteria and the radiographs of one patient were not available. As a result, 77 patients (80%) could be included. A total of 41 patients were included in the anatomical reconstruction group (AR), while 36 patients were included in the tenodesis group (TE).

Baseline characteristics, surgical procedure

All the patients in the AR group underwent a Broström procedure. In 13 patients the anatomical reconstruction was reinforced by means of a regional periosteal flap. Postoperatively, all the patients wore a plaster cast for six weeks, whereafter the range of motion and proprioceptive training began. There were no significant differences in outcome between the patients with and without regional periosteal flap reinforcement.

In the TE group, 14 patients underwent an Evans procedure and one patient a Watson-Jones procedure as originally described by the same authors. Nine patients underwent a modified Castroin procedure using a peroneus brevis hemitendon. In this technique, the peroneus brevis tendon is split and released and severed in its proximal part in order to free the distal 15 cm of the tendon. Twelve patients underwent a Vierstein procedure. In this procedure, the proximal part of the peroneus brevis tendon is routed through the calcaneus and attached to the distal fibula. All the reconstructions were performed with the foot in slight eversion. Postoperatively, all the patients wore a plaster cast for six weeks, whereafter the range of motion and proprioceptive training were started. No significant differences in final results between the different tenodesis procedures could be identified.

The baseline characteristics of both groups are shown in Table I. There were no significant differences in baseline characteristics between the two groups. The patients in the TE group
were one year older on average (mean age at operation 27 years; SD ± 5.2) than the patients in the AR group (mean age at operation 26 years; SD ± 4.7). Both groups were similar in terms of the preinjury Tegner activity level, male/female ratio and left/right ratio. The most common principal sports activities were soccer, basketball and volleyball. The mean follow-up period was 5.4 years (SD ± 1.8) in the AR group and 5.4 years (SD ± 2.3) in the TE group (p=0.955).

Postoperative complications
The results at the final follow-up are shown in Table II. In the AR group, one postoperative complication was registered; this involved hypoanaesthesia due to peroperative damage to the superficial peroneal nerve. In the TE group, two patients sustained a postoperative complication; marginal wound necrosis and hypoanaesthesia due to peroperative damage to the superficial peroneal nerve. One patient in the AR group underwent a revision two years after the index operation due to a recurrence of symptoms.

Subjective results
At the follow-up, 19 patients in the AR group and 24 patients in the TE group had a reduced Tegner activity level. Seventeen patients in the TE group related this reduction to the current status of their operated ankle while in the AR group the corresponding number was four (p<0.001). In terms of the scale developed by Good et al., there were significantly more patients in the AR group who had an excellent or good result; 36 patients compared with 21 in the TE group (p=0.003). Seven patients in the TE group graded their functional outcome as fair or poor because they experienced reduced push-off power in their operated ankle while performing sports. The other five patients who graded their functional outcome as fair or poor complained of limited dorsiflexion. Three patients in the TE group suffered from recurrent giving-way and therefore graded their outcome as fair or poor. In the AR group, three patients graded their functional outcome as fair or poor because of limited dorsiflexion and two patients suffered from recurrent swelling and giving-way. There were no significant differences between the groups in terms of the Karlsson score values (p=0.105).

Objective results
At physical examination, significantly more patients in the TE group (n=15) had limited dorsiflexion than in the AR group (n=3, p<0.001). Patients did not have limited plantarflexion, inversion or eversion in either group. There was no difference in the number of
patients with pain on palpation and swelling. The number of patients with a positive anterior drawer test was similar in the two groups; five in the AR group and six in the TE group.

**Radiographic results**

The total number of patients with degenerative changes as seen on standard AP and lateral radiographs was similar in both groups. In the AR group, seven patients displayed anteriorly located osteophytes compared with four in the TE group (p=0.456). There were seven patients in the AR group who had laterally located osteophytes compared with three in the TE group (p=0.255). Eleven patients in the TE group displayed medially located osteophytes compared with two in the AR group (p=0.02). One patient in the AR group had a posteriorly located spur compared with none in the TE group (p=0.346). At the stress radiographic examination, the mean talar tilt (p=0.004) and the anterior talar translation (p=0.001) were significantly higher in the TE group. According to the criteria drawn up by Lindstrand et al., three patients in the AR group had positive stress radiographs compared with eight in the TE group (p=0.06) (Table III).
Discussion

The aim of the present study was to compare the outcome of anatomical reconstruction and tenodesis in an athletic competitive population (i.e. Tegner activity level ≥ 7). All the participating centres used the same standard follow-up protocol. All the radiographs were assessed by one independent observer.

At the follow-up, significantly more athletes in the tenodesis group had a reduced activity level due to the current status of their operated ankle. Significantly more athletes suffered from a limited dorsiflexion at physical examination. The stress radiographic examination revealed increased mechanical laxity for athletes in the tenodesis group and degenerative changes in the medial compartment of the ankle joint were seen significantly more often in the tenodesis group. The number of good and excellent results as assessed by the Good score was significantly higher in the anatomical reconstruction group.

Lateral ligament injuries to the ankle joint are the most common sports-related injuries. Recurrent or chronic instability is found in 10-20 per cent of patients. In particular in athletes, these residual problems are disabling. In these cases, surgical treatment is often indicated. More than 60 surgical procedures for the stabilization of the chronically unstable ankle have been described. They can be divided into two main categories; non-anatomical reconstructions using tenodesis and anatomical reconstructions using the direct repair or imbrication of the lateral ankle ligaments. The results of the present study reveal that a larger number of athletes in the anatomical reconstruction group were able to maintain their preinjury Tegner activity level than in the tenodesis group. Almost 50% of the patients in the tenodesis group had a reduced Tegner activity level at follow-up, 2-10 years after the reconstruction. In the tenodesis group, a significant number of athletes complained of reduction in push-off power in their operated ankle. The tenodesis procedure requires the sacrifice of part or all of the peroneus brevis tendon, involves a long scar and extensive soft-tissue dissection, prolonged immobilization, and reduces ankle motion and weakens the peroneal tendon. For athletes or professionals (such as ballet dancers or soccer players) who require extensive ankle balance or kinesthetic sense, these procedures may be career-ending.

Several experimental studies report that a tenodesis procedure limits the range of ankle motion and often fails to restore the laxity of the ankle joint. From the results of a cadaveric study, Colville (1992) concluded that the Evans procedure does not prevent laxity
and the Watson-Jones reconstruction only controls anterior talar translation and internal rotation at the expense of the range of ankle motion.\textsuperscript{11} He also concluded that the Chrisman-Snook method only prevents inversion laxity at the expense of the range of ankle motion. The anatomical repair, however, controlled instability in all directions without reducing the range of ankle motion. Liu and Baker compared anterior talar translation and talar tilt with low and high forces after the Broström, Chrisman-Snook and Watson-Jones procedures in an experimental study.\textsuperscript{35} At both forces, the Broström procedure was less lax. The simultaneous occurrence of limited range of ankle motion and increased mechanical laxity provided by the tenodesis is explained by the non-anatomical position in which the transferred tendon is placed.\textsuperscript{2,26,31,35,36} The present study reveals that significantly more patients in the tenodesis group had limited range of ankle dorsiflexion. Furthermore, at the stress radiographic examination, the mean values for anterior talar translation and talar tilt were significantly higher in this group. This mechanical laxity may result in considerable functional instability and a potential reduction in function, strength, and proprioception, particularly if rehabilitation is deficient or inadequate. Qualitatively, the risk of lost training time and performance opportunities is a major problem for the athlete.

There are few studies that report on the outcome of either anatomical reconstruction or tenodesis in athletes. Riegler reported good results one to nine years after a Chrisman-Snook tenodesis in basketball players.\textsuperscript{43} These patients impose, when compared with patients who are only involved in leisure activities, heavier demands on ankle joint function and may therefore require more knowledge of the prognosis of a surgical intervention. From the studies by Karlsson et al. and Van der Rijt et al., it is known that the functional results after tenodesis tend to deteriorate over time.\textsuperscript{26,38,47,50} Success rates vary from 50\% to 70\%. In the present study, we found 58\% good or excellent results in the tenodesis group versus 88\% in the anatomical reconstruction group, a significant difference. In highly active athletes in particular, the failure to return to the original sports activity level, increased mechanical laxity, limitation of range of ankle motion and a higher risk of degenerative changes in the medial compartment of the ankle joint have a negative effect on patient satisfaction. This may explain the significantly higher number of patients with a fair or poor result in the tenodesis group as assessed by the Good score.

In 1996, van Dijk et al. provided evidence that an inversion injury includes a high risk of the occurrence of cartilage damage between the medial malleolus and the medial facet of the
Chronic mechanical laxity may lead to recurrent inversion injuries. Subsequently, repetitive shear stresses weaken the cartilage on the medial talar facet and the anterior aspect of the medial malleolus. In the long-term, the cartilage damage leads to degenerative changes in the medial compartment of the ankle joint. In 1979, Harrington performed an arthroscopy in 12 of 36 patients with chronic ankle instability; in all 12 cases, degenerative changes were seen in the medial compartment of the ankle joint. We found that increased mechanical laxity was more frequent in patients with a tenodesis than in patients who underwent anatomical reconstruction. The patients in the tenodesis group also displayed medially located osteophytes significantly more frequently (Figure 1). The tenodesis, therefore, includes a higher risk of medially located degenerative changes in the ankle joint.

Figure 1: Anteroposterior radiograph of a professional soccer players’ ankle seven years after Evans tenodesis. Note particularly osteophyte formation at the medial malleolus and the ossicle just near the medial talar facet.
Conclusion

Athletes impose heavy demands on ankle joint function. Surgical treatment for chronic ankle instability should therefore be aimed at restoring normal joint kinematics. Based on the results of the present study, we conclude that a tenodesis procedure impairs athletic performance by disturbing normal joint kinematics. Anatomical reconstruction should therefore be the primary choice for the surgical treatment of chronic ankle instability in athletes.
<table>
<thead>
<tr>
<th></th>
<th>AR n=41</th>
<th>TE n=36</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tegner preinjury (median)</td>
<td>9 (range 7-10)</td>
<td>9 (range 7-10)</td>
<td>0.644</td>
</tr>
<tr>
<td>Age (yrs; mean ± SD)</td>
<td>26 (± 5.2)</td>
<td>27 (± 4.7)</td>
<td>0.402</td>
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<tr>
<td>Male/female ratio (%)</td>
<td>51 / 49</td>
<td>56 / 44</td>
<td>0.704</td>
</tr>
<tr>
<td>Left/right ratio (%)</td>
<td>54 / 46</td>
<td>47 / 53</td>
<td>0.573</td>
</tr>
<tr>
<td>Follow-up (yrs)</td>
<td>5.4 (± 1.8)</td>
<td>5.4 (± 2.3)</td>
<td>0.955</td>
</tr>
</tbody>
</table>

SD = standard deviation
AR = anatomical reconstruction
TE = tenodesis
Table II.
Final results

<table>
<thead>
<tr>
<th></th>
<th>AR n=41</th>
<th>TE n=36</th>
<th>p-value</th>
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<tr>
<td>Tegner: preinjury (median)</td>
<td>9 (range 7-10)</td>
<td>9 (range 7-10)</td>
<td>0.664</td>
</tr>
<tr>
<td>Follow-up</td>
<td>8 (range 4-10)</td>
<td>8 (range 4-10)</td>
<td>0.793</td>
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<tr>
<td>Difference</td>
<td>1 (-1 - 5)</td>
<td>1 (-1 - 2)</td>
<td>0.688</td>
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<tr>
<td>Decrease Tegner (n)*</td>
<td>4</td>
<td>17</td>
<td>&lt;0.001*</td>
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<tr>
<td>Postop. Complications</td>
<td>1</td>
<td>2</td>
<td>0.481</td>
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<tr>
<td>Reoperations</td>
<td>1</td>
<td>0</td>
<td>0.346</td>
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<tr>
<td>Restricted ROM</td>
<td>3</td>
<td>15</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Pain on palpation</td>
<td>3</td>
<td>4</td>
<td>0.532</td>
</tr>
<tr>
<td>Anterior drawer sign</td>
<td>5</td>
<td>6</td>
<td>0.576</td>
</tr>
<tr>
<td>Arthrosis (van Dijk)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>24</td>
<td>18</td>
<td>0.453</td>
</tr>
<tr>
<td>Grade I</td>
<td>13</td>
<td>15</td>
<td>0.365</td>
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<tr>
<td>Grade II</td>
<td>4</td>
<td>3</td>
<td>0.828</td>
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<tr>
<td>Grade III</td>
<td>0</td>
<td>0</td>
<td>-</td>
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<tr>
<td>Karlsson*** score (points)</td>
<td>91 (± 5.9)</td>
<td>89 (± 6.2)</td>
<td>0.105</td>
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<tr>
<td>Good**** score (grade):</td>
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<tr>
<td>Excellent/good</td>
<td>36</td>
<td>21</td>
<td>0.003*</td>
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<tr>
<td>Fair/poor</td>
<td>5</td>
<td>15</td>
<td>0.003*</td>
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SD = standard deviation
* Significantly different, chi-square, p<0.05
* Decrease due to the current status of the operated ankle
** Acc. to van Dijk et al.33
*** Acc. to Karlsson et al.28
**** Acc. to Good et al.19
Table III.
Results of stress radiographic examination

<table>
<thead>
<tr>
<th></th>
<th>AR n=41</th>
<th>TE n=36</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive stress X-rays (%)(^a)</td>
<td>3</td>
<td>8</td>
<td>0.062</td>
</tr>
<tr>
<td>TT affected ankle (°)</td>
<td>3.3 (± 2.1)</td>
<td>4.8 (± 2.0)</td>
<td>0.004 (^b)</td>
</tr>
<tr>
<td>TT unaffected ankle</td>
<td>3.4 (± 1.4)</td>
<td>3.6 (± 1.8)</td>
<td>0.548</td>
</tr>
<tr>
<td>TT difference</td>
<td>-0.04 (± 2.6)</td>
<td>1.2 (± 2.8)</td>
<td>0.720</td>
</tr>
<tr>
<td>ATT affected ankle (mm)</td>
<td>3.0 (± 1.3)</td>
<td>4.1 (± 1.5)</td>
<td>0.001 (^b)</td>
</tr>
<tr>
<td>ATT unaffected ankle</td>
<td>3.4 (± 0.9)</td>
<td>3.8 (± 1.8)</td>
<td>0.215</td>
</tr>
<tr>
<td>ATT difference</td>
<td>-0.44 (± 1.3)</td>
<td>0.22 (± 2.2)</td>
<td>0.114</td>
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</table>

\(^a\) Acc. to Lindstrand et al. [32]

\(^b\) Significantly different, ANOVA, p<0.05

SD = standard deviation

TT = talar tilt

ATT = anterior talar translation
References


