On the surgical treatment of chronic anterolateral ankle instability

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Chapter IV

ANATOMICAL RECONSTRUCTION VERSUS TENODESIS FOR THE TREATMENT OF CHRONIC ANTEROLATERAL INSTABILITY OF THE ANKLE JOINT; A 2-10-YEAR FOLLOW-UP

A multi-centre study*

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- Abstract -

The clinical outcome of anatomical reconstruction or tenodesis in the treatment of chronic anterolateral ankle instability was assessed in a retrospective multicentre study. The anatomical reconstruction group (Group A) consisted of 106 patients (mean age at operation, 24 years; SD ± 8.4) and the tenodesis group (Group B) of 110 patients (mean age at operation, 26 years; SD ± 11.4). Patients were evaluated at a mean follow-up of 5.5 years (SD ± 2.8) for Group A and 5.2 years (SD ± 2.9) for Group B.

The review protocol included patient characteristics, physical examination, two ankle scoring scales to evaluate the functional results, as well as standard AP and lateral radiographs to evaluate degenerative changes. Mechanical laxity was evaluated using standardized stress radiographs.

A larger number of reoperations was performed in Group B (p=0.008). At physical examination, more patients in Group B had a restricted range of ankle motion compared with Group A (p=0.009). A larger number of patients in Group B had medially located osteophytes, as seen on standard radiographs (p=0.04). Using stress radiographic examination, the mean talar tilt (p=0.001) and mean anterior talar translation (p<0.001) were significantly increased in group B as compared with Group A. There were no differences in the mean Karlsson score between the groups, but more patients in Group A had an excellent result when the Good score was used (p=0.011).

Unlike anatomical reconstructions, tenodeses do not restore the normal anatomy of the lateral ankle ligaments. This results in restricted range of ankle motion, reduced long-term stability, an increased risk of medially located degenerative changes, a larger number of reoperations and less satisfactory overall results.
- Introduction -

Chronic anterolateral instability of the ankle joint is defined as instability with a duration of more than six months. Ligament laxity can be demonstrated by physical examination and stress radiographs. In patients with symptoms of giving-way, but no signs of mechanical laxity on stress radiographic examination, several etiological factors can be present. These factors include; proprioceptive deficit, peroneal muscle weakness, tibiofibular sprain and mechanical instability of the subtalar joints.\(^{25,27,45}\) In some cases, chronic ankle instability may be associated with generalized joint hyperlaxity or the neglect of an acute injury to the lateral ankle ligaments.\(^{31}\) In spite of adequate treatment for an acute lateral ankle ligament rupture, 30 to 40 percent of patients develop chronic symptoms of giving-way.\(^{9,11,16,25,27}\) The instability can be disabling, especially in patients with high demands in terms of ankle joint function.\(^{18,31}\) Surgical reconstruction is indicated when a rehabilitation programme does not produce a satisfactory functional outcome and when mechanical instability is present.\(^{29}\) 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 groups: non-anatomical reconstructions using tenodesis or anatomical reconstructions using direct repair or imbrication of the lateral ankle ligaments. In the case of 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.\(^{1,10,11,16-18,37,41,48,50}\) In the case of anatomical reconstruction, the ends of the ruptured or elongated remnants of the lateral ankle ligaments are utilized.\(^{6,9,25,27,34,38}\)

There are few comparative studies in literature. Hennrikus et al.\(^{22}\) and Wallenböck et al.\(^{49}\) reported superior functional results for anatomical reconstructions. Experimental studies report that tenodeses have a negative effect on the kinematic coupling of the ankle joint and thus do not prevent instability. In addition, they restrict the range of ankle motion.\(^{3,7,33}\)

The aim of this retrospective multicentre study was to compare the results of anatomical reconstruction with those of tenodesis in a large series of patients with a 2–10 year follow-up. Furthermore, the results were analysed to determine whether inferior mechanical stability leads to degenerative changes and a deterioration in functional results in the medium or long term.
- Patients and Methods -

Five European centres participated in the study. Between 1987 and 1995, a total of 324 reconstructions were performed for chronic anterolateral instability of the ankle at these five centres. All patients had experienced complaints for at least six months and had undergone rehabilitation with range of motion and proprioceptive training before the operation. Preoperatively, mechanical stability was assessed by stress radiographs in both the frontal plane; talar tilt (TT), and sagittal plane; anterior talar translation (ATT) according to the criteria of Lindstrand et al. The indication to perform an anatomical reconstruction or a tenodesis was surgeon dependent and independent of the the type of instability or other patient characteristics.

One hundred and fifty two patients underwent anatomical reconstruction and 172 underwent tenodesis. The following inclusion criteria were employed: 1) age at operation between 14 and 60 years; 2) an uninjured contralateral ankle; 3) no history of previous fractures of the affected ankle; 4) no prior surgery other than an anatomical reconstruction or tenodesis of the affected ankle; 5) no prior surgery of the contralateral ankle; 6) no history of bilateral hyperlaxity; 7) no history of subtalar instability; 8) 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. The review protocol consisted of a registration of postoperative complications, the number of reoperations and an assessment of the Tegner activity level. Functional outcome was graded using two ankle scores; the Karlsson score and the scoring scale of Good et al. Absence of symptoms was considered as an excellent result.

At physical examination the range of ankle motion was determined by measuring dorsiflexion and plantarflexion to the nearest five degrees using a goniometer. A reduction of more than five degrees in comparison with the contralateral ankle was considered as a restricted range of ankle motion. Also the presence of swelling and pain on palpation were determined.

Stability was tested by the anterior drawer test with the ankle in 15 degrees of plantarflexion. This test was regarded as positive when there was considered to be 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 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 Newton using a Telos®
apparatus. The development of degenerative changes was graded according to the scale
suggested 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).
Of the original 324 patients, 30% of the patients were lost to follow-up: 47 patients were
untraceable, 32 did not want to participate, 11 had emigrated to another city or country, three
patients had died and four were in prison. With regard to the number of patients that were lost
to follow-up there were no significant differences between the centres. After further analysis,
3% of the patients had to be excluded: four patients did not meet the inclusion criteria and the
radiographs for seven patients were not available. As a result, 216 patients could be included.
In terms of the anatomical reconstructions the following significant differences were
identified between the centres: the left/right ratio (%) at one centre was 66/34, while the
overall ratio was 43/67 (p=0.034). At two other centres, the male/female ratio was 76/24 and
69/31 respectively, while the overall ratio was 53/47 (p=0.028, p=0.041). At one centre, there
were seven cases of disturbed skin sensitivity at follow-up, corresponding to peroperative
superficial peroneal nerve injury, while the overall number of direct postoperative
complications was three (p=0.031). With regard to the tenodeses, only one significant
difference between the centres was identified: at one centre the male/female ratio was 85/15,
while the overall ratio was 56/44 (p=0.021).

A total number of 106 patients were included in the anatomical reconstruction group (Group
A) while 110 patients were included in the tenodesis group (Group B). 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 Group B were two years older
on average (mean age at operation; 26 years; SD ± 11.4) than the patients in Group A (mean
age at operation; 24 years; SD ± 8.4). There was a difference of one point on average in the
median preinjury Tegner activity level, six (range; 1-10) in Group A compared with five
(range; 0–9) in Group B (p=0.554). Both groups were similar in terms of male/female ratio,
left/right ratio and the duration of follow-up. The mean follow-up period was 5.5 years (SD ±
2.8) in Group A and 5.2 years (SD ± 2.9) in Group B (p=0.31).
In Group A, 63 patients at two centres underwent imbrication using a regional periosteal flap and 43 patients at one centre underwent a Broström procedure. Postoperatively, all patients had plaster cast for six weeks and thereafter range of motion and proprioceptive training. There were no significant differences in results between the different procedures.

In Group B, 35 patients were treated with an Evans procedure at one centre, 43 patients with a modified Castaing procedure using a peroneus brevis hemitendon at two centres, 22 patients with a Viernstein procedure at one centre and 10 patients with a Watson-Jones procedure at one centre. All procedures were performed with the foot in slight eversion. Postoperatively, all patients received plaster cast for six weeks and thereafter range of motion and proprioceptive training. No significant differences in final results between the different tenodesis procedures could be identified.
- Statistical analysis -

Differences in baseline characteristics and final results were calculated using the Multi Analysis of Variance (MANOVA) for a comparison of mean 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 and the chi-square test for proportions. A p-value of <0.05 was considered as statistically significant.
- Results -

The results at the final follow-up are shown in Table II. In Group A, in 8% of the patients postoperative complications were registered; in all cases this involved disturbed skin sensitivity due to peroperative damage to the superficial peroneal nerve. In Group B, in 15% of the patients postoperative complications were registered; skin necrosis in seven patients, neuroma in seven patients, wound infection in two patients and hypoanaesthesia due to peroperative damage to the superficial peroneal nerve in one patient.

The number of reoperations was higher in Group B: 17% versus in 5% Group A (p=0.008). In Group B three patients who underwent an Evans tenodesis, one patient who underwent a modified Castaing procedure, two patients who underwent a Viernstein procedure and two patients who underwent a Watson-Jones procedure were reoperated to release an overly tight tenodesis. In these cases the tendon was released from its original sutures and reattached to the distal fibula. Furthermore in Group B two patients who underwent an Evans procedure, three patients who underwent a Viernstein procedure and four patients who underwent a modified Castaing procedure who complained of persisting pain located anteriorly near the lateral malleolus, were reoperated to remove bony spurs near the drillhole of the tenodesis. In Group A five patients were reoperated to release an overly tight reconstruction.

At physical examination, there was a significant difference in the number of patients with a restricted range of ankle motion between the two groups (p=0.009). In Group A 10% had a restricted range of ankle motion. Five patients had a restricted dorsiflexion, three patients a restricted plantarflexion and three patients both. In Group B 33% had a restricted range of ankle motion. Nineteen patients had a restricted dorsiflexion, four patients a restricted plantarflexion and 13 patients both.

The number of patients with a positive anterior drawer test was similar between the two groups; 31% in Group A and 33% in Group B.

In terms of the scale of Good et al.41, there were significantly more patients who had an excellent result (i.e. free from symptoms) in Group A; 58% compared with 36% in Group B (p=0.012). There were no significant differences between the groups in terms of the Tegner and Karlsson scores.

The number of patients with degenerative changes as seen on standard AP and lateral radiographs were similar in both groups. Two patients in Group B had developed severe osteoarthritis (Grade III). Seventeen percent of the patients in Group B demonstrated
medially located osteophytes compared with 7% in Group A (p=0.04). When it came to the stress radiographic examination, the mean talar tilt (p=0.001) and the anterior talar translation (p<0.011) were significantly higher in Group B. According to the criteria of Lindstrand et al. in Group A 22% of the patients had positive stress radiographs compared with 41% in Group B (p=0.009) (Table III).
More than 60 surgical procedures for the correction of chronic anterolateral instability of the ankle joint have been described. Most of these procedures involve non-anatomical reconstruction. In most procedures, the peroneus brevis tendon or a part of it is used to establish a tenodesis between the distal fibula and the calcaneus, the talus or the base of the fifth metatarsal. Other authors have recommended tendon transfer in which replacement of the lateral ankle ligaments is performed in a more anatomical fashion, e.g. by using a split peroneus brevis tendon. In this way, the potential risk of losing eversion strength is reduced.

There are several classic tenodeses such as the Elmslie, Evans, Chrisman-Snook and Watson-Jones procedures. These procedures usually include the reconstruction of the anterior talo-fibular and calcaneo-fibular ligaments to correct instability in the talocrural and subtalar joint. In the literature, the clinical outcomes of tenodeses vary. Many studies report good short-term results. There have been few reports of long-term results, but Snook et al. reported satisfactory long-term results after using the Chrisman-Snook procedure. On the other hand, some long-term studies have shown that tenodeses do not prevent mechanical instability and may lead to subsequent degenerative changes, result in a restricted range of ankle motion and decrease eversion strength.

In recent literature, anatomical reconstruction has acquired increasing popularity. These procedures make use of the ruptured or elongated remnants of the ligaments to restore normal ligament stability. A problem arises in anatomical reconstruction when the local ligament tissue is severely damaged. In these cases, augmentation with an autograft may be necessary. To reinforce the ligaments, autografts with mechanical properties similar to those of the normal ligaments are most frequently used. They include periosteal flaps or the inferior extensor retinaculum. Some authors advocate the use of the fascia lata or free sections of the achilles or plantaris tendon to reconstruct the anterior talo-fibular ligament. Nachtkamp et al. investigated the histological changes in periosteal flaps in patients with chronic anterolateral ankle instability. They noted structural alignment of the collagenous fibres in the periosteal flap into a ligament-like structure eight to 12 weeks after the operation. Anatomical reconstructions have been reported to produce satisfactory long-term results in a large proportion of patient.

Both anatomical reconstruction and tenodesis have been the subject of experimental studies. Most of these studies report that a tendon transfer procedure limits the range of ankle motion

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and prevents neither anterior talar translation nor talar tilt.\textsuperscript{3,23,30,33,44} Liu et al.\textsuperscript{33} found similar results in a cadaveric model, i.e. that the Watson-Jones and Evans tenodesis provided less mechanical stability than the modified Broström procedure. In terms of these experimental results, it is evident that a tenodesis has a negative effect on the kinematic coupling of the ankle joint complex.\textsuperscript{6} Our data are in accordance with these experimental findings. Stress radiographic examinations revealed that patients in the anatomical reconstruction group had significantly less talar tilt and anterior talar translation. Instability has been associated with the development of degenerative changes as seen on standard radiographs.\textsuperscript{21} As the results of stress radiographic examinations in our series demonstrated inferior mechanical stability for the tenodesis group, a larger number of patients with degenerative changes could be expected. A larger number of patients in the tenodesis group displayed medially located osteophytes compared with the anatomical reconstruction group (Figure 1). On the basis of these two observations, we feel that there is a correlation between the decrease in mechanical stability and the development of medially located degenerative changes in the ankle joint. The same phenomenon has been found by Harrington\textsuperscript{21}, who performed arthroscopics 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. It has been demonstrated that, in supination trauma, cartilage damage occurs in 65\% at the medial talar facet and tip of the medial malleolus.\textsuperscript{46} In a trauma of this kind, the talus rotates out of the ankle mortice and, in this subluxated, supinated position, the weight causes axial compression through the medial malleolus and the medial talar facet. This impaction force explains the cartilage damage which can successively lead to degenerative changes.\textsuperscript{3,12,23,30,33,39,44,46}

Our results reveal that a larger number of patients in the tenodesis group had a restricted range of dorsi- or plantarflexion. This may appear in conflict with our finding of decreased mechanical laxity provided by the tenodesis. As the transferred tendon is placed in a non-anatomical position or when the reconstruction is too tight, this can restrict dorsi- or plantarflexion and simultaneously may not prevent tilt and anterior translation of the talus. Although this phenomenon has also been found by several cadaver studies, the exact explanation for the simultaneous finding of restriction of the physiological range of ankle motion and increased mechanical laxity after a tenodesis reconstruction remains unclear.\textsuperscript{3,23,30,33,40}

As many tenodeses are performed with the foot placed in mild eversion, the lateral side of the ankle joint can easily become overtightened. Significantly more patients required the release of an overly tight reconstruction after tenodesis than after anatomical reconstruction. Another
problem that has been reported in conjunction with tenodesis procedures is the development of symptomatic anterolateral bony spurs. The tendon, which is routed through a drill hole in the narrow lateral malleolus, may perforate the external cortex, leading to the development of symptomatic bony spurs.\textsuperscript{4} Our results revealed that a significant number of patients in the tenodesis group required a second operation to remove symptomatic bony spurs.

![Image](image.jpg)

Figure 1: Lateral and AP view of a left ankle of a 32-year old male, 8 years after tenodesis. Note the formation of anteromedially located talar and tibial osteophytes.

When comparing the two groups with regard to functional stability using the scale of Good et al.\textsuperscript{41}, we found that significantly more patients in the anatomical reconstruction group had an excellent result. Significantly more patients were therefore free from symptoms of giving-way. This finding is supported by a prospective study by Hennrikus et al.\textsuperscript{22} which showed that the modified Broström procedure resulted in significantly higher scores according to the scale of Good et al. than the Chrisman-Snook tenodesis. Wallenböck et al.\textsuperscript{49} also found
superior functional results for anatomical reconstructions compared with the Evans and Watson-Jones tenodeses.

In the present multicentre study, all the participating centres used the same standard protocol to review their patients and assess the clinical outcome. A large series of 216 patients was re-examined at a medium or long-term follow-up (2–10 years). All the radiographs were assessed by one independent observer. The limitations of the present study include inhomogeneous male/female and left/right ratios for comparisons between the centres. However, we are not aware of any study that reports that differences in male/female or left/right ratio influence the results of the surgical treatment of chronic anterolateral ankle instability. At one centre, there was a significantly larger number of postoperative complications than at the other centres. However, this included in all cases minor damage to the superficial peroneal nerve.
- Conclusion -

We conclude that, unlike anatomical reconstruction, tenodesis does not restore the normal anatomy of the lateral ankle ligaments. These procedures result in a restricted range of ankle motion, a higher number of reoperations and less satisfactory functional results. Furthermore, we conclude that tenodesis does not prevent mechanical laxity after 2–10 years, thereby leading to subsequent degenerative changes on the medial side of the ankle joint.
### Table I. Anatomical reconstruction (Group A) vs tenodesis (Group B)  
**Baseline characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Group A n=106</th>
<th>Group B n=110</th>
<th>Sign. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>24.3 (± 8.4)</td>
<td>26.2 (± 11.4)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Male/female ratio (%)</td>
<td>53/47</td>
<td>56/44</td>
<td>n.s.</td>
</tr>
<tr>
<td>Left/right ratio (%)</td>
<td>43/57</td>
<td>37/63</td>
<td>n.s.</td>
</tr>
<tr>
<td>Tegner preinjury (median)</td>
<td>6 (range; 1-10)</td>
<td>5 (range; 0-9)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Follow-up (yrs)</td>
<td>5.5 (± 2.8)</td>
<td>5.2 (± 2.9)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

SD = Standard Deviation

### Table II. Anatomical reconstruction (Group A) vs tenodesis (Group B)  
**Final results**

<table>
<thead>
<tr>
<th></th>
<th>Group A n=106</th>
<th>Group B n=110</th>
<th>Sign. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postop. complications (%)</td>
<td>8</td>
<td>15</td>
<td>n.s.</td>
</tr>
<tr>
<td>Reoperations (%)</td>
<td>5 *</td>
<td>17</td>
<td>0.008</td>
</tr>
<tr>
<td>Tegner: preinjury (median)</td>
<td>6 (range; 1-10)</td>
<td>5 (range; 0-9)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Follow-up</td>
<td>6 (range; 1-10)</td>
<td>5 (range; 0-9)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Difference</td>
<td>1 (range; -5 - 4)</td>
<td>1 (range; -4 - 3)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Restricted ROM (%)</td>
<td>10 *</td>
<td>33</td>
<td>0.009</td>
</tr>
<tr>
<td>Pain on palpation (%)</td>
<td>25</td>
<td>25</td>
<td>n.s.</td>
</tr>
<tr>
<td>Anterior drawer sign (%)</td>
<td>33</td>
<td>36</td>
<td>n.s.</td>
</tr>
<tr>
<td>Arthrosis (van Dijk) (%)</td>
<td></td>
<td></td>
<td>n.s.</td>
</tr>
<tr>
<td>Grade 0</td>
<td>71</td>
<td>68</td>
<td>n.s.</td>
</tr>
<tr>
<td>Grade I</td>
<td>21</td>
<td>22</td>
<td>n.s.</td>
</tr>
<tr>
<td>Grade II</td>
<td>8</td>
<td>8</td>
<td>n.s.</td>
</tr>
<tr>
<td>Grade III</td>
<td>0</td>
<td>2</td>
<td>n.s.</td>
</tr>
<tr>
<td>Karlsson score (points)</td>
<td>92 (±10.3)</td>
<td>91 (±10.8)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Good score (grade) (%)</td>
<td></td>
<td></td>
<td>n.s.</td>
</tr>
<tr>
<td>Excellent</td>
<td>58 *</td>
<td>36</td>
<td>0.012</td>
</tr>
<tr>
<td>Good</td>
<td>25 *</td>
<td>45</td>
<td>0.016</td>
</tr>
<tr>
<td>Fair</td>
<td>12</td>
<td>15</td>
<td>n.s.</td>
</tr>
<tr>
<td>Poor</td>
<td>5</td>
<td>4</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

SD = Standard Deviation  
* Significantly different, chi-square, p<0.05  
* Significantly different, ANOVA, p<0.05
### Table III. Anatomical reconstruction (Group A) vs tenodesis (Group B)

Results of stress radiographic examination

<table>
<thead>
<tr>
<th></th>
<th>Group A n=106</th>
<th>Group B n=110</th>
<th>Sign. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive stress radiographs (%)</td>
<td>22 ± 4.55</td>
<td>41 ± 6.77</td>
<td>0.009</td>
</tr>
<tr>
<td>TT affected ankle (°)</td>
<td>4.5 ± 2.7</td>
<td>6.7 ± 2.1</td>
<td>0.001</td>
</tr>
<tr>
<td>TT unaffected ankle</td>
<td>4.0 ± 3.1</td>
<td>5.0 ± 4.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>TT difference</td>
<td>0.61 ± 2.6</td>
<td>1.8 ± 2.1</td>
<td>0.015</td>
</tr>
<tr>
<td>ATT affected ankle (mm)</td>
<td>2.9 ± 2.2</td>
<td>4.7 ± 1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ATT unaffected ankle</td>
<td>3.0 ± 1.2</td>
<td>3.7 ± 2.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>ATT difference</td>
<td>-0.14 ± 2.1</td>
<td>1.0 ± 1.6</td>
<td>0.031</td>
</tr>
</tbody>
</table>

*acc. to Lindstrand et al. [32]

*Significantly different, chi-square, p<0.05

*Significantly different, A-NOVA, p<0.05

SD = Standard Deviation

TT = Talar Tilt

ATT = Anterior Talar Translation
References


