THE NATURAL HISTORY OF STAGE 5 OSTEOCHONDRAL TALAR LESIONS

by

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Abstract

Objective

To describe the natural history of conservatively managed stage 5 osteochondral talar lesions.

Background

Osteochondral talar lesions (OLT) are a well recognized cause of chronic post traumatic ankle pain. In 1959 Berndt and Harty (1) described a 4 stage OLT classification scheme which has been universally adopted by the orthopedic and sports medicine communities. However, it has recently been recognized that the majority (77%) of chronic OLT exist as a radiolucent defect (subchondral cystic lesion) that does not fit into this classification scheme (2). This radiolucent defect has been classified as a stage 5 OLT(2) and is felt to represent avascular necrosis of lower stage lesions as a result of failed healing (2,3,4). The natural history of stage 5 OLT has not been described.

Methodology

Twenty-five subjects (26 ankles) with conservatively managed stage 5 OLT were reassessed at 2 or more years post diagnosis (mean 39 months). Five (6 ankles) of the 25 subjects opted for surgical management after a failed trial of conservative treatment. Their data was included only up to the point of the end of failed conservative management. Pain at rest, pain to walk, pain to run, and activity level were assessed at follow-up and retrospectively at the time of diagnosis using a 100 mm retrospective

visual analogue scale (VAS) (end points no pain and the worst pain from this injury, or full activity and most limited activity level from this injury). Mean VAS pain scores at follow-up and diagnosis were compared via repeated measure Hotellings T squared. Mean VAS activity level scores at follow-up and diagnosis were compared via repeated measure t-test. The overall clinical result at follow-up was rated excellent, good, fair or poor based on a combination of symptom persistence, sport limitation, and pain frequency.

CT scan and plain Xray were obtained at follow-up on 19/25 and 20/25 subjects respectively. The CT scans at diagnosis (where available, n=11) and follow-up were compared via repeated measure t-test for changes in lesion size. Plain X-rays were examined for the presence or absence and degree of degenerative changes. Osteophytes, sclerosis and narrowing were each considered sufficient to diagnose degenerative change. The degree of degenerative change was determined according to a scale based on the size of the largest osteophyte, the presence or absence of sclerosis, and the presence or absence of focal or diffuse narrowing.

Main results

VAS results demonstrated a significant decrease in pain to run (29 mm = 29% of the worst pain to run from this injury, p=.005) and a significant decrease in pain to walk (23.5 mm = 23.5 % of the worst pain to walk from this injury, p=.009). Pain at rest decreased and activity level increased, however, neither was statistically significant.

The overall clinical result was good or excellent in 50%, fair in 15% and poor in 35%.

Lesions tended to increase in size, however this was not statistically significant. There was no correlation between changes in lesion size and clinical results.

Mild degenerative changes were found in 13/20 ankles with OLT. All (10/10) subjects with asymmetric degenerative changes between their 2 ankles had the higher grade of degenerative change on the side with the OLT. This suggested a relationship between stage 5 OLT and the development of degenerative changes. However these degenerative changes were not found to be related to the clinical result.

Lateral lesions tended to do better than medial lesions and adults tended to do better than juveniles (<20 yr. age at diagnosis).

Conclusion

At a mean follow-up of 39 months conservatively managed stage 5 OLT were found to significantly improve clinically with respect to pain to run and pain to walk. The overall clinical result was good or excellent in 50 %, fair in 15 % and poor in 35%. Radiographically the lesions tended to increase in size (trend only), however changes in lesion size were not found to correlate with clinical result. Mild degenerative changes were common and appear to be related to the presence of stage 5 OLT. The presence or absence of theses degenerative changes does not appear to be related to the clinical result.

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Introduction

Osteochondral lesions of the talus (OLT) are a relatively common cause of chronic post traumatic ankle pain that pose a difficult challenge to the physician. A lack of information regarding the natural history of OLT increases the difficulty of this challenge.

The typical patient with an OLT presents with chronic activity related pain following an inversion injury to the ankle (2,5). Traditionally OLT are classified according to the Berndt and Harty 4 stage system (1) based on X-ray appearance (table 1 & figure 1).

The current literature that discusses the natural history of OLT is based on plain X-ray studies (6,7,8,9,10). It has become clear, however, that plain X-ray is inadequate when assessing OLT (2,3,4). These reviews of the natural history of OLT based on plain X-ray are now outdated and their validity must be questioned.

CT scan and MRI have allowed us to recognize that the majority (77%) of chronic OLT are radiolucent defects (subchondral cystic lesions) (2). These radiolucent defects do not fit into the Berndt and Harty 4 stage classification system and have, therefore, been designated as stage 5 OLT (2) (figure 1).

These stage 5 lesions have been found to arise from lower stage Berndt and Harty lesions (11,2,3,4). The pathology of stage 5 OLT has been described as fibrous (2), granulation (12), and fibrous with fluid and bone fragments (13). It is felt that the stage

5 OLT represents avascular necrosis as a result of failed healing of lower stage lesions (2,3,4).

Current treatment of stage 5 OLT may be either conservative (consisting of observation, medications, physiotherapy, braces, and supports) or surgical (drilling and curretage of the defect) (2). However, a lack of knowledge of the natural history of stage 5 OLT increases the difficulty of clinical management.

What is the natural history of stage 5 OLT? Do subjects with stage 5 OLT improve clinically over time? Do the lesions heal radiographically? Is there a correlation between clinical resolution and radiographic healing? Do lesion location and age of diagnosis affect the clinical result? What is the risk of developing degenerative changes (osteoarthritis (OA)) and what is the role of degenerative changes in symptom persistence? In this study we reassessed a series of conservatively managed stage 5 OLT at 2 or more years post diagnosis in an attempt to answer these questions.

Natural History of Stage 5 OLT - Review of Literature

Any review of the natural history of stage 5 OLT must be accompanied by a discussion of OLT in general. It is clear that our knowledge of the natural history of OLT and in particularly stage 5 OLT is limited.

Nomenclature

There have been many names used to describe the osteochondral lesions found in the dome of the talus. These include osteochondritis dissecans, osteochondral fractures of the talar dome, transchondral fractures of the talar dome, chip fractures of the talus, and osteochondral lesions of the talus (2,11). These appear to be referring to the same condition. For this study the term osteochondral lesions of the talus (OLT) is adopted as a purely descriptive name which remains valid regardless of etiology.

Etiology and Epidemiology

There have been numerous theories proposed regarding the etiology of osteochondral talar lesions. These include: embolic phenomenon, congenital factors, vascular abnormalities, and hormonal changes (11,14). However, there appears to be a general consensus that the majority of osteochondral lesions of the talus are traumatic in origin (1,6,11,15).

Berndt and Harty provided a good mechanistic model supporting a traumatic etiology with their cadaver experiments in 1959 (1). Through an inversion mechanism they were able to create talar dome lesions that were similar in location and morphology to those

seen clinically. These lesions tend to be found in 2 characteristic locations: anterolateral and posteromedial. The anterolateral lesions tend to be thin and wafer like (11). According to Berndt and Harty they occur during inversion injuries with the foot in dorsiflexion as the talar dome contacts the medial aspect of the fibula causing a shearing type injury (1). The posteromedial lesions tend to be deep and crater like (6,11). According to Berndt and Harty they occur with inversion injuries when the ankle is plantar flexed and the tibia rotated laterally on the talus. This is thought to create a compression type injury on the posteromedial aspect of the talus as it impinges on the distal tibia .

The majority of talar lesions seen clinically do fit the above descriptions. However, not all patients with osteochondral lesions of the talus are able to provide a history of trauma to the ankle, not all lesions are found in the classical locations, and not all lesions have the classical morphology.

Flick and Gould, in their literature review (11), found that 98% of lateral lesions had a history of trauma whereas only 70% of medial lesions had a history of trauma. Loomer et al (2), in a series of 92 patients, reported a history of trauma in 89% (71% of these with an inversion mechanism). Naumetz et al (16) in a series of 31 patients found a history of trauma in 84% . Canale et al (6) found that all lateral lesions had a history of trauma whereas only 9/14 medial lesions had a history of trauma.

Loomer et al (2) described 36% anterolateral, 25% posteromedial, 16% anteromedial, 6% posterolateral, 12% midmedial, 4% midlateral, and 1 % midanterior. Ly et al(4) describe

finding 10 of 16 medial lesions in anterior or central positions. They also found 13 of 51 lateral lesions in central or posterior positions (4).

Ly et al (4) also describe finding 3 lateral lesions which were deep and cup shaped as opposed to the classical thin wafer like lateral lesions.

The incidence of OLT is not well known. The figure of 6.75 % of all ankle sprains is often quoted in the literature (1,11). This is in reference to a study by Boisen et all (17) in 1955. They followed 133 ankle sprains and radiographically 9 cortical talar fractures were found -yielding a figure of approximately 6.75%. However, as they stated in the original paper, 4 of 9 fractures appeared to be old - eliminating these there would be 5 of 133 or approximately 3.76%. Perhaps more important than this discrepancy is the fact that these numbers were produced in an old study using outdated imaging technology. Loomer(2) describes that only 50-66% of OLT found on CT scan are seen on plain X-ray. Anderson (3) describes 7 cases of OLT confirmed on CT scan that were absent on X-ray. Clearly plain radiographs are inadequate when assessing OLT.

Many osteochondral lesions are asymptomatic (10,11). Since only those with chronic disability or with changes found fortuitously on routine x-ray for an acute ankle sprain have been studied, the true incidence of OLT and the relative proportion of these that will become symptomatic or develop complications is unknown.

Clinical Presentation and Diagnosis

The typical patient presents following an inversion injury to the ankle (2,5), however other mechanisms such as eversion or poorly described trauma have been reported (6).

Differentiating between an acute OLT and a simple inversion sprain is often impossible at initial presentation. The history and physical exam are remarkably unhelpful in making this differentiation (1,5,18). The diagnosis may be made acutely in some cases if X-rays are ordered. However, the X-rays are often not helpful, either because the lesion is missed or not present on the films. Flick and Gould (1) reported that ER physicians missed 12 of 16 cases of OLT in their series. Of these 12 missed diagnoses, 7 had positive X-rays but were misread by the ER physician. Loomer (2) noted that of 92 cases only 50% were seen on initial X-rays, this increased to 66% when these same X-rays were examined retrospectively after the diagnosis had been made by other means.

It can therefore be concluded that it is difficult to make a diagnosis of acute OLT. The diagnosis of OLT is more commonly made as a result of the persistence of symptoms following what was initially thought to be a simple ankle sprain. Chronic ankle pain - usually activity related - , swelling, stiffness, night pain, instability, locking, and crepitus are commonly cited symptoms (1,2,5). Loomer (2) found that pain was a "universal complaint ", they found that 94% had activity related pain, and 36 % had night pain. Sixty-eight % reported swelling.

The delay between symptom onset and diagnosis is variable but may be protracted. This may be in part due to delayed presentation on the part of the patient, however, the

diagnosis is often delayed even after presentation to a physician. Flick and Gould (11) found a diagnostic delay of up to 2 years after physician evaluation. Loomer et al (2) found an average delay of 36 months from symptom onset to diagnosis.

In these chronic presentations bone scan, CT and MRI are useful. Tc 99 bone scan is an excellent screening tool with a sensitivity of 94% (19) however its specificity is only 76% (19). A positive bone scan is usually followed with a CT scan to further identify, localize and stage the lesions(19). Tomograms may have a role (4) when CT is not available and MRI has been proposed as an alternative to CT. MRI seems to be better able to detect stage 1 lesions (3), however, the clinical significance of this detection is debatable (2).

Staging of OLT Lesions

The classical paper by Berndt and Harty (1955) (1) described a four level staging system that was universally adopted by the orthopedic and sports medicine communities (table 1).

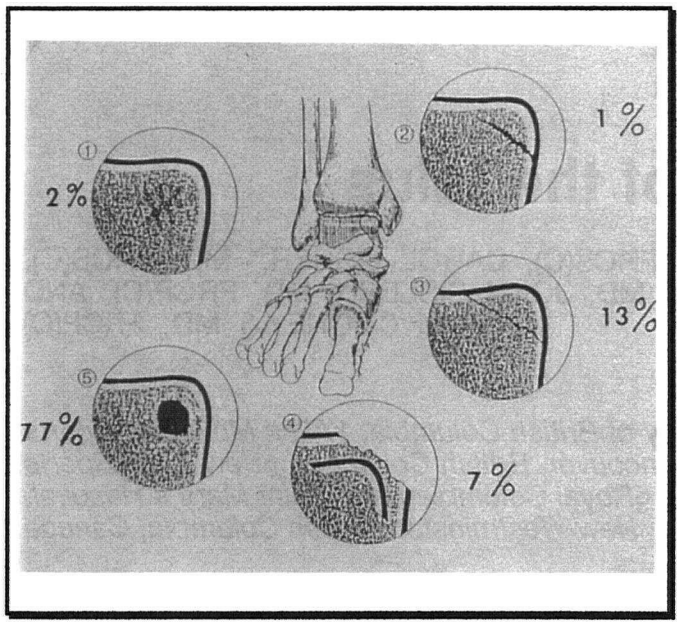
Table 1

Berndt and Harty Classification

stage 1	compression injury with subchondral compression
stage 2	partially detached osteochondral fragment
stage 3	detached osteochondral fragment, non-displaced
stage 4	detached and displaced osteochondral fragment

Relatively recently this classification scheme was modified to incorporate the finding of radiolucent defects (subchondral cystic lesions) (2,3) (figure 1).

Figure 1



Modified Berndt and Harty classification scheme (from Loomer (2)). Note that stage 1 - 4 are unchanged from the Berndt and Harty scheme (table 1) and that subchondral cystic lesions have been added as stage 5. The percentages refer to the frequency of each stage as per Loomer (2).

Loomer (2) has published the largest series of subchondral cystic lesions - 71 pts (77% of 92 cases of OLT(figure 1)). They suggest that these stage 5 lesions represent the majority of chronic OLT lesions. Other authors, including Anderson (3), Flick and

Gould (11), Scharling (20), Yuan (13), Desmet (12), and Ly (4) have described these lesions in smaller numbers.

Flick and Gould (11) describe talar subchondral cysts in 3 patients. In one patient they followed the evolution of a stage 3 medial talar dome lesion into a subchondral cyst.

Yuan (13), described 3 cases of talar cysts associated with osteochondritis dissecans and filled with fibrous tissue, fluid and bone fragments.

Scharling (20) described 10 cases with subchondral cysts (3 solitary and 7 multilocular). They felt that the solitary cyst represented a stage of development of osteochondritis dissecans. They did not comment on the origin of the multilocular cysts.

Anderson (3) found 8 cases of subchondral cysts in their series of 24 patients. Six of these had negative initial radiographs from which it was concluded that they had arisen from stage 1 lesions. They proposed that stage 2a be added to Berndt and Harty's classification to reflect the possibility that the subchondral cystic lesion (2a) can arise from stage 1 or stage 2 lesions.

Ly et al (4) recognized that avascular necrosis of transchondral lesions can lead to a radiolucent defect in the subchondral bone. They proposed a 2 stage classification system where stage 1 would represent all acute injuries and stage 2 would represent the avascular necrosis stage.

Desmet (12) described 5 cystic lesions filled with granulation tissue at the bases of unstable osteochondral lesions.

Loomer (2) describes 2 patients with undisplaced talar fractures that went on to develop subchondral cystic lesions. The pathology of these lesions was noted to be fibrous at surgery and it was concluded that the cystic lesion represents avascular necrosis in cases of failed healing. Loomer proposed that stage 5 be added to the Berndt and Harty classification scheme to recognize that the subchondral cyst can arise from stage 1, 2, or 3 lesions.

It would appear that there is good evidence of an association between OLT and the development of the radiolucent defect. This likely represents avascular necrosis as a result of failed healing. The stage 5 classification system of Loomer will be adopted here.

Natural History of Stage 5 OLT

The natural history of OLT is very poorly understood. This is particularly true with respect to the chronic stage 5 lesions.

Healing of OLT

Do osteochondral talar lesions heal with time and conservative therapy?

Radiographic healing of OLT is described in the literature. Canale et al (6) reported that 2 out of 16 lesions treated conservatively showed radiographic union. McCullough et al (7) reported that of 6 lesions treated conservatively, 1 lesion healed. Bauer et al (8) described healing in 4 of 5 children treated conservatively. Mukherjee et al (9) reported healing in 3 of 10 lesions. Roden et al (10) described healing in 12 of 53 cases.

All of these claims of healing were based on X-ray evidence of union. X-rays, as discussed above, are clearly inadequate in assessing OLT. Not only do plain X-rays miss OLT (2,3) but it is difficult to stage OLT based on plain X-ray (4). Loomer (2) describes patients who appear as stage 1, 2, or 3 on plain X-ray and are stage 5 on CT. No study to date has assessed the healing of OLT based on CT or MRI findings.

Loomer (2) believes stage 5 lesions will heal if given time but does not describe any cases as having healed. The other authors describing stage 5 OLT do not discuss it's natural history.

Natural History of Symptoms of OLT

The correlation between radiographic OLT and symptoms is not always clear. One would expect radiographic healing to coincide with symptom resolution - as has been reported (9). Clearly symptoms can persist in association with radiological evidence of lesion persistence (11). However, OLT may also be asymptomatic. Lesions have been detected coincidentally on radiographs (1,10) and in some cases symptoms have disappeared despite radiological evidence of a lack of healing (6,7). Loomer (unpublished) has described patients with asymptomatic contralateral stage 5 lesions discovered incidentally on CT scan.

There is no data available in the literature describing the natural history of symptoms for the stage 5 lesion or the relationship between the change in symptoms and the change in stage 5 lesion size.

The Development of Osteoarthritis (OA) in OLT

Osteoarthritis of the ankle is, in general, rare (21). The risk of developing OA as a result of OLT is unclear. Various authors have come to different conclusions regarding this risk.

Canale et al (6) found OA in 15 of 31 cases of OLT. Interestingly, they found that while poor clinical results always correlated with X-ray evidence of OA, seven of their cases had no symptoms despite X-ray evidence of advanced OA. Unfortunately their criteria for the diagnosis of OA was not supplied. Bauer et al (8) found OA in only 2 of 31 OLT cases at an average follow-up of 21 years. Their criteria for the diagnosis of OA was joint narrowing, sclerosis, or cyst formation. Osteophytes alone was not considered evidence of OA. McCullough et al (7) followed 10 patients an average of 15.9 years and found OA in only 3 patients. Their criteria for the diagnosis of OA was joint narrowing, bony sclerosis, erosions and osteophytosis. Loomer believes the risk of OA is small (2).

It is clear that the risk and significance of OA arising from OLT is still poorly understood. This paper considers degenerative changes and osteoarthritis to be synonymous.

Age of Diagnosis and Result

The role of age of diagnosis in the course of OLT is poorly understood. There have been limited numbers of adolescents/children with OLT reported in the literature.

Berndt and Harty (1) reported that conservative therapy in children < 15 years of age was generally unsuccessful. Poor results were obtained in 11 of 15 cases, seven of which required surgery at a later date.

Bauer et al (8) reported on 5 cases in children - all treated conservatively. Four of these healed radiographically. Four were reported as excellent (no symptoms) and one as good (mild symptoms).

Roden (10) described 6 patients less than 17 years of age who were treated conservatively. At an average follow-up of 5.6 years (range 1-11 yr.) two were symptom free.

Davidson (15) reported on 4 conservatively managed patients diagnosed at < 17 years of age. One had a very good, one had a good, one had a fair, and one had a poor result.

Flick and Gould (11) conservatively managed 3 patients younger than 16 years of age. All did poorly and required later surgery.

Yvars (13) describes one case of a 15 yr. female treated conservatively. She still had limitation of activity due to pain at 15 months follow-up.

Mukherjee (9) reported on a 17 year old female who was treated conservatively and was symptom free at 27 months.

McCullough (6) reported on 1 case of a 13 year old treated conservatively who at 24 years of follow-up had excellent results.

Bruns et al (22) reported that 13 adolescents had much better results than 13 adults. All were treated surgically.

The literature is clearly confusing and contradictory with respect to adolescents/children and the results of conservative therapy for OLT. No study reports on stage 5 OLT in the younger age group.

The Role of Lesion Location in the Natural History of OLT

As discussed earlier the classical lesions are either posteromedial (deep cup shaped) or anterolateral (shallow wafer like). It is not inconceivable that these different lesions might behave differently. There is some evidence in the literature that this is the case.

Canale (6) found that lateral lesions cause more prolonged symptoms and more degenerative changes than do medial lesions. They attributed these findings to differing pathogenesis and to differing stresses on the lateral and medial aspects of the ankle.

Roden (10) found that medial lesions produced much milder symptoms than lateral lesions.

Not all series agree with these conclusions. Mukerjee (9) found similar results for medial and lateral lesions. They reported on 6 lateral lesions, 2 of which were treated conservatively. Five of 6 had no symptoms and 1 (treated conservatively) had mild symptoms at an average of 17 months follow-up. Their 3 medial cases were all treated conservatively and all had no symptoms at an average of 17 months follow-up..

There is no report comparing the results of conservative therapy for medial and lateral stage 5 lesions.

Conclusions From the Literature Regarding Stage 5 OLT

The literature is sparse with respect to stage 5 OLT. It appears that they represent the majority of chronic lesions, are typically post traumatic in origin, and are the result of avascular necrosis of lower stage lesions. The natural history of these lesions with respect to clinical result, radiographic healing and the development of OA is unknown. The role of the age of diagnosis and lesion location in the natural history of stage 5 OLT is similarly unknown.

Statement of the Problem

The natural history of stage 5 OLT has not been described. Do these lesions heal radiographically? Do subjects with these lesions improve clinically in terms of symptoms and activity impairment? Is there a correlation between symptomatic resolution and radiographic healing? Do lesion location and the age of diagnosis affect the clinical result? What is the risk of developing osteoarthritis (OA) and what is the role of osteoarthritis in symptom persistence?

This study was designed in an attempt to answer these questions.

Methodology

Sample Selection

Subjects were selected from the files of Dr. Richard Loomer and were considered eligible for the study if at least 2 years previously they had been diagnosed with a symptomatic stage 5 OLT and if they were either managed conservatively for these 2 years or if they had opted for surgical treatment having failed a trial of at least 1 year of conservative therapy (in which case only the conservative period of the subjects management was included in the study).

Eligible subjects were approached by mail and invited to participate in the study. If mail contact failed then telephone follow-up was attempted.

Assessment

The time of follow-up refers to either the date the subject was seen as part of this study or in the case of those who had opted for surgery after failed conservative therapy it was considered to be immediately preoperatively. In these cases of failed conservative therapy assessments were done retrospectively for historical and VAS data. Physical exam data was not available in these cases.

Basic Descriptive Data

Basic Data was collected on age, sex, age at diagnosis, length of follow-up since diagnosis, and lesion location (medial Vs lateral).

History

At the time of follow-up the presence or absence of pain, activity related pain, night pain, swelling, locking or catching and instability was recorded. The presence or absence of a history of ankle trauma and the mechanism of trauma was also recorded. Work and sport limitations at follow-up were recorded as unlimited, some limitation, or unable. Previous symptom persistence at follow-up was recorded as gone, greatly improved, slightly improved, same or worse. Pain frequency at follow-up was recorded as daily, weekly, or monthly.

Physical Exam

Ankle and subtalar range of motion was measured and the presence or absence of swelling and tenderness (including the site of tenderness) was recorded.

Overall Clinical Result

The overall clinical result was rated as excellent, good, fair, or poor based on a combination of symptom persistence, sport limitation and pain frequency (appendix 4 - Modified Loomer Scale)

VAS Assessment of Pain and Activity Levels

Changes in the levels of pain at rest, pain to walk, and pain to run from the time of diagnosis to follow-up were assessed using the following visual analogue scale (VAS) technique. A 100 mm VAS was used with no pain at the '0' extreme and the worst pain felt in the ankle from this injury at the '100' extreme. For each activity level (rest,

walking, and running) the subject was asked where on the VAS the level of pain at the time of follow-up and diagnosis fits.

Changes in activity level were assessed in a similar manner using a 100 mm VAS with the '100' extreme representing full activity and the '0' extreme representing the level of activity when the present injury impaired them the most. Please refer to appendix 1 for a discussion of this retrospective VAS including it's validity and reliability.

The mean VAS scores for each of pain at rest, pain to walk, and pain to run, at each of the 2 times were compared using a repeated measures hotelings T - squared test. A significant multivariate result was to be followed by 1 tailed univariate repeated measure t-test to determine the source of significance. The mean VAS scores for activity level were compared by 1 tailed repeated measure t-test.

Imaging

Subjects had CT scan and supine AP and lateral X-rays of each ankle performed at the time of follow-up. Those who had opted for surgery following a trial of conservative therapy did not have imaging repeated. However, for these subjects attempts were made to obtain any imaging performed immediately preoperatively.

Lesion size was calculated from CT scans using the appropriate scales on the respective scans. Measurements were made of the maximal width and maximal depth (appendix 3). Maximal area was calculated (maximal area = maximal width x maximal depth). A second set of measurements were made - blinded to the first set - one week following

the first set. The mean of these 2 measurements was taken as the final value of width (W), depth (D), and area (A). These calculations were performed on the follow-up CT scans and CT scans at diagnosis (where available). The presence or absence of a significant change in size was determined for each lesion (appendix 3). The mean lesion sizes at diagnosis and follow-up were compared by 2 tailed repeat measure t-test.

Changes in Lesion Size and Clinical Result

Pearson correlation coefficients were calculated between percent change in size of lesions (depth, width, area) and each of : VAS change in pain to run, VAS change in pain to walk, VAS change in pain at rest, and VAS change in activity level.

The presence or absence of a relationship between the direction of significant size changes and the direction of changes in pain to run, pain to walk and overall clinical result were analyzed descriptively.

Degenerative Changes

The presence or absence of degenerative changes in the ankles were determined from the plain X-rays according to the criteria described in appendix 2. The degree of degenerative change was determined according to the Loomer/Shearer OA grading scale (appendix 2).

The relationships between the presence or absence of degenerative changes and changes in pain to run, activity level, and overall clinical result were assessed by comparing cases with and without degenerative changes with respect to the direction of

change in pain to run, the direction of change in activity level and the overall clinical result.

The relationship between the presence or absence of OLT and the presence or absence of degenerative changes was assessed by comparing the presence and absence and grade of OA in ankles with and without OLT.

Lesion Location and Clinical Result

The relationships between lesion location and change in pain to run, lesion location and change in activity level, and lesion location and overall clinical result were assessed by comparing medial and lateral lesions with respect to the direction of change in pain to run, the direction of change in activity level and the overall clinical result.

Age of Diagnosis and Clinical Result

Subjects were classified into adult onset (≥ 20yrs old at diagnosis) and juvenile onset (<20 yr. old at diagnosis).

The relationships between age of diagnosis and change in pain to run, age of diagnosis and change in activity level, and age of diagnosis and overall clinical result were assessed by comparing adult and juvenile onset cases with respect to the direction of change in pain to run, the direction of change in activity level, and the overall clinical result.

Statistical Analysis

Mean VAS scores for pain to run, pain to walk, and pain at rest were compared at follow-up and diagnosis by repeated measure Hotellings T squared. A significant F was followed with univariate 1 tailed repeated measure t-test to determine the source of significance.

Mean VAS scores for activity level were compared at follow-up and diagnosis by 1 tailed repeated measure t- test.

Changes in lesion maximal width, maximal depth, and area were compared by 2 tailed repeated measure t-tests.

The numbers of subjects was not large enough to permit statistical analysis of the effect of degenerative changes, lesion location or age of diagnosis on clinical results.

Statistical significance was considered present at p=.05.

All statistics were run on Systat for windows (version 5.0).

Delimitations

This study is delimited to those subjects with stage 5 OLT who were 2 years post diagnosis and had received at least 1 year of conservative therapy.

The assessment of clinical result is delimited to the assessment of activity related pain, activity level and an overall clinical result based on a combination of symptom persistence, sport limitations, and pain frequency. It is further delimited by the VAS technique and the Modified Loomer Overall Activity Level scale.

The assessment of lesion size is delimited by the use of CT scans and the technique used to measure lesion size from the CT scans.

The assessment of the degenerative changes is delimited by the criteria used to determine the presence or absence of OA and the scale used to grade any degenerative changes that were present.

Limitations

The delimitations described in the previous section lead to the following limitations of the study.

Subject selection

There is a selection bias which must be acknowledged. The subjects referred to our clinic with a diagnosis of stage 5 OLT likely represent a population of subjects who have already failed a period of conservative management. Of these, some will be treated surgically and some with further conservative management. The decision between surgical and conservative management depends solely on the severity of symptoms. Therefore, those subjects eligible for this study represent those whose symptoms were severe enough to be referred to our clinic but whose symptoms were not severe enough to be managed surgically.

Clinical Result

The study is limited to the assessment of activity related pain and activity level via the retrospective VAS, and the overall clinical result via the modified Loomer scale. Activity related pain is the only universal complaint in patients with stage 5 OLT(2). The multidimensional overall clinical score was included in an attempt to broaden the scope of the assessment of the clinical result.

Both the VAS and the Modified Loomer scale contain retrospective components. In each case the subject is asked to compare present symptoms and/or activity level to

those at the time of diagnosis. The memory of chronic pain using VAS is discussed further in appendix 1. The retrospective VAS has been shown to be reliable for both pain and activity level (see appendix 1).

Imaging

The assessment of lesion size is limited to the CT scan determination of lesion size. The validity and reliability of this assessment is discussed in appendix 3.

The assessment of the presence and grade of degenerative changes is limited by our definition of degenerative changes and the scale used to grade the degenerative changes. A full discussion of the criteria used to determine the presence or absence of degenerative changes and the scale devised to grade any degenerative changes present may be found in appendix 3.

Results

Sample Population

Forty-seven subjects fulfilled the eligibility criteria. Contact was made with 25 subjects (26 ankles) and all agreed to participate. Of the 22 "lost" subjects 12 had already been followed-up previously by Richard Loomer and although data is not available on these 12 subjects for all aspects of the study, enough data is available to combine the 2 groups in determining the overall clinical result (see below).

Descriptive Data

A total of 25 subjects (15 male, 10 female) of average age 38 years (range 21-69) with 26 ankles affected by OLT (16 medial, 8 lateral and 2 with medial and lateral lesions) were followed-up at an average of 39 months (range 17-85 months) post diagnosis. The average duration of symptoms before diagnosis was 44 months. Five subjects (6 ankles) had opted for surgical therapy after at least 1 year (average 25.5 months, range 13 to 33 months) of conservative therapy.

Conservative therapy had consisted of physiotherapy (15/25), chiropractor (1/25), massage therapy (2/25), bracing (11/25), and weight bearing aids (7/25 - all only immediately after injury and pre-diagnosis).

Twenty-one of 26 ankles had a history of trauma preceding the onset of symptoms - although the significance of the trauma was not always obvious. Mechanisms of

trauma included inversion (13/21), eversion (1/21), plantar flexion (1/21), forward shearing (1/21), and unclear mechanisms (5/21).

There were 7 juvenile OLT (6 subjects) of average 16 years age at diagnosis (range 12 - 18 years), of these 4/7 had no history of trauma. Only 1/19 adults had no history of trauma.

All 7 lateral lesions had a history of trauma. Fourteen of 19 medial lesion had a history of trauma.

At follow-up 17/26 reported pain, 16/26 reported activity related pain, and 10/26 reported night pain. Eleven of 26 reported swelling, 10/26 complained of instability, and 5/26 reported locking or catching. Fourteen of 26 were happy with the results of conservative therapy, 11 were unhappy and one was unsure.

Sport participation was unlimited in 10/25, some limitation in 13/25, and unable in 2/25. Work participation was unlimited in 20/25, some limitation in 5/25 and unable in none. Previous symptoms were gone in 8/26, greatly improved in 3/26, slightly improved in 4/26, and the same or worse in 11/26.

Five ankles were tender on examination (4 medial and 1 lateral). In 2/5 ankles with tenderness the side of tenderness did not correspond to the side of the lesion. Examination also revealed swelling in 5/20, decreased ankle ROM in 8/20, and decreased subtalar ROM in 3/20.

Overall Clinical Result

The overall clinical result was good or excellent in 13/26 , fair in 4/26, and poor in 9/26. When combined with the data collected previously on the 12 "lost" subjects the overall clinical results were good or excellent in 20/38, fair in 7/38, and poor in 11/38 (figures 2 & 3).

Figure 2

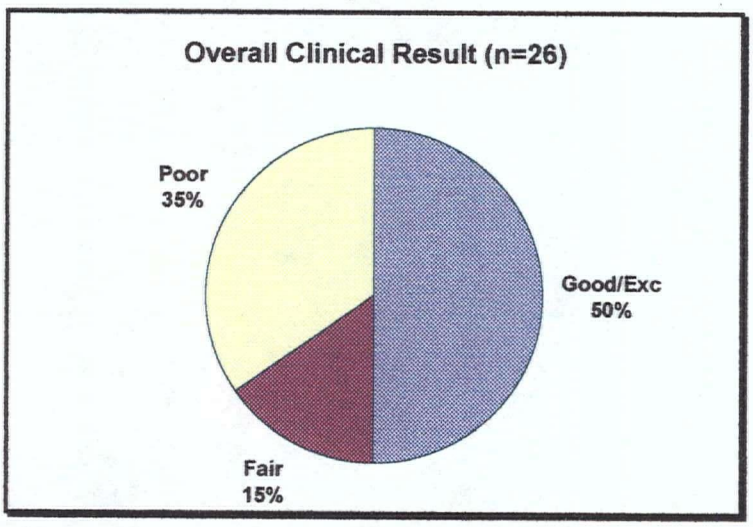
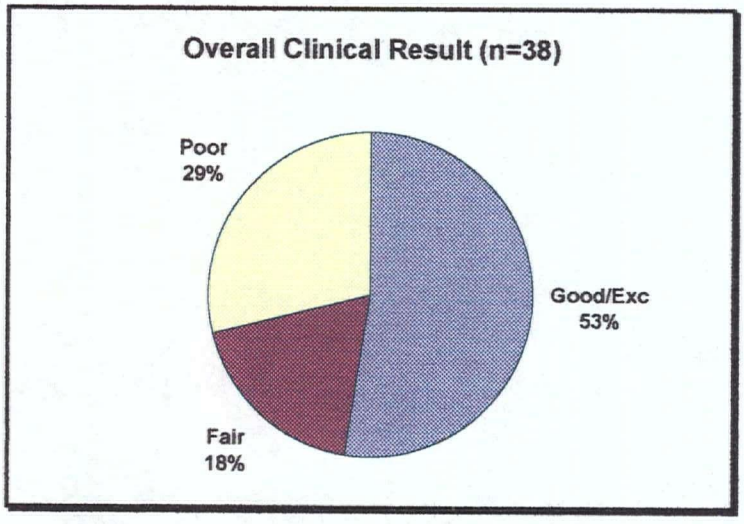


Figure 3



VAS Assessment of Pain and Activity Levels

Pain to run at follow-up was 0 mm in 7/25 and < 5 mm in a further 3/25. Pain to walk at follow-up was 0 mm in 6/26 and< 5 mm in a further 6/26. Pain at rest at follow-up was 0 mm in 10/26 and < 5 mm in a further 4/26.

The multivariate repeated measure Hotellings T squared test on pain to run, pain to walk, and pain at rest was significant at p=.06. One tailed repeated measure univariate t-tests show this significance to be due to pain to run (decreased on average by 29mm, p=.005) and pain to walk (decreased on average by 23.5mm, p=.009). Pain at rest revealed a nonsignificant decrease of 9.5mm (p=.105).

Activity level increased an average of 9.6mm (p=.168, non significant).

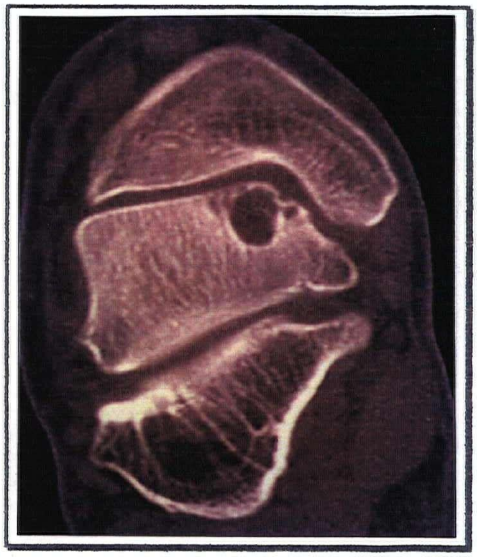
Imaging

Nineteen subjects had follow-up CT scans and 20 had follow-up X-rays performed. One subject was trying to become pregnant and had no radiological investigations. One subject opted to have only plain X-ray and no CT. One subject (2 ankles), who opted for surgery after failed conservative therapy had a CT scan performed immediately pre-operatively which would have been included as follow-up CT scanning if the scan had not been lost.

Radiographic Appearance

The majority of stage 5 OLT are irregularly shaped, well defined, cystic appearing radiolucencies with or without sclerotic borders and occasionally with bone fragments inside or near the lesion (figure 4).

Figure 4



Coronal view of a typical stage 5 OLT.

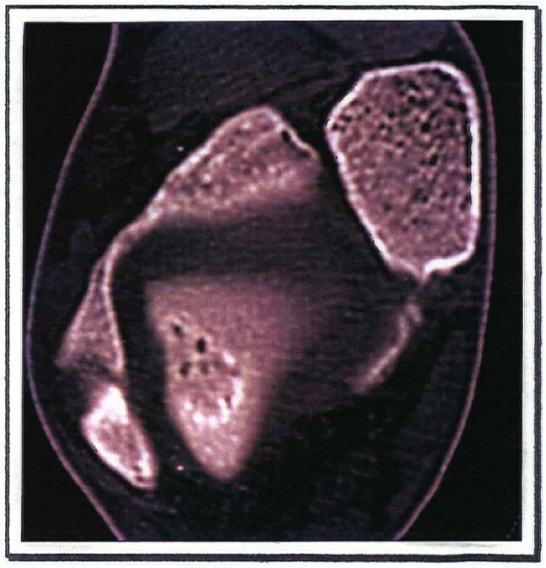
There was a subset of OLT that had a multifocal cystic appearance on CT scan (figure 5). Of the 26 ankles, 6 ankles (5 subjects) had this unusual appearance on CT scan. All but one of these was bilateral and all but one was medial. Only one bilateral case had a history of symptoms in both ankles[1]. Of the seven juvenile ankles three were of this appearance, 2 of these 3 had no history of trauma. Of the 19 adult ankles 3 were also of

[1] hence the other 5 bilateral cases only counted as 1 OLT each in this study.

this appearance and all had a history of trauma. All 3 juveniles with this multifocal appearance were doing poorly and all 3 adults with the multifocal appearance had excellent results.

In addition to the OLT, other pathology was found in 7/19 subjects with CT scans. Two subjects had subtalar OA. Two had medial malleolar subchondral cysts. One subject had a distal tibial subchondral cyst. One subject had a subtalar subchondral cyst. One subject had a distal tibial subchondral cyst, a navicular subchondral cyst and a subtalar subchondral cyst.

Figure 5



Axial view of a typical multifocal cystic stage 5 OTL.

Change in Lesion Size

Eleven of 19 subjects with follow-up CT scans also had initial CT scans at diagnosis that were available to the study. Two subjects' initial CT scans performed at diagnosis had been lost and were not available to the study. In 5 subjects the initial imaging was tomogram and in one subject it was plain X-ray neither of which permits an accurate enough determination of size to permit comparison to CT scans at follow-up. The eleven subjects with initial and follow-up CT scans available to the study were used to determine the following mean changes in lesion size.

Average depth increased by 2.0mm from 7.2mm to 9.2 mm (p=.18,). Average width increased by 1.0mm from 8.0mm to 9.0 mm (p=.06,). Average area increased by 35mm sq. from 58 to 93 mm sq. (p=.07).

Changes in width and depth were congruent. No subject with an increase in depth had a decrease in width and no subject with an increase in width had a decrease in depth.

Change in Lesion Size and Clinical Result

Six subjects had either an increase in width or an increase in depth or both. Of these 6 subjects, 5 had a decrease in pain to run and pain to walk. The remaining patient had an increase in pain to run and pain to walk. Four of these 6 had good or excellent results, one had a fair result, and one had a poor result.

Two patients had either a decrease in width or a decrease in depth. Both reported a decrease in pain to run and pain to walk and both had good or excellent results.

All measures of change of size (percent change in width, depth, and area) correlated negatively with change in pain to run, change in pain to walk, and change in pain at rest. All measures of change of size correlated positively with change in activity. No correlation was statistically significant[2] (table 2).

Table 2

Pearson Correlation Coefficients for % Change in Size and VAS Change in Pain or VAS Change in Activity Level

	Percent Change in Area	Percent Change in Depth	Percent Change in Width
Change in Pain to Run	-.451	-.436	-.374
Change in Pain Walk	-.454	-.454	-.349
Change in Pain at Rest	-.464	-.474	-.280
Change in Activity Level	.379	.364	.318

There were no subjects with complete resolution of lesions on CT scan imaging despite the fact that 8 subjects reported that their previous symptoms were gone and most of these 8 subjects retained full activity level (6/8 100% activity, 1/8 98% activity, 1/8 74% activity). One subject with tomogram diagnosis had almost complete resolution of his lesion on follow-up CT scan. He had an excellent result clinically, his previous symptoms were gone and he was at full activity.

[2] r= .602 is required for 2 tailed statistical significance for n = 11 subjects (47)

Degenerative Changes and Clinical Result

Thirteen of 20 patients had degenerative changes in the ankle with the OLT. Most of these had a minor degree of degenerative change - only 3 subjects scored greater than 1 on the Loomer/Shearer OA grading scale.

There is no relationship between the direction of change in pain to run, the direction of change in activity level, or the overall clinical result and the presence or absence of degenerative changes (figures 6, 7 & 8).

Of those with asymmetric OA (different grades of OA in their 2 ankles) 100% (10/10) had the higher OA score on the side of the osteochondral lesion. No subject had a higher OA score on the ankle without the lesion - although 3 subjects did have OA on the non-lesion ankle.

Of the 3 subjects with significant OA (grade>1), 1 had no pain and an excellent result, 1 had a fair result and 1 had a poor result.

Figure 6

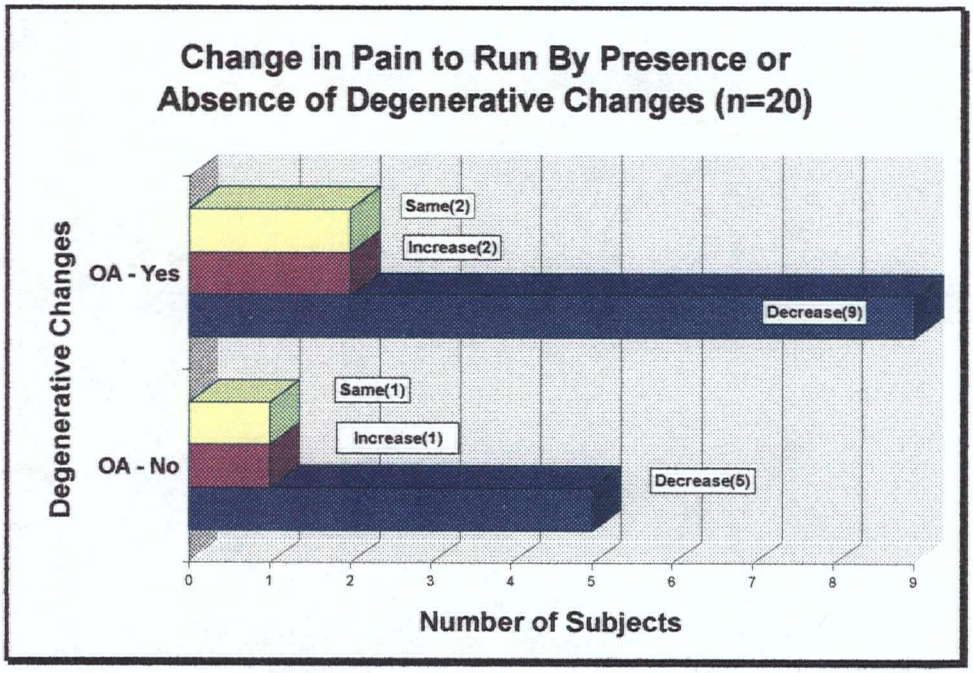


Figure 7

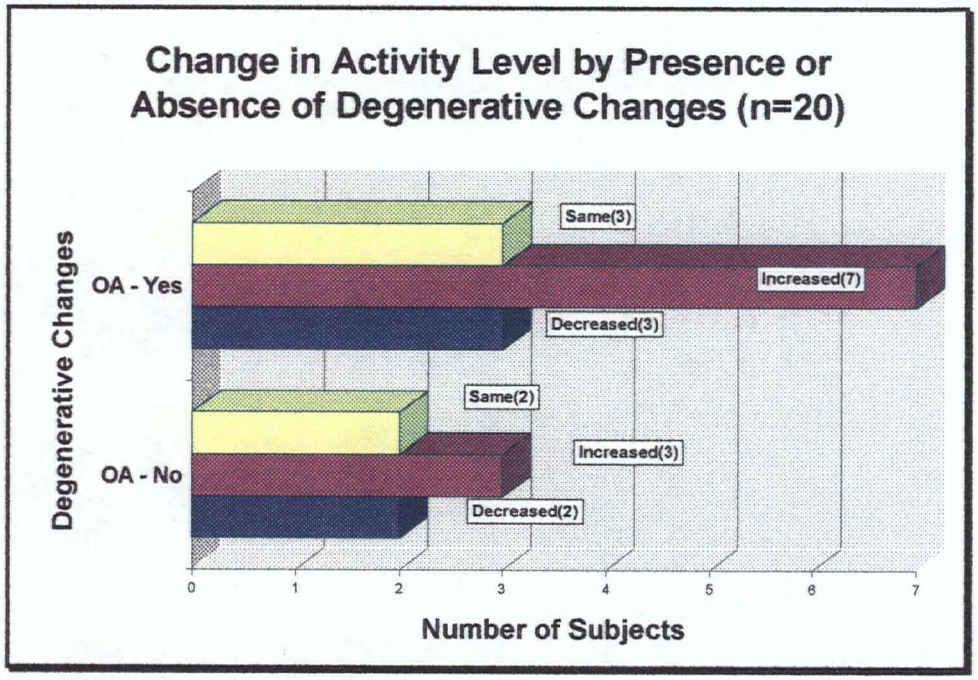
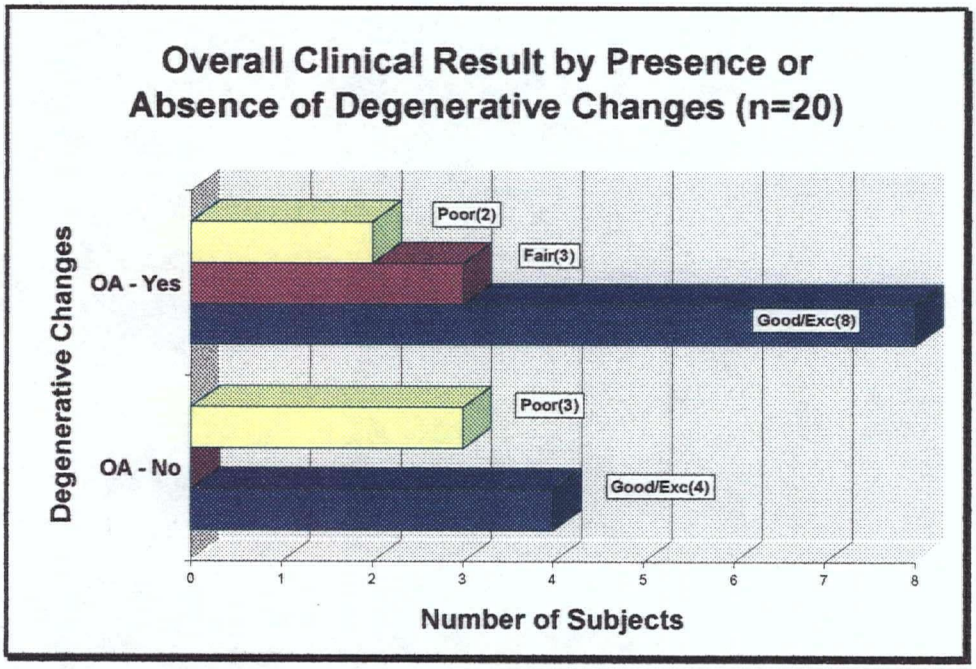


Figure 8


Overall Clinical Result by Presence or Absence of Degenerative Changes (n=20)
Degenerative Changes
OA - Yes
OA - No
Poor(2)
Fair(3)
Good/Exc(8)
Poor(3)
Good/Exc(4)
0
1
2
3
4
5
6
7
8
Number of Subjects

Lesion Location and Clinical Result

There appears to be a relationship between lesion location and clinical result. The trend is for lateral lesions to do better than medial lesions (figures 9, 10, 11 & 12).

Figure 9

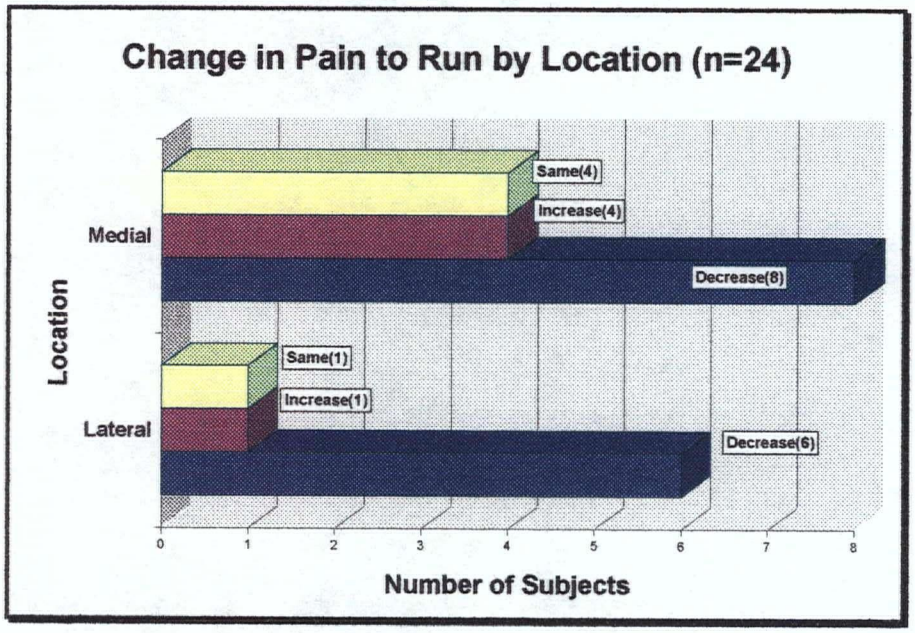


Figure 10

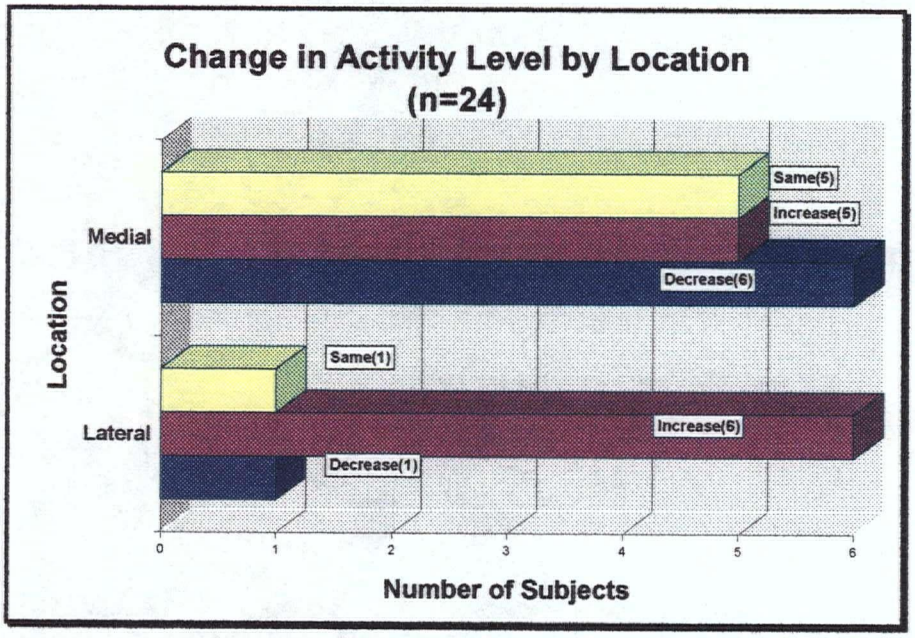


Figure 11

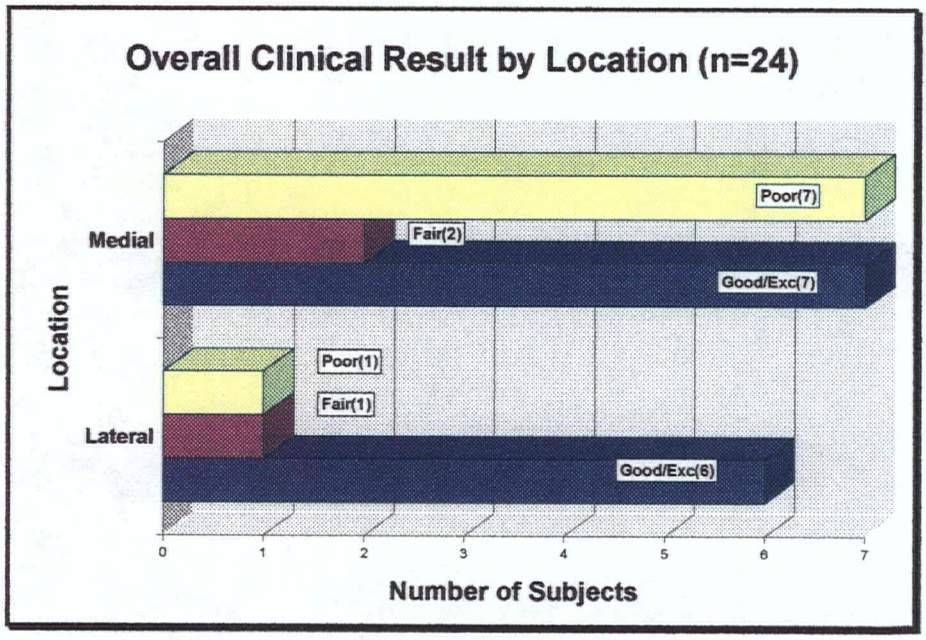
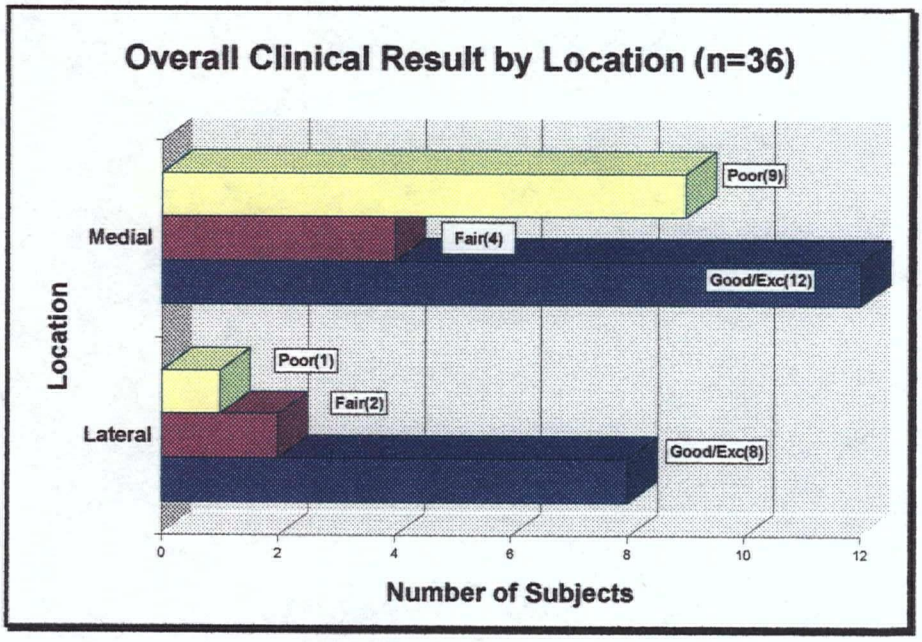


Figure 12



Age of Diagnosis and Clinical Result

There appears to be a relationship between age of diagnosis and clinical result. The trend is for juveniles to do worse than adults (figures 13, 14, 15 & 16).

Figure 13

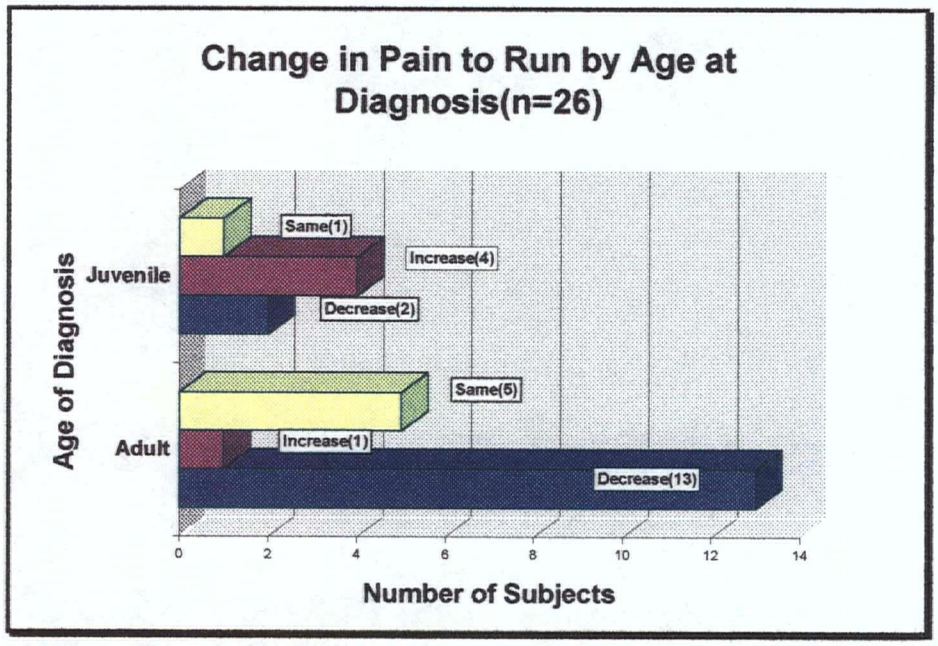


Figure 14

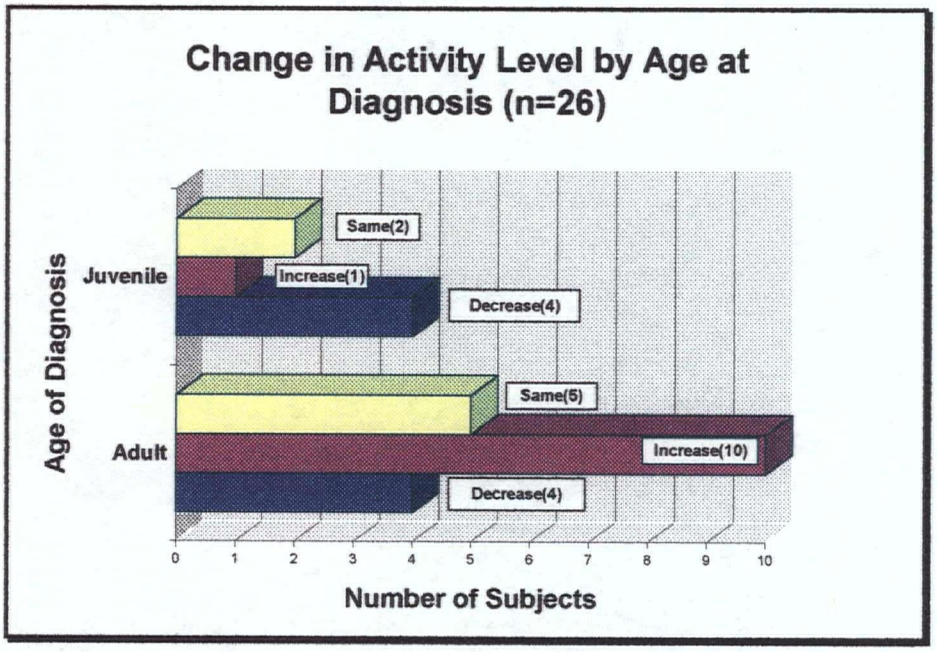


Figure 15

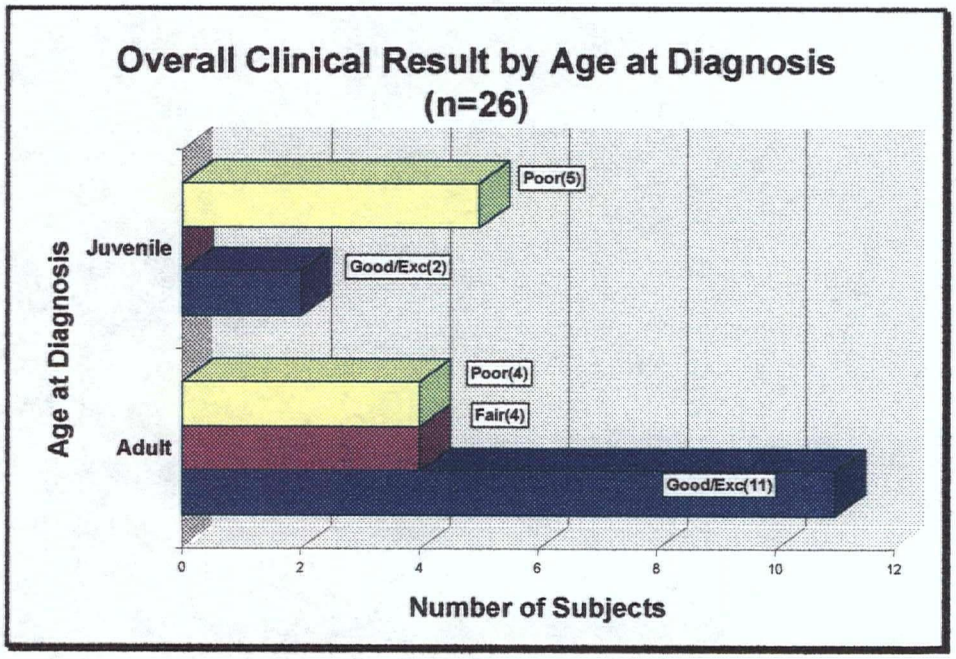
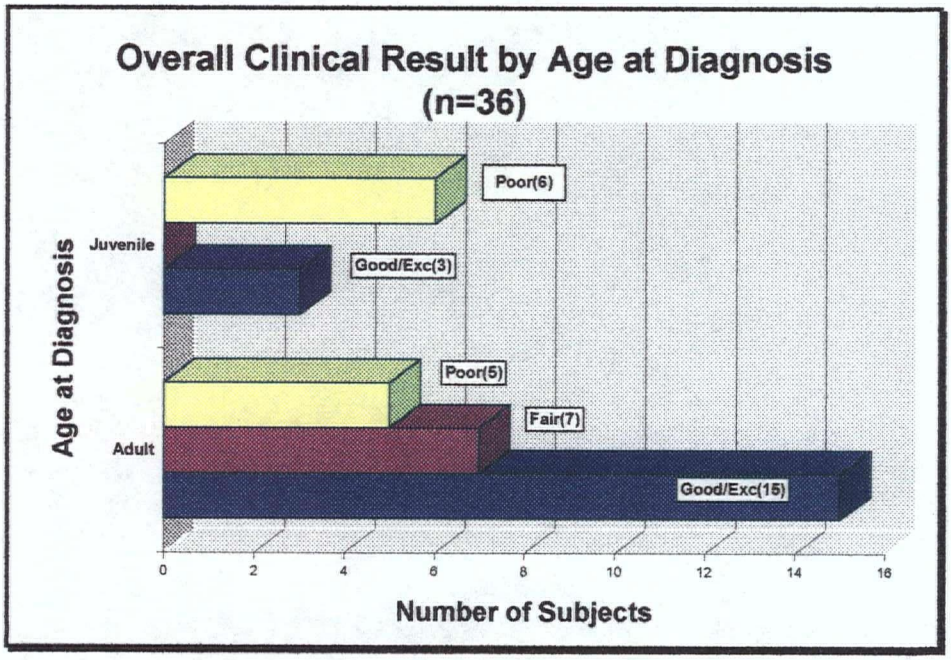


Figure 16



Discussion

Sample Population

As this study progressed it became clear that there was a selection bias involved in recruiting subjects. Those who were the first to respond tended to be doing poorly. Those who were asymptomatic were more difficult to contact. For this reason vigorous attempts were made to contact as many eligible subjects as possible. Following the initial letter of invitation to participate in the study attempts were made to contact the subject by telephone making use of home numbers, works numbers, friends, family and family physicians. One hundred percent of those contacted agreed to participate. This yielded a retrieval rate of 53% of eligible subjects (25/47). Of those subjects we were unable to contact 12 had been seen in follow-up previously and the data previously collected allowed them to be included in the section on overall clinical result. This yielded a retrieval rate of 79% (37/47). A comparison of the overall clinical results for n=26 and n=38 (Figures 2 & 3), and the overall clinical results by age at diagnosis for n=26 and n=36 (Figures 15 & 16), and the overall clinical results by location for n= 24 and n=36 (Figures 11 & 12), suggests that the 2 groups are not appreciably different. It is argued that this similarity validates the generalization of all results from the lower retrieval group.

We believe that had those patients who were "lost" to the study been available, the results may have been even more favorable to conservative management. Although

some subjects may have left the community, many are likely still in the community. Given that there is a tendency for subjects who are not doing well to initiate their own follow-up and that most of the local orthopedic and sports medicine community recognize Richard Loomer as the local "expert" in chronic OLT, we feel that it is likely that the "lost" group would be biased towards those who are generally doing well.

The inclusion of those subjects who had opted for surgical therapy after a trial of conservative therapy was necessary in order to avoid a bias toward good results. Therefore, while inclusion criteria for the study included 2 or more years of conservative therapy it was necessary to include those who had failed conservative therapy and opted for surgery at > 1 year. It was felt that subjects who had not waited 1 full year to have surgery did not have an adequate trial of conservative therapy.

For this study the start of conservative therapy was defined as the time of diagnosis. This was the only practical starting point as many subjects did not recall exactly when their symptoms started. It is also unclear - and in fact unlikely - that when they first developed symptoms they had a stage 5 lesion.

Descriptive Data

We found a history of trauma with all lateral (7/7) lesions and most (14/19) medial lesions. This is consistent with the general OLT literature (6,11). The general futility of the physical exam in making the diagnosis of OLT demonstrated in this study is also consistent with the general OLT literature (1,5,18,).

No subjects were unable to work as a result of their OLT and most (20/25) had no work limitations at all. It is in the area of sports participation that stage 5 OLT are limiting.

Clinical Results

It is clear from this study that conservative management is a viable option for stage 5 OLT. At an average of 39 months follow-up there was a significant decrease in pain to run and pain to walk and 50 to 53% had good or excellent results. There was a trend towards decreasing pain at rest and towards increased activity level although neither reached statistical significance. Forty % had no or almost no pain to run (< 5mm on VAS), 46% had no or almost no pain to walk.

The multivariate repeat measure Hotellings T squared on pain to run, pain to walk, and pain at rest was considered significant at p=.06. Hotellings T squared was utilized in an attempt to control for the possible inflation of experimentwise type 1 error resulting from the analysis of multiple variables. Although this study was designed in a one tailed format (expecting to find decreased pain and increased activity level), the Hotellings T squared test is, by definition, a two tailed test. Hotellings T squared will be significant when there is a high correlation between the variables being measured (23). The correlation between change in pain to run and change in pain to walk is high (r=.923). However, pain at rest has a lower correlation with pain to run (r=.678) and pain to walk (r=.702). The univariate one tailed repeat measure t-tests reveal that change in pain to run (p=.005) and change in pain to walk (p=.009) are highly significant and change in pain at rest is highly non significant (p=.105). It seems clear that the

change in pain at rest, due to its poor correlation with the other 2 variables has elevated the p value of the Hotellings T squared above the "accepted standard" for significance (p=.05). In view of the "closeness to significance" (p=.06) of the Hotellings T squared, the 2 tailed nature of the Hotellings T squared, the poor correlation between pain at rest and pain to run/pain to walk, and the highly significant univariate t - tests for pain to run and pain to walk, it is argued that the results should be considered significant for change in pain to run and change in pain to walk.

If we interpret a one mm change on the VAS's utilized in this study as representing a 1% change in the measured variable (based on the percentage of the worst pain ever from the injury or full activity), then pain to run can be said to have decreased on average by 29% (p=.005) and pain to walk to have decreased on average by 23.5% (p=.009). Pain at rest decreased on average by 9.5% (NS), and activity level increased on average by 9.6% (NS).

It is interesting that pain with activity did decrease and yet no significant increase was found in activity level. Pain with activity is obviously not independent of activity level. It may be that the amount of a given activity performed was titrated to pain levels. In other words subjects may have run less and therefore had less pain when they did run. Subjects also have different tolerances to pain. Some subjects were able to maintain high activity levels despite their pain. These particular subjects did not show a great increase in activity level when their symptoms subsided.

The purpose of this study was not to compare conservative management to surgical management. However, it is interesting to compare the 53% good or excellent, 18% fair, and 29% poor results for conservative management (n=38) from this study to RL's follow-up of surgically managed stage 5 OLT with 69% good or excellent, 31% fair and no poor results (n=39) (Loomer unpublished). The patients referred to us may represent a skewed population in that some of them may have already failed some form of conservative therapy. Of these patients some are treated surgically and some with further conservative therapy. The decision between conservative and surgical therapy at this stage has depended on the severity of the symptoms and the patients desire to proceed with surgery. The subjects in this study represent those patients with symptoms severe enough to be referred to our clinic and yet not severe enough to be treated surgically. It is likely that the conservative group represents less severe cases of OLT than the surgical group. In view of this selection bias it appears that surgical treatment gives slightly superior results.

It is interesting to note that of the five subjects (six ankles) who failed conservative therapy and opted for surgical management all had good or excellent results at an average of 25 months postoperative follow-up. It appears that a trial of conservative therapy does not decrease the chance of success of subsequent surgical management.

Change in Lesion Size

There was a trend towards increasing lesion size which in the cases of width and area were close to reaching statistical significance. We were unable to demonstrate a

significant correlation between changing lesion size and clinical result. In fact, if anything, there was a trend towards an inverse relationship between the change in lesion size and clinical result. Although both subjects with decreases in lesion size had improvements in their symptoms, most (5/6) subjects with increases in lesion size also had improvement in their symptoms. This likely reflects the fact that most subjects improved whether or not their lesions diminished or increased in size, rather than a true inverse relationship. It must be pointed out that for the majority (7/9) of patients with poor results change in size calculation was not possible due to incomplete availability of CT data. It is conceivable that availability of these subjects CT scans may have changed the results in this area. It is also possible that there are unrecognized factors - i.e. other than size of the lesion that account for the symptoms of the OLT. Seven of 19 CT scans were found to have other pathology in addition to OLT. It is possible that in some cases the subjects symptoms were due to the "other" pathology. It is also recognized that the CT scans - taken in slices of 2-3 mm - could potentially miss true maximal lesion dimensions. This error is not calculable but is likely to be small as lesion borders were not found to undulate appreciably.

Degenerative Changes and Clinical Result

Minor degenerative changes (Loomer/Shearer OA grading scale .5 or 1) were common in ankles with stage 5 OLT. However, there was no relationship demonstrated between the direction of change in pain to run, the direction of change in activity level, or the overall clinical result and the presence or absence of degenerative changes. This

is not surprising as it is well recognized that there is an imperfect correlation between radiographic signs of OA and clinical symptoms (24). This study did utilize a liberal definition of radiographic OA and hence many very mild cases were assigned to the OA group that in other classification schemes may have been considered to be in the non-OA group. This potential criticism is accepted as we were interested in knowing whether the presence of even minimal degenerative change was related to the result. It is interesting to note that the lack of a relationship between the presence or absence of degenerative changes and the clinical result holds true even for the 3 cases with significant OA ($\geq$ 1.5 on Loomer/Shearer OA scale).

Only longer follow-up studies will reveal whether or not these minor degenerative changes will lead to more significant changes and whether or not they become clinically significant.

It does seem clear that there is a relationship between stage 5 OLT and the development of degenerative changes. One hundred percent of the subjects with evidence of asymmetric degenerative changes between their two ankles had the higher grade of OA on the side of the OLT. This argues strongly for a relationship between stage 5 OLT and the development of OA.

Lesion Location and Clinical Result

Although the numbers are not large enough to allow statistical analysis there is a trend for lateral lesions to do better than medial lesions (Figure 9, 10, 11 &12). This appears to

contradict the findings of Canale (6) and Roden (10) although it is important to keep in mind that these authors were not studying stage 5 lesions.

It is interesting to note that lateral lesions are generally easier to access surgically than medial lesions (Loomer (2)), this may lead to a bias towards operative management in lateral lesions. Loomer's data (unpublished) reveals that he has operated on 61% (17/28) of lateral lesions and only 47% (22/47) of medial lesions. One could hypothesize that this would lead to a bias towards good results in surgical subjects. However, lateral and medial lesions treated surgically had 68% and 70% good or excellent results respectively (Loomer unpublished). It appears that the slightly superior results achieved surgically as compared to conservatively are not an artifact of a selection bias based on lesion location.

Age of Diagnosis and Clinical Result

There appears to be an impression in the sports medicine community that juvenile cases of OLT do better than adult cases. This assumption is not well supported by the literature (1,6,8,9,10,11,15,25). For stage 5 OLT it appears that juvenile cases do worse than adult cases. The numbers do not allow statistical analysis, however, the trend is quite clear.

It could be argued that the age of 20 is too high to be used to divide adult from juvenile cases. It is admitted that this is an arbitrary definition, however, when one considers

that the average time from symptom onset to diagnosis was 44 months this boundary does not seem unreasonable.

The difference in clinical result based on age of diagnosis is not simply due to a longer follow-up period for juveniles and a resultant deterioration overtime. The average follow-up time was 42 months for the juvenile group and 38 months for the adult group.

It is conceivable that the poorer clinical results for juveniles is a result of higher absolute activity levels in juveniles than adults. However, this study did not measure absolute activity level.

Interestingly, it was much more common to have no history of trauma in juveniles than it was in adults. This may merely represent the fact that the adults have lived longer and had more time to accumulate episodes of trauma. However, the majority of adults were able to date their ankle problems to a specific incident of trauma. It is possible that an etiology other than trauma was responsible for the juvenile OLT. However, it was not necessarily those juveniles lacking a history of trauma that did poorly.

The multifocal cystic lesions are interesting. Not only do they have different appearances but they tend to be bilateral (4/5 subjects), medial (4/5 subjects), and often (3/5 subjects) only one side is symptomatic. Juveniles appear to have these lesions more commonly(3/7) than do adults (3/19). Juveniles with these lesions tend to do poorly (3/3). Adults with these lesions tend to do excellently (3/3). Two of the 3

juvenile cases had no history of trauma. All 3 adult cases did have a history of trauma. Although the numbers are far too small to draw any conclusions it is interesting to speculate on etiologies other than trauma in these cases.

Conclusions

Stage 5 OLT do improve significantly with respect to pain to run and pain to walk.

Fifty % have good or excellent results, 15% have fair results, and 35% have poor results.

There was no significant change found in pain at rest and activity level.

There was no significant change in lesion size and there was no correlation between change in lesion size and clinical result.

Degenerative changes (generally mild) were seen in 13/20 ankles with stage 5 OLT. There appears to be a relationship between the presence of stage 5 OLT and the development of degenerative changes. However, there was no relationship found between the presence or absence of degenerative changes and clinical result.

Medial lesions tend to do worse clinically than lateral lesions.

Juveniles (<20 yr. at diagnosis) tend to do worse clinically than adults.

Management Recommendations

Although this study was not designed to compare the various treatments for stage 5 OLT the following comments about the management of theses lesions seem pertinent. Clearly conservative management of these lesions is a viable option. A combination of physiotherapy, activity modification, braces, and weight bearing aids can be expected to yield good or excellant results in 50% of patients at an average of 39 months. This study does not allow the recommendation of one form of conservative therapy over another.

Although not formally assessed in this study it is suggested in the discussion that surgical management may be slightly superior to conservative management. Therefore, in some cases (e.g. the elite athlete or extremely disabled patients) the slightly greater rate of success with surgical management(70% good or excellant) may outweigh the risks of surgical procedure and early surgical intervention may be reasonable.

It is also tempting to recommend a more aggressive approach for medial and juvenile lesions as they seem to do worse with conservative management than do adults and lateral lesions. However, no firm recommendations can be made here as the subject numbers were small and statistical significance could not be assigned to the trends that were found. Nonetheless, it does seem reasonable to recommend an individualized approach based on a combination of lesion location, the age of the patient at diagnosis, and most importantly the degree of disability and the level of the patients demands.

References

1. Berndt AL, Harty M: Transchondral Fractures (Osteochondritis dissecans) of the talus: The Journal of Bone and Joint Surgery, Vol. 41A, #6 September 1959, 988-989
2. Loomer R, Fisher C, Lloyd-Smith R, Sisler J, Cooney T: Osteochondral lesions of the talus:The American Journal of Sports Medicine Vol. 21 #1,1993, 13-19.
3. Anderson IF, Grattan-Smith T, Brazier D: Osteochondral Fractures of the Dome of the Talus: J Bone Joint Surg: Vol. 71A,#8 Sept 1989, 1143-1152.
4. Ly PN, Fallat LM: Transchondral Fractures of the Talus: A Review of Surgical Cases: The Journal of Foot and Ankle Surgery. Vol. 32, #4,1993. pages 352-374.
5. Shea MP, Manoli A: Recognizing Talar Dome Lesions: The Physician and Sportsmedicine Vol. 21, #3 March 93, 109-121.
6. Canale ST, Belding RH: Osteochondral lesions of the talus. J Bone Joint Surg (AM) 1980;62(1):97-102.
7. McCullough CJ, Venugopal V: Osteochondritis dissecans of the talus: the natural history. Clin orthop 1979;Oct(144):264-68.
8. Bauer M, Jonsson K, Linden B: Osteochondritis Dissecans of the Ankle: J Bone Joint Surg Vol. 69B, #1, Jan 1987, 93-96.
9. Mukherjee SK, Young AB: Dome Fracture of the Talus a report of Ten Cases: J Bone Joint Surg Vol. 55B, #2 May 1973, 319-326.
10. Roden S, Tillegard P, Unander-Scharin L: Osteochondritis Dissecans and Similar Lesions of the Talus. Report of Fifty-five cases with special reference to treatment: Acta Orthop. Scand., 23:51-66, 1953.
11. Flick AB, Gould N: Osteochondritis dissecans of the talus (transchondral fractures of the talus): review of the literature and a new surgical approach for the medial dome lesions. Foot Ankle 1985;5(4):165-185
12. Desmet A: Value of MR Imaging in staging osteochondral lesions of the talus (osteochondritis dissecans): results in 14 patients. AJR 154: 555-558, March 1990.
13. Yuan H: Osteochondritis Dissecans of the Talus Associated with subchondral cysts. JBJS Vol 61-A, No. 8, Dec 1979, PP 1249-51.
14. Pettine KA, Morrey BF: Osteochondral Fractures of the Talus: a long-term follow-up. J Bone Joint Surg(BR) 1987;69(1):89-92.
15. Davidson AM, Steele HD, MacKenzie DA, Penny JA: A review of twenty-one cases of transchondral fracture of the talus: The Journal of Trauma: Vol. 7,#3, 1967,378-415.

16. Naumetz VA, Schwiegel JF: Osteocartilagenous Lesions of the Talar Dome: The Journal of Trauma Vol. 20, #11, 1980, 924-927.

17. Bosien WR, Russel SW: Residual Disability Following Acute Ankle Sprains: J Bone Joint Surg:Vol. 37A, #6, Dec 1955, 1237-1243.

18. Chen DS, Wertheimer SJ: Centrally Located Osteochondral Fracture of the Talus: The Journal of Foot Surgery Volume 31, #2 1992, 134-140.

19. Urman M, Ammann W, Sisler J, Lentle BC, Lloyd-Smith R, Loomer R, Fisher C: The Role of Bone Scintigraphy in the Evaluation of Talar Dome Fractures: Journal of Nuclear Medicine, Vol. 32, #12, Dec 1991, 2241-2244.

20. Scharling M: Osteochondritis Dissecans of the Talus: Acta Orthop Scand 49,89-94,1978.

21. Bauer M, Jonsson K, Nilsson B: Thirty-year follow-up of ankle fractures. Acta Orthop Scand 56, 103-106, 1985.

22. Bruns J: Osteochondritis Dissecans of the Talus. Arch Orthop Traum Surg, 1992, 112: 23-27.

23. Stevens J: Applied Multivariate Statistics for the Social Sciences. Lawrence Erlbaum Associates , Publishers, 1986, Hillsdale New Jersey, PP 113.

24. Gresham G, Rathey U: Osteoarthritis in Knees of Aged Persons. Relationship Between Roentgenographic and Clinical Manifestations. JAMA, July 14, 1975, Vol. 233, No. 2, pages 168-170.

25. Yvars M: Osteochondral Fractures of the Dome of the Talus. Clinical Orthopedics and Related Research, No. 114, Jan-Feb 1976, PP 185-91

26. Huskisson EC: Measurement of Pain. The Lancet. Nov 9, 1974. 1127-1131.

27. Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Anderson JA: Studies with pain rating scales. Annals of the Rheumatic Diseases. 1978, 37,378-81.

28. Langley GB, Sheppeard H: The visual analogue scale: Its use in pain measurement. Rheumatol Ine (1985) 5: 145-148.

29. Price DD, McGrath PA, Rafii A, Buckingham B: The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain, 17(1983), 45-56.

30. Scott J, Huskisson EC: Accuracy of subjective measurements made with or without previous scores: an important source of error in serial measurement of subjective states. Annals of the Rheumatic Diseases, 1979, 38,558-559.

31. Scott J, Huskison EC: Vertical or horizontal visual analogue scales: Annals of the Rheumatic Diseases. 1979, 38, 560.

32. Dixon JS, Bird HA: Reproducibility along a 10 cm vertical visual analogue scale. Annals of the Rheumatic Diseases. 1981, 40, 87-89.

33. Quiding H, Haggquist SO: Visual analogue scale and the analysis of analgesic action. Eur J Clin Pharmacol (1983) 24, 475-478.

34. Linton S, Melin L: The Accuracy of Remembering Chronic Pain. Pain , 13 (1982), 281-285.

35. Linton S: Memory For Chronic Pain Intensity: Correlates of Accuracy. Perceptual and Motor Skills. (1991),72, pages 1092-1095.

36. Bryant R: Memory for pain and affect in chronic pain patients. Pain, 54 (1993), 347-351.

37. Miller M, Ferris D: Measurement of Subjective Phenomena in Primary Care Research: The Visual Analogue Scale. Family Practice Research Journal, Vol.13, No. 1, 1993, pages 15-24.

38. _____, Pathologic Basis of Disease. Robbins, Cottran, Kumar. WB Saunders Company, 1984, Toronto, page 1349-1351.

39. Kellegren J, Lawrence J: Radiological Assessment of Osteo-Arthrosis. Ann. Rheum. Dis. (1957), 16, pages 494-502.

40. Magnusson R: On the late results in non-operated cases of malleolar fractures. Fractures by external rotation. Acta Chir. Scand Suppl. 84. 1944.

41. Wyss C, Zollinger H: The Causes of Subsequent Arthrodesis of the Ankle Joint. Acta Orthopedica Belgica. Vol. 57 - Suppl. 1 (1991), pages 22-27.

42. Jonsson K. Fredin H, Cederlund C, Bauer M: Width of the Normal Ankle Joint. Acta Radiologica Diagnosis 25 (1984), pages 147-149.

43. Bauer M, Bergstrom B, Hemborg A: Arthrosis of the Ankle Evaluated on Films in Weight-Bearing Position. Acta Radiologica Diagnosis 20 (1979), pages 88-92.

44. Brenner DE: Volume Determinations in Computed Tomography. JAMA March 5, 1982, Vol 247, No. 9, pp 1299-1302.

45. Breiman RS: Volume Determinations using Computed Tomography. AJR: 138, Feb 1982. pp 329-333.

46. Staron RB: Computed Tomographic Volumetric Calculation Reproducibility. Investigative Radiology, Vol 21, March 1986, pp 272-274.

47. Fisher and Yates: Statistics for Biological, Agricultural, and Medical Research. Longman Group, London UK.

48. Meyers J, Well A: Research Design and Statistical Analysis. Harper Collins Publishers, New York, 1991, pages 63-64.

Appendix 1 - Visual Analogue Scales and the Measurement of Change in Subjective Variables

Introduction

The literature discussing OLT contains numerous different methods to record the outcome of treatment.

Rhoden et al (10) simply recorded whether the patients were or were not symptom free at the time of reassessment. This is a very simplistic system that is insensitive to small changes in the degree of symptoms or function.

Most authors (1,6,7,8) have used a 3 or 4 level classification system (poor, fair, good, or excellent) based on symptom persistence and disability. For example McCullough et al (7) rated the result of treatment as excellent if there were no symptoms, good if there were occasional symptoms but no limitations, fair if there was occasional pain on rough ground or with prolonged walking, and poor if normal activity was limited by pain or locking. Descriptive scales such as these, while an improvement on that of Rhoden are still very insensitive. The reproducibility of these scales has not been addressed by any of the authors utilising them.

Flick and Gould (11) made use of a 100 point scale based on numerous points of subjective and objective evaluation. This system, while potentially sensitive is highly suspect with respect to validity and reproducibility.

Loomer et al (2) rated their patients result as excellent, good, fair, or poor based on descriptions of pain frequency, sports participation, changes in preoperative symptoms, and a willingness to have the surgery performed again if they had to do it again. This scale is an improvement on that of McCullough et. However, the description of the scale leaves the very real possibility that a given patient would be excellent in some categories and good or fair in others. This would leave the overall rating for that patient in doubt. A modified form the of the Loomer rating scale has been utilized in the present study (appendix 4).

The Visual Analog Scale

Visual analog scales (VAS), while not perfect, are a useful tool to aid in the measurement of subjective phenomenon. VAS's consist of a 100 mm line with well demarcated ends that represent the extremes of the subjective experience being measured. For example, the extremes of a VAS pain scale could represent no pain at one end and the worst pain ever at the other. The patient is asked to make a mark on the scale which represents his position on the continuum defined by the VAS. The distance along the line that this mark measures is taken as an objective measure of the patients subjective experience.

VAS's have been used primarily to measure pain. However other subjective variables have been measured successfully (see below). The VAS is very easy to use and very sensitive (26).

Validity of VAS Pain Scales

Pain is a subjective phenomenon and as such there can be no "gold standard" for pain measurement. When someone says that they are in pain they are in pain. It is therefore difficult to assess the validity of the VAS in the assessment of pain.

Pain intensity, as measured by the VAS, has been shown to correlate well with assessments of pain intensity using other forms of pain scales. Simple descriptive scales (a 5 point system based on verbal descriptions of pain) yielded a correlation coefficient of .726 with horizontal VAS (27). Numerical rating scales (pain scores on a 0 to 10 scale) yielded a correlation coefficient of .616 with horizontal VAS (27). This does provide evidence that the 2 scales are measuring the same entity. However, it has been argued, and probably rightly so, that such agreement between 2 similar subjective pain scales does not necessarily validate them (28).

Price et al (29) exposed patients to various noxious thermal stimuli and derived a mathematical equation for visual analogue pain scores based on the experimental stimulus intensity. They then asked patients to describe their chronic pain by VAS. The patients were also asked to describe the level of experimental pain which was the same as the level of their chronic pain. These experimental pain levels were then used to calculate the VAS equivalent from the previously derived mathematical equation. There was very close agreement between the chronic pain VAS described by the patients and those calculated on the basis of the equivalent experimental pain. This

internal consistency was interpreted as evidence of the validity of the VAS for measuring pain.

Price et al (29) also followed patients who were being treated for chronic back pain. They found a correlation of .7 between the VAS score for pain and the physician rating of improvement.

It is clear that the subjective nature of pain makes the definitive proof of the validity of the VAS impossible to obtain. However, pain intensity or pain relief is often the major variable of interest. It appears that the use of the VAS is a valid approach to this problem.

Reliability of the VAS to Assess Pain

The reliability of a test is usually determined by its test/re-test correlation. Such studies are difficult to perform with respect to pain measurement as it is not possible to ensure that the pain remains the same from one test to another (even over very short time spans (26)). However, there have been attempts to address the question of the reliability of pain assessment as measured by VAS.

Downy et al (27) found a correlation of .907 between pain intensity scores as measured with vertical and horizontal VAS's. Increasing the time between measurements to approximately 10 minutes yielded a correlation of .886.

Scott and Huskisson (30) studied a set of arthritic patients who were already taking part in therapeutic trials and serial pain measurements utilizing VAS. In this study they

were asked to complete a visual analog pain scale without access to their initial visual analogue scores. They were then shown their visual analogue score from the initial visit at the onset of treatment and asked to complete a second VAS. The correlation between the two scores (i.e. the visual analogue scores recorded on the same visit with and without exposure to the initial visual analogue score) ranged from .96 to .76.

Scott and Husskisson (31), in another study, compared vertical to horizontal VAS scores by arthritic patients and found a correlation of .99 between the 2 forms.

Price et al (29) found a correlation of .97 between 2 sessions of experimentally induced pain. In this study VAS pain intensities were recorded for given noxious thermal impulses. The same impulses applied a second time yielded VAS scores that correlated highly (.97) with the first set. The time between the sessions was not recorded.

Linearity of the VAS

The assumption of linearity of the VAS is important. The analysis of the data obtained from the VAS using parametric techniques is dependent on this assumption[3]. The validity of this assumption has been debated. Is 1 cm change at the middle of the VAS representative of the same change in pain as 1 cm change at the extremes of the VAS?

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[3]The assumption of normality has also been cited as a necessary criterion for the use of parametric techniques to analyze VAS data (33). However, parametric t-tests have been shown to be robust to this assumption except in the case of very skewed distributions (48). Huskisson (26) has shown the distribution of a pain VAS to be uniform and not skewed.

Dixon et al (32) found that the reproducibilty varied along the length of the VAS (more accurate at the extremes). This implies that the error may change along the line but not necessarily the linearity.

Quiding and Huggquist (33) chose to utilize both parametric and non-parametric techniques to analyze their data as they were concerned about the validity of the assumptions required to utilize parametric techniques.

Price et al (29) found that the VAS scores were a logarithmic function of experimental pain stimulus intensity. This, however, does not refute the assumptions of linearity of the VAS. There is no reason to assume that pain intensity is a linear function of the intensity of the experimental stimulus.

Langley and Sheppard (28) argue that the presence of fixed extremes on the VAS tend to create a cramming effect. This effect occurs as improvement continues (or pain continues to increase) and there is no more room to place marks on the scale. One's impression of the worst pain ever may change over time as greater levels of pain are experienced. This change in one's perception of the endpoint cannot be expressed on such fixed extreme VAS. In other words, this cramming effect appears to occur as a result of fixed end points that are outside of the realm of the subjects experience. If, however, the extremes of the VAS were within the realm of the subjects experience, (no pain, or worst pain during this injury) then this conceptual attack on the linearity of the visual analog pain scale would not be valid.

For this reason the form of VAS being utilized in this study has 2 fixed extremes. '0' represents no pain and '100' represents the worst pain from this injury. Both extremes should be well within the realm of experience for the subjects. Therefore, if it is made clear to the subjects that the VAS is meant to be a linear representation of their pain experience then the assumption of linearity should hold. It is also important to note that this format would allow for the recording of either an increase or a decrease in pain as appropriate.

The Memory of Chronic Pain using VAS

The present study wishes to compare pain and activity level at present to pain and activity level at the time of diagnosis (2 or more years earlier). This will be achieved using a retrospective VAS that requires the patient to describe two instances in time on the same VAS. This obviously requires the subject to remember the pain and activity levels in the past. There will clearly be some error involved in the memory of pain and activity level.

The ability to recall chronic pain using VAS's has been assessed by several authors (34,35,36). While the general consensus is that the accuracy of recall of chronic pain is poor, Bryant (36) found no significant difference between the initial and recalled pain. There is an important methodological flaw in these studies that would appear to be inherent in the process. In order to compare the pain at present and in the past one must use VAS's that can not be considered equivalent over time due to the potential changing of the endpoints. For example Linton and Melin (34) used a VAS with "no

pain" at the 0 extreme and "terrible excruciating pain" at the 100 extreme. It is impossible to state that this VAS continuum represents the same pain experience at both times.

While clearly there will be some error inherent in the memory component required for the retrospective VAS designed for this study, it is argued that the patient's perception of the change in symptoms over time is the clinically important variable. This will be adequately assessed via the retrospective VAS.

VAS versus Other Forms of Pain Scales

Other pain scales have been described. Simple descriptive pain scales assign values to descriptive words such as mild, moderate and severe. These scales are much less sensitive than VAS to small changes in the degree of pain (26). The linearity of simple pain scales is even more of a concern than with VAS.

Numerical rating scales, where the subjects rate their pain on a scale of 1 - 10, are similar to the VAS. However, they lack the theoretical sensitivity of the VAS.

Downie et al (27) found a high correlation between these various rating scales.

Vertical versus Horizontal VAS

The VAS line may be horizontal or vertical. The 2 forms are highly correlated (r=.99 (31), r=.907(27)). The scores on horizontal VAS tended to be slightly higher that on vertical VAS(31), it is therefore important that the position of the VAS be standard throughout the experiment.

VAS and measurement of subjective phenomenon other than pain

VAS's have been used to measure many subjective variables. Miller and Ferris (37), in their review of VAS's in research, report that VAS's have been utilized to measure such subjective variables as mood, anxiety and distress, craving for cigarettes, quality of life, dyspnea, fatigue and others.

The use of VAS's to measure activity level does not appear to have been described in the literature.

An Assessment of the reliability of the Retrospective VAS for Pain and Activity Level

To assess the reliability of the retrospective VAS a pilot study was performed on 10 patients with a variety of running injuries of at least 3 months duration. These patients were seen as part of their regular visits to our clinic. At the start of their visit they were asked to record their level of pain with slow running at present (PN1) and 3 months previously (PT1) on a VAS with the '0' extreme set at no pain and the '10' extreme set at the worst pain during this injury. They were also asked to record their overall activity level at present (AN1) and 3 months previously (AT1) on a VAS with the '0' endpoint set at the most limited activity level due to this injury and the '10' endpoint set at full activity level. The patients were then distracted for 15 minutes and then asked to complete a duplicate set of VAS's. This yielded scores for the pain with slow running at present (PN2), pain with slow running 3 months previously (PT2), overall activity level at present (AN2) and overall activity level 3 months previously (AT2). No physical examination or discussion of prognosis had taken place during the 15 minute

distraction period. The patients did not know that they would be asked to complete the second set of VAS's and they did not have access to their first set of VAS scores when completing the second set.

The pearson correlation coefficients between the first and second set of VAS scores were calculated to determine the reliability of these measures (table 3).

Table 3

Reliability of Retrospective VAS

Measure	Correlation
pain at present (PN1 Vs PN2)	.962
pain 3 months ago (PT1 Vs PT2)	.949
activity at present (AN1 Vs AN2)	.969
activity 3 months ago (AT1 Vs AT2)	.954

The pearson correlation coefficients were found to be high suggesting good reliability of the retrospective VAS in assessing pain and activity level in both the present and past tense.

Conclusion

VAS's are a sensitive , facile, reliable and valid technique for measuring subjective phenomenon. It is possible to structure the VAS to validate the assumption of linearity and allow the use of parametric techniques in analyzing the data.

Appendix 2 - Criteria and Grading Scales for the Radiological Diagnosis of Osteoarthritis

Introduction

Osteoarthritis (OA) is a well recognized degenerative disease in which joints are affected by cartilage destruction, erosion, subchondral sclerosis, the formation of osteophytes and subchondral cysts (38). The clinical presentation is that of activity related pain, swelling, stiffness and crepitus (38). Clearly, this is a similar clinical presentation to that of OLT.

It is well recognized that trauma involving the joint surface can predispose to the development of OA (38). OLT involve the joint surface but do they lead to the development of ankle OA? Is OA involved in the symptomatology of OLT? To address these questions we must be able to define OA of the ankle. Clearly, clinical criteria are not helpful as the clinical presentation of OA and OLT are so similar. We are, therefore, left with the radiological diagnosis of OA.

Radiography of OA in general

Kellegren and Lawrence (39) have described the radiological features generally considered as evidence of osteoarthritis:

- The formation of osteophytes on the joint margins.
- Narrowing of the joint cartilage associated with sclerosis of the subchondral bone.
- Small pseudocystic areas with sclerotic walls situated usually in the subchondral bone.
- Altered shape of the bone ends.

Although the clinical and radiographic pictures do not always correlate perfectly, pain, swelling and crepitus have been found to be significantly more common in those with radiographic findings of OA than with normal radiographs (24).

Radiography of OA in the Ankle

The literature discussing OA of the ankle is relatively sparse. This likely reflects the relative rarity of OA of the ankle (21)

The authors who have discussed osteoarthritis in OLT have used different definitions of osteoarthritis. Bauer et al (8) used the criteria of joint narrowing, sclerosis or cyst formation. They did not consider osteophytes alone to be sufficient to diagnose OA. McCullough et al (7) used the presence of joint narrowing, bony sclerosis, or erosions and osteophytes as criteria for the diagnosis of OA. Other authors did not describe their criteria used to diagnose OA.

Magnusson (40) described a scale to rate the degree of osteoarthritis in the ankle (table 4).

Table 4

Magnusson OA Rating Scale

(+)	slight reduction of joint space and slight formation of osteophytes on joint margins.
+	more marked abnormalities, possibly with addition of a sclerotic zone within subchondral osseous tissue of tibia
++	Joint space only about half as high as on uninjured side and rather marked formation of osteophytes
+++	Joint space has completely or almost disappeared

Wyss and Zollinger (41) have described another scale for osteoarthritis in the ankle (table 5).

Table 5

Wyss and Zollinger OA Rating Scale

stage 0	no degenerative changes present.
stage 1	sclerosis without narrowing of the joint cavity.
stage 2	sclerosis and the development of a marginal rim and slight narrowing of the joint.
stage 3	more marked narrowing with furrows and roughening of the subchondral lamella.
stage 4	cystic radiotranslucencies and marked sclerosis in addition to the findings of stage 3.

Neither classification scheme has been analyzed with respect to reliability.

Criteria for the Radiographic Diagnosis of OA

This study adopted a liberal definition of OA and includes osteophytes as a sufficient criteria. We were interested in knowing whether ankles with OLT had any evidence of OA, however mild, and whether the presence of this OA had any relation to the clinical result.

Jonsson et al (42) described the normal width of an ankle joint in males and females averaged over 6 well defined places of measurement on standard supine X-rays. They found that varying the position of the beam did not make a significant difference. There was no significant difference between right and left or with age. Males averaged 3.4mm (standard deviation .4mm) and females averaged 2.9 $\pm$ .4 mm. Using this data

allows us to standardize the assessment of joint space narrowing. There does not appear to be a significant benefit in obtaining weight bearing radiographs when assessing joint space narrowing (43). Therefore, in this study, AP and lateral X-rays were taken of both ankles in the standard supine position.

Osteoarthritis was considered to be present if any of the following existed:

- osteophyte formation on the tibia/fibula-talar joint
- joint space narrowing - joint space greater than 2 standard deviations smaller than the population mean (i.e. .8 mm smaller) or .5 mm smaller than the contralateral side as determined by the method of Jonsson (42).
- Sclerosis of the subchondral bone as compared to the contralateral ankle and agreed upon by 2 investigators of the study.

The presence of subchondral cysts has been intentionally omitted from the list of criteria to avoid confusion with the subchondral cyst of the OLT. This is should be insignificant as the formation of subchondral cysts in osteoarthritis is recognized to represent advanced osteoarthritis (41) and would be found in association with other radiographic signs that would result in the correct diagnosis of OA.

All ankles with OA in this study did have osteophytes. Sclerosis was never seen without at least small osteophytes. The one subject with narrowing according to the criteria of Jonsson (42) also had marked osteophytosis.

Grading scale for the degree of OA

The OA grading scales of Magnusson (21) and Wyss and Zolinger (41) proved to be not useful in that they are difficult to apply. The most common evidence of degenerative

changes we see is that of osteophytes alone with no evidence of narrowing or sclerosis. There is no place in either of the above mentioned scales for osteophytes alone. In fact both scales make sense only if osteoarthritis always progresses through the same stages in the same order. These 2 scales are actually inconsistent when compared to each other as they both grade OA based on different patterns of progression. For example the lowest stage for Magnusson possessed narrowing and osteophytes and the lowest stage for Wyss and Zollinger includes sclerosis only.

We have designed an OA scale that recognizes that the radiographic evidence of OA may not always progress in the same pattern. Therefore points are given for any of osteophytes, sclerosis, or narrowing. It is also recognized that osteophytes are relatively minor expressions of OA when compared to narrowing. Points are awarded for the presence of the various elements of radiographic evidence of OA (table 6).

Table 6

Loomer/Shearer OA Grading Scale

Radiographic Finding	Points Given
Largest tib/fib-talar osteophyte: < 2 mm	0.5
Largest tib/fib-talar osteophyte: 2-4 mm	1.0
Largest tib/fib-talar osteophyte: >4 mm	1.5
sclerosis	0.5
focal narrowing [4]	2.0
diffuse narrowing [5]	3.0

[4] For this scale focal and diffuse narrowing were determined by visual comparison with the opposite ankle.

[5] Diffuse narrowing refers to narrowing of most of the joint surface.

Reliability of the Loomer/Shearer OA Grading Scale

The inter and intraobserver reliability was assessed with test/ retest pearson correlation coefficients. The grading scale was applied to the 20 subjects in this study with X-rays (both ankles). Measurements were performed by CS on 2 occasions separated by 1 week and blinded to the first set of results on the second occasion. Pearson correlation revealed r=.872. Directional agreement (defined as the 2 trials agreeing on the ankle with more advance OA) was found in 19/20 subjects.

The same X-rays were then graded independently by RL. Pearson correlation's yielded coefficients of r=.839 with CS first set of measurements and r=.857 with CS second set of measurements. Directional agreement was found in 18/20.

In all 3 cases of directional disagreement one of the measurements scored the two ankles as equivalent. In other words it was never the case that the 2 sets of measurements determined that opposite ankles had higher grades of OA.

It appears that this scale is highly reproducible and therefore highly reliable.

Appendix 3 - Lesion Size as Assessed by CT Scan

Introduction

CT scans were obtained at various British Columbia hospitals (UBC, RCH, Surrey, Richmond, Kamloops). All CT scans contained a scale from which it was possible to measure the size of lesions.

The difficulty in accurately assessing the volume of irregularly shaped lesions with CT scanning is well recognized. While computer software - built into CT scanners - has been designed to solve this problem (44,45,46), they were not practical with respect to this study. This was particularly true when considering the initial scans in retrospect.

It was therefore decided to measure maximal width and depth in the coronal plane. Unfortunately not all CT scans provided axial views and therefore the calculation of length was not possible in many cases. As a result length was not calculated at all. It was hypothesized that a change in lesion volume would likely be equal in all 3 dimensions. This hypothesis is supported by a high correlation found between change in width and change in depth (r=.831, n=11). Maximal width (W) was defined as the maximal diameter of the lesion in the coronal plane parallel to the top of the talus. Maximal depth (D) was defined as the maximal diameter of the lesion, in the coronal plane, perpendicular to the top of the talus. The maximal Area was defined as A = W x D.

The Reliability of the Measurement of the Size of the Lesions

To assess the reliability of the measurements of lesion size 51 dimensions were measured (m1) on the available CT scans. Repeat measurements (by the same individual - CS) of the same dimensions (m2) one week later (blinded to the first result) revealed r=.98 for pearson correlation coefficient. Clearly the measuring process is highly reliable.

Calculating the Error in Determining Lesion Size

The distribution of the differences (D = m1 - m2) between the first (m1) and the second (m2) measurements of the 51 dimensions described earlier in this appendix can be used to determine the error in measuring lesion size. Two standard deviations of this distribution of differences represents the error term for either set of measurements (m1 or m2) within 95% confidence limits. For the 51 measurements the standard deviation (s) = .85mm.

By using the mean of the 2 measurements ((m1 + m2)/2 = M) as the best estimate of the size of the given dimension (as opposed to m1 or m2) the error term is halved. For this study the average of 2 measurements was used as the best estimate of the actual dimension size. Therefore the error term is 1.7 mm/2 = .85mm. In other words the best estimate of the size of a given dimension is the mean of the 2 measurements +/- .85 mm (95% of the time).

Determination of the Significance of Individual Changes in Size of CT Scan Dimensions.

For each lesion with initial and follow-up CT scans available to the study maximal width and maximal depth were measured twice on each CT scan (the second measurement being made 1 week following the first and blinded to the result of the first). The average of the 2 measurements for each dimension on each CT scan was used as the final value for width (W) and depth (D). Each subject then had an initial W and D and a follow-up W and D. If the difference between W initial and W final or D initial and D final was $\geq .85$ mm then a significant difference in the respective dimension was said to exist (within 95% confidence limits).

Appendix 4 - Modified Loomer Scale for Overall Clinical Result

The Loomer scale for assessing clinical results of OLT (2) is useful in that it combines multiple variables into a poor/fair/good/excellent result. However it is clearly designed with surgical patients in mind as it directly inquires about preoperative symptom persistence and whether or not the subject would consider surgery again. The Loomer scale is also problematic in that it is not always clear into which category subjects will fit due to possible overlap. The Modified Loomer scale (table 7) has been devised in an attempt to remove any ambiguity regarding which result to apply to each subject.

Table 7

Modified Loomer Scale for OLT

		SPORT LIMITATIONS		
		UNLIMITED	SOME LIMITATION	UNABLE
SYMPTOM PERSISTENCE	GONE	excellent	good	XXXXXXXXX
	GREATLY IMPROVED	excellent	good	fair
	SLIGHTLY IMPROVED	good	fair	poor
	SAME	fair	Pain w-m[6] fair / Pain daily poor	poor
	WORSE	poor	poor	poor

[6] Pain w-m: pain frequency weekly or monthly