Available online at www.sciencedirect.com
ScienceDirect
Foot and Ankle Surgery 13 (2007) 171–176
FOOT AND ANKLE SURGERY
www.elsevier.com/locate/fas

Deficiencies of MRI in the diagnosis of chronic symptomatic lateral ankle ligament injuries

V. Kumar MRCS (Glasg), BTEC (sports)*, I. Triantafyllopoulos MD, A. Panagopoulos MD, S. Fitzgerald FRCR, L. van Niekerk FRCS, FRCS (Tr & Orth)

Centre for Sports Orthopaedics Surgery, Department of Orthopaedics, Friarage and Duchess of Kent Military Hospitals, North Yorkshire, United Kingdom

Received 22 November 2006; accepted 17 April 2007

Abstract

Background: Stress radiography and more recently magnetic resonance imaging have been used to study the integrity of lateral ankle ligaments in chronic symptomatic instability after injury.
Aim: Our aim was to see if magnetic resonance imaging was as good as examination under anaesthesia and stress radiography, for diagnosing injury to the lateral ankle ligaments.
Methodology: Fifty eight patients, 47 men and 11 women, who were athletes or military personnel, with symptomatic instability of their ankle were included in the study. This cohort of patients had MRI scans, stress radiography and arthroscopy of their ankle. Integrity of the calcaneo-fibular ligament (CFL) was recorded arthroscopically.The sensitivity, specificity, positive and negative predictive value of MRI and stress views, in assessing integrity of the CFL, were compared against arthroscopic findings.
Results: Stress radiography under anaesthesia and MRI had sensitivity of 94% and 47% respectively and specificity of 98% and 83% respectively, for diagnosing injury to the CFL. Stress radiography has a higher accuracy in diagnosing CFL injuries as compared to MRI.
Conclusion: The results of this study casts doubt on the efficacy of MRI in the diagnosis of serious ankle ligament injuries.

Keywords: Ligaments; Ankles; Magnetic resonance imaging; Instability

1. Introduction

Injury to the lateral ankle ligaments is the most common lower extremity injury treated by healthcare providers involved in sports injuries and one of the most common musculo-skeletal injuries overall [15–17,25,32].

The convention is to divide lateral ligament injuries into categories reflecting the severity of trauma. The vast majority of ankle soft tissue injuries are grade I and II injuries and respond well to rest and physiotherapy. A grade III injury reflects total disruption of one or more ligaments of the lateral complex. Twenty to forty percent of patients with these injuries go on to experience chronic instability and pain and seek further medical attention [13,19,30,34].

The lateral ankle ligament complex consists of three major ligaments: the anterior talofibular (ATFL), the calcaneo-fibular (CFL) and the posterior talofibular ligament [28]. The ATFL extends from the anterior and inferior borders of the fibula to the neck of the talus; it is a discrete thickening of the capsule, about 7 mm in diameter and 16 mm in length. The stronger CFL arises from the tip of the fibula and passes obliquely downwards and posterior to insert into the peroneus tubercle of the calcaneus. It is about 5 mm in diameter, 25 mm in length and closely related to the inner sheath of the peroneal tendons [6,14]. The ATFL and the CFL are commonly injured in lateral ligament injuries. The posterior talofibular ligament is rarely torn except in complete dislocation of the ankle [3,22]. For the purpose of this study, we concentrated on the diagnosis of grade III CFL

* Corresponding author at: 44, New Adel Lane, Adel, Leeds, West Yorkshire LS16 6AN, United Kingdom. Tel.: +44 1132 817724; fax: +44 1609 764638.
E-mail address: geo_bug@yahoo.com (V. Kumar).

1268-7731/$ – see front matter
doi:10.1016/j.fas.2007.04.002

and ATFL injuries. Associated intra-articular pathology was noted, as this often gives rise to functional instability which mimics ligament insufficiency.

Diagnosis of ankle instability is traditionally based on a history of a forefoot supination/hind foot inversion injury, clinical signs and radiological features. The clinical signs aim to demonstrate abnormal movement of the talus in the joint mortise. These signs have been described as 'anterior drawer' by Brostrom [4], to test the integrity of the ATFL and the talar tilt test [32] to test the integrity of the CFL. Radiographic studies can provide objective data to determine the integrity of these ligaments. Stress views under fluoroscopy objectively demonstrate the two signs. More recently, magnetic resonance imaging (MRI) has been used to diagnose ligament injuries of the ankle [2,21,26].

Evaluation of MRI as a diagnostic tool for ankle ligament injuries has had mixed reviews [7,14,21,27,28,31,35]. The aim of our study was to compare the diagnosis made by examination under anaesthesia and the stress radiographs, with the diagnosis made by MRI and then to correlate this with the arthroscopic findings. Arthroscopy allows visualisation and quantification of injury to the ATFL and CFL [11,18,31].

Fig. 1. Axial MRI image demonstrating the ligaments. The ATFL (arrow) is discontinuous and irregular. CFL (arrowhead) is of diffusely increased signal anteriorly.

2. Methods

Between 2003 and 2005, 11 women and 47 men, underwent arthroscopic assessment and treatment for instability and pain. This was following unilateral ankle ligament injury unresponsive to physiotherapy and non-operative management for at least 6 months. Patients ranged in age from 18 to 50 years (mean age 28). All patients were high demand recreational athletes or active military personnel. Symptoms included recurrent inversion injuries, pain on activity, a feeling of 'giving way', swelling and stiffness that restricted their daily activities, sports or military training. Patients with generalised ligamentous laxity (Beighton score $> 4/9$) [1], previous ankle surgery or fractures were excluded from the study. We also excluded all patients with a history of injury to the contralateral ankle.

Pre-operatively, a detailed history was obtained and a thorough clinical examination was performed. Plain radiographs (antero-posterior and lateral views) were obtained to exclude bony abnormalities. All 58 patients had pre-operative MRI scans of the injured ankle, in an attempt to evaluate injury of the ATFL, CFL and deltoid ligaments. These scans were reported on by a senior musculo-skeletal radiologist. Criteria used to diagnose ligament tears included lack of visible ligament, ligament irregularity and thickening and heterogeneity of ligament signal (Figs. 1 and 2). Our radiologist also reported on the presence of cartilage lesions, bone bruising and peroneal tendon tears. Scans were performed on a Philips Intera 1.5 T MRI scanner using a quadrature knee coil. The foot was imaged in 20–30° plantar flexion. Sagittal T1 and STIR (3/0.3 mm), Axial T1 and T2 (3–4/0.3–0.4 mm), Coronal T2 and usually T1 (3–4/0.3–0.4 mm).

Examination and stress fluoroscopy to assess talar tilt was performed under general anaesthesia. It was then repeated on the contralateral (uninjured) side. The anterior drawer translation was measured on the lateral stress

Fig. 2. Coronal MRI image demonstrating the ATFL ligament with increased signal.

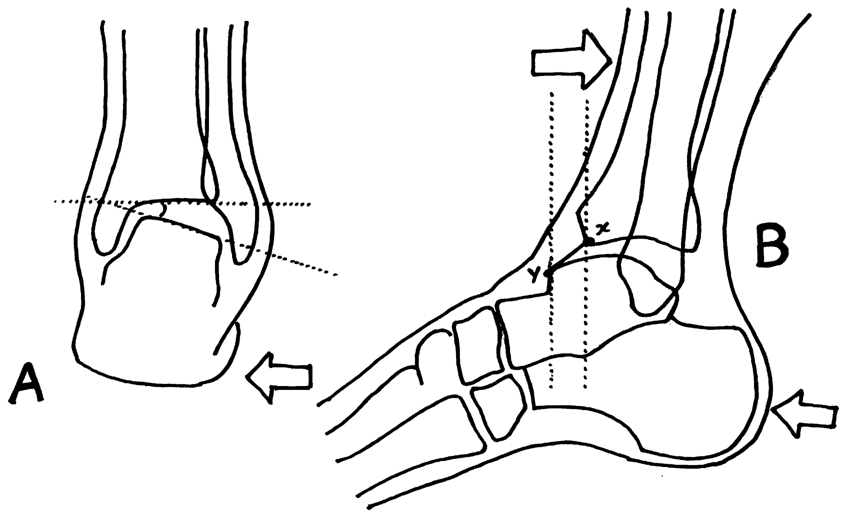

Fig. 3. Stress examination (A) talar tilt test and (B) anterior drawer test—talar translation measured between reference points x and y.

radiograph. The provocation for anterior drawer was performed with the ankle in the plantigrade position. The anterior tibial translation was measured with a reference point on the anterior tibial border (Fig. 3B) to the most anterior point on the articular surface of the talus. The anterior drawer test was considered positive when the difference between the anterior displacement of the talus on the affected side and normal side was 10 mm or more [33,24]. The talar tilt angle was measured in the usual way: two lines were drawn on the AP stress radiography; one line was placed against the articular surface of the distal tibia and the other was drawn along the tibial articular surface of the talus (Fig. 3A). The talar tilt test was regarded as being positive when the difference between the normal and affected side was more than 15° [3,8]. The senior author (LVN) performed all these tests to remove any possibility of inter-observer variation. He was blinded to findings of the MRI.

Arthroscopy was performed under ankle traction with a Guhl ankle distractor (ACUFEX, Smith & Nephew, Inc., Andover, MA) with a standard 4.5 mm cannula and arthroscope through an anterolateral, anteromedial and antero-central portal in each patient. The integrity of the lateral ligaments and other intra-articular lesions were identified, if present, and documented. Loss of integrity was diagnosed if there was avulsion, mid-substance tears, attenuation or elongation of the ligaments. The sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) were calculated for the MRI and for stress views and were compared with the arthroscopic findings for the integrity of the CFL and ATFL (Figs. 4 and 5).

Fig. 4. Arthroscopy demonstrating an intact CFL (calcaneo-fibular ligament).

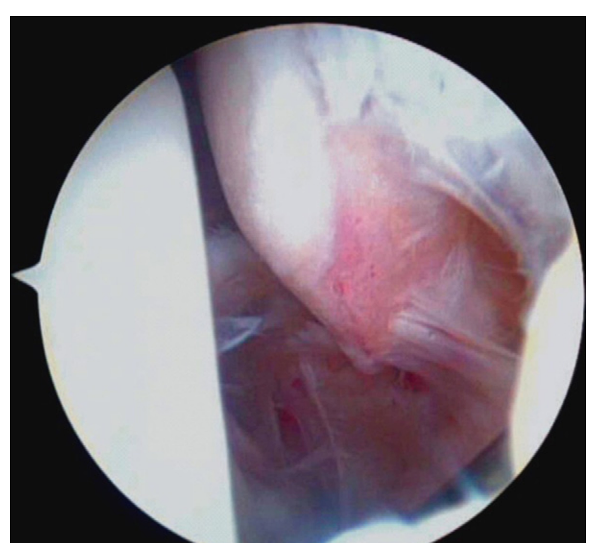

Fig. 5. Arthroscopy demonstrating a ruptured CFL (calcaneo-fibular ligament).

Table 1
Associated lesions picked up by the magnetic resonance scan and arthroscopy ($N = 58$)

	MRI	Arthroscopy
Deltoid ligament lesion	3	3
Syndesmotic lesion	2	2
Peroneal tendon abnormalities	2	2
Cartilage lesions	19	24
Loose bodies	6	10
Synovitis/hypertrophy	18	22
Osteophytes	14	17

3. Results

At surgery, a total of 25 patients had ATFL tears, 18 had CFL tears and seven had only ATFL tears. None had only CFL tears and 33 patients had intact ligaments. Three patients had a tear of the medial deltoid ligament. In addition, osteophytes, loose bodies and osteochondral defects of the talus were also identified in these patients (Table 1). Eighteen patients underwent a reconstruction of the CFL, as described by Brostrom [15]. Among the patients who had tears of both ATFL and CFL, three had cartilage lesions on the talus, eight had loose bodies, three patients had osteophytes and nine had evidence of synovitis.

The sensitivity and specificity of MRI and stress radiography were not very high for diagnosis of ATFL tears (Table 2). Stress radiography however had better sensitivity (94%) and specificity (98%), for injury to the CFL, as compared with those of the MRI scans (sensitivity 47% and specificity of 83%). Thus, there was a difference in diagnostic accuracy of the two methods of investigation for injury to the CFL. The accuracy of the examination under anaesthesia and stress radiographs was greater than that of the MRI scan for both the ATFL and the CFL (Table 2).

The positive predictive value (PPV) and the negative predictive (NPV) value for the two modalities of investigation were also compared. The PPV for the ATFL using the MRI and stress radiographs was 59% and 87%, respectively and the NPV was comparable at 88% and 89%, respectively.

Table 2
Comparison of MRI and EUA (arthroscopy as gold standard)

	MRI	EUA (+stress radiographs)
ATFL[a]		
Sensitivity	87% (CI 73–100)[b]	83% (CI 68–99)
Specificity	60% (CI 43–77)	91% (CI 81–100)
Accuracy	71% (CI 59–83)	88% (CI 79–96)
CFL[c]		
Sensitivity	47% (CI 23–71)	94% (CI 83–100)
Specificity	83% (CI 71–95)	98% (CI 93–100)
Accuracy	72% (CI 61–84)	97% (CI 92–100)

[a] Anterior talofibular ligament.
[b] 95% confidence intervals.
[c] Calcaneo-fibular ligament.

The stress radiographs had better predictive values for calcaneo-fibular ligament injuries with a PPV of 94% and NPV of 98% as compared to a PPV of 53% and NPV of 79% for the MRI. A high negative predictive value for the stress radiographs indicate, that if a diagnosis of an intact CFL is made based on examination under anaesthesia, the chance of it being right is high, even approaching 100%. This means that a negative talar tilt test can be reliably used to rule out a torn CFL. Similarly, a high positive predictive value suggests that a positive talar tilt test (compared to the contralateral side) is a good indicator or a torn or avulsed CFL. The results indicate that MRI scanning is comparable to stress radiography in the diagnosis of ATFL injury, but it is less accurate and has a poor predictive value for the diagnosis CFL injury.

4. Discussion

A study involving long term follow-up of inversion trauma of the ankle has shown that the overall percentage of residual complaints was 39% [34]. These residual symptoms included pain, fear of giving way, actual instability and swelling. Symptomatic ankle instability is a very disabling condition. Diagnosis of loss of ligamentous integrity is of importance in planning management in patients with symptomatic ankle instability. MRI has been widely used as an investigative tool to assess the integrity of the lateral ligaments. Previous authors have debated the accuracy and the role of the MRI scans in diagnosis of acute ankle sprains and antero–lateral impingement syndromes [14,18,21,28,31,35].

In the current study, patients had recurrent and chronic symptoms of instability, lasting more than 6 months and that were resistant to non-operative measures. MRI scans were found to be less specific and sensitive for the CFL as compared to the stress views and also, the accuracy for both the ATFL and the CFL were less as compared to the stress views. Magnetic resonance imaging scans provide high soft tissue contrast and are capable of demonstrating anatomically intact ligaments over some of their lengths. A MRI scan of acutely injured ankle ligaments may demonstrate the presence of haemorrhage in the joint space and soft tissue swelling over the lateral malleolus as well as high bone signal at ligament avulsion sites. These findings may be absent in patients with recurrent or chronic problems [28] and thus may make the diagnosis more difficult. Magnetic resonance scans can highlight certain morphological abnormalities, but do not allow dynamic assessment of stability as opposed to physical examination and stress views. The magnetic resonance scans can however provide useful information on associated pathology such as chondral lesions and loose bodies causing functional instability which may mimic structural instability secondary to ligament deficiency (Table 2). Previous studies evaluating the role of MRI scans in diagnosing soft tissue impingements around the ankle have demonstrated the limited role of scans as compared to the expedient, cost saving stress radiographic techniques [9,12,21,28]. These studies have involved small numbers of patients and have not looked at the role of the scans in assessing lateral ankle ligaments in chronic instability. New methods of imaging such as dynamic MRI or three-dimensional MRI may provide more accurate information [35]. A previous study comparing MRI and MRI arthrography for chronic ankle instability showed that though MRI had a poor sensitivity (50%) and accuracy (63%) in picking up CFL tears; MRI arthrography had good sensitivity (90%), and accuracy (82%) in identifying this lesion [9]. The disadvantage of this is that MRI arthrography is an invasive procedure.

We believe that stress radiography provides a reliable dynamic test of the integrity of the lateral ligaments. A previous study has shown that significant correlation exists between functional instability and mechanical instability (radiographic) and that stress radiographs are of value in the diagnostic work up of functional instability of the ankle joint [20]. However, the criteria for diagnosing mechanical lateral ankle instability with stress radiography are controversial. An abnormality of talar tilt does not always correlate with functional instability of the ankle [13]. An increased varus talar tilt of up to 20° may occur in otherwise normal uninjured ankles [29]. Because of the wide variance of normal values, some authors feel that this test is not a reliable indicator of ankle stability. There is no consensus in the literature about the cut off talar tilt angle (compared with the unaffected ankle) beyond which a diagnosis of loss of integrity of the lateral ligaments can be made. The values range from 5° [10] to 30°. However, asymmetry with the contralateral ankle is rarely found and hence a comparison with the unaffected side can be fairly useful [23] and give a better idea of the integrity of the ligaments. In the current study we used a difference of 15° or above between the symptomatic and unaffected side as being suggestive of loss of ligamentous integrity. This criteria for the cut off was chosen based on previous studies which showed that a difference of 15° was highly indicative of loss of ligament integrity and thus the function [3,8]. In the current study, a difference in antero-posterior drawer of 10 mm between the affected and normal side was used as the cut off [3,24]. Previous studies comparing MRI with stress radiographs in acute lateral ligament injuries have reported a poor agreement between the two modalities [9,14], with stress radiography tending to over- or underestimate ligament damage. However, there was no surgical confirmation in these studies [5,14]. A prospective study involving 17 patients comparing MRI with stress radiography for chronic ankle instability, has reported poor sensitivity (57%) and accuracy (65%) of stress radiography. However, the study reported stress radiograph to have very good specificity (100%) [9]. A study involving radiographic evaluation of the ankle joint using the stress radiographs have shown them to have high sensitivity and specificity with very few false negatives and false positives [20]. In our current study, stress radiograph had a high sensitivity (94%), specificity (98%) and accuracy (97%) in detecting CFL tears.

One limitation of the current study may be that we did not use a stress apparatus to quantify ankle laxity. The use of stress apparatus has some disadvantages. The force required to recreate joint instability is not standardised. The degrees of talar tilt and the amount of anterior drawers translation that would characterise these tests as positive are also not standardised. In order to standardise our stress views and make them more reliable, the same senior author (LVN) performed the tests in all the patients. All patients were under full general anaesthesia and therefore there was no pain inhibition to influence the values of stress radiography that may occur with or without stress apparatus in an un-anaesthetised patient.

Another limitation of the study design is the absence of a control group without symptoms of instability. Ethical limitations would however restrict us to MRI scanning only thereby making comparisons with stress radiography under general anaesthesia and arthroscopy nonsensical. It can be argued that MRI is a static investigation, whereas stress radiograph is a dynamic investigation and these should not be compared. However, these investigations are used currently to make and quantify diagnosis and our aim was simply to compare the ability of these investigations in identifying the loss of integrity in the lateral ankle ligaments in chronic ankle instability. In the current study a simple comparison was made between the MRI findings and the stress radiographs under general anaesthetic as measured against arthroscopy and the accuracy of the MRI was found to be inferior to that of the stress radiographs in assessing the integrity of the lateral ankle ligaments.

5. Conclusion

MRI did not demonstrate any distinct advantage over the examination under anaesthesia and stress radiography in the diagnosis of grade III lateral ankle ligament injuries. Stress radiographs under general anaesthesia can be performed to quantify loss of ligament integrity and then ligament repair or reconstruction performed after an arthroscopic confirmation of the tear or avulsion under the same anaesthetic. MRI may however provide useful information on injuries associated with ligament rupture aiding pre-operative planning. Newer methods such as dynamic MRI and MR arthrography may provide a more accurate diagnosis of lateral ligament injuries.

References

[1] Garrick JG. The frequency of injury, mechanism of injury and epidemiology of ankle sprains. Am J Sports Med 1977;5:241–2.

[2] Glasgow M, Jackson A, Jamieson AM. Instability of the ankle after injury to the lateral ligaments. J Bone Joint Surg 1980;62B:196.
[3] Hawkins RB. Arthroscopic repair for chronic lateral ankle instability. In: Guhl AF, editor. Foot and ankle arthroscopy. Thorafore, NJ: Slack; 1993. p. 155.
[4] Mack RP. Ankle injuries in athletes. Clin Sports Med 1982;1:71–84.
[5] Sefton GK, George J, Fitton JM, McMullen H. Reconstruction of the anterior talo-fibular ligament for the treatment of the unstable ankle. J Bone Joint Surg 1970;61B:352.
[6] Freeman MAR. Instability of the foot after injuries to the lateral ligaments of the ankle. J Bone Joint Surg 1965;47B:669–77.
[7] Karlsson J, Bergsten T, Lansinger O. Lateral instability of the ankle treated by the Evans procedure. A long term clinical and radiological follow-up. J Bone Joint Surg 1988;70B:476–80.
[8] Sammarco GJ, DiRaimondo CV. Surgical treatment of lateral ankle instability syndrome. Am J Sports Med 1988;16:501–11.
[9] Verhagen RAW, de Keizer G, van Dijk CN. Long-term follow-up of inversion trauma of the ankle. Arch Orthop Trauma Surg 1995;114:92–6.
[10] Rijke AM, Goitz HT, McCue FC, Dee PM. Magnetic resonance imaging of injury to the lateral ankle ligaments. Am J Sports Med 1993;21:528–34.
[11] Burks RT, Morgan J. Anatomy of the lateral ankle ligaments. Am J Sports Med 1994;22:72–7.
[12] Frey C, Bell J, Teresi L, Kerr R, Feder K. A comparison of MRI and clinical examination of acute lateral ankle sprains. Foot Ankle Int 1996;17:533–7.
[13] Berquist TH. Radiology of the foot and ankle. New York: Raven Press; 1989. p. 99–104.
[14] Kulund DN. The injured athlete. Philadelphia: JB Lippincott; 1988. p. 521–31.
[15] Brostrom L. Sprained ankles. VI. Surgical treatment of chronic ligament ruptures. Acta Chirur Scand 1966;132:551–65.
[16] Beltran J, Noto AM, Mosure JC. Ankle: surface coil MR imaging at 1.5 T. Radiology 1986;161:203–9.
[17] Kingston S. Magnetic resonance imaging of the ankle and foot. Clin Sports Med 1988;7:15–28.
[18] Noto AM, Cheung Y, Rosenberg ZS. MR imaging of the ankle: normal variants. Radiology 1989;170:121–4.
[19] Cardone BW, Erickson SJ, Den Hartog BD, Carrera GF. MRI of injury to the lateral collateral ligamentous complex of the ankle. J Comput Assist Tomogr 1993;17:102–7.
[20] Oloff LM, Sullivan BT, Heard GS, Thornton MC. Magnetic resonance imaging of traumatized ligaments of the ankle. J Am Podiatr Med Assoc 1992;82:25–32.
[21] Schaffler GJ, Tirman PFJ, Stoller DW, Genant HK. Impingement syndrome of the ankle following supination external rotation trauma: MR imaging findings with arthroscopic correlation. Eur Radiol 2003;13:1357–62.
[22] Verhaven EF, Shahabpour M, Handelberg FW, Vaes PH, Opdecam PJ. The accuracy of three dimensional magnetic resonance imaging in the diagnosis of ruptures of lateral ligaments of the ankle. Am J Sports Med 1991;19:583–7.
[23] De Simoni C, Wetz HH, Zanetti M, Hodler J, Jacob H, Zollinger H. Clinical examination and magnetic resonance imaging in the assessment of ankle sprains treated with an orthosis. Foot Ankle Int 1996;17:177–82.
[24] Hintermann B, Boss A, Schafer D. Arthroscopic findings in patients with chronic ankle instability. Am J Sports Med 2002;30:402–9.
[25] Beighton P, Solomon L, Soskolne CL. Articular mobility in an African population. Ann Rheum Dis 1973;32:413–8.
[26] Smith RW, Reischi SF. Treatment of ankle sprains in young athletes. Am J Sports Med 1986;14:465–71.
[27] Lindstrand A, Mortensson W. Anterior instability in the ankle joint following acute lateral sprain. Acta Radiol 1977;18:529–39.
[28] Cass JR, Morrey BF. Ankle instability: current concepts, diagnosis and treatment. Mayo Clinic Proc 1984;59:165–70.
[29] Chandnani VP, Harper MT, Ficke JR, Gagliardi JA, Rolling L, Christensen KP, et al. Chronic ankle instability: evaluation with MR arthrography, MR imaging and stress radiography. Radiology 1994;192:189–94.
[30] Ferkel RD, Fasulo GJ. Arthroscopic treatment of ankle injuries. Orthop Clin North Am 1994;25:17–32.
[31] Karlsson J, Bergsten T, Peterson L, Zachrisson BE. Radiographic evaluation of ankle joint stability. Clin J Sport Med 1991;1:166–75.
[32] Rubin G, Witten M. The talar-tilt angle and the fibular collateral ligaments. J Bone Joint Surg 1960;42A:311–26.
[33] Cox JS, Hewes TF. 'Normal' talar tilt angle. Clin Orthop 1979;140:37–41.
[34] Laurin C, Mathieu J. Sagittal mobility of the normal ankle. Clin Orthop Relat Res 1975;108:99–109.
[35] Breitenseher MJ, Trattnig S, Kukla C, Gaebler C, Kaider A, Baldt MM, et al. MRI versus lateral stress radiography in acute lateral ankle ligament injuries. J Comput Assist Tomogr 1997;21:280–5.