Case Study AJPM

Isolated subtalar joint fusion. A case presentation of malposition

Angelo Salerno, *M Pod (Podiatric Surgery)*

ABSTRACT

The purpose of this paper is to highlight the importance and understand the detail for appropriate surgical planning and position placement of the subtalar joint as a fusion site. Furthermore, it is important to have an understanding of the repercussions if things do not go to plan, whilst still being able to provide an opportunity to improve on poor surgical outcomes if required.

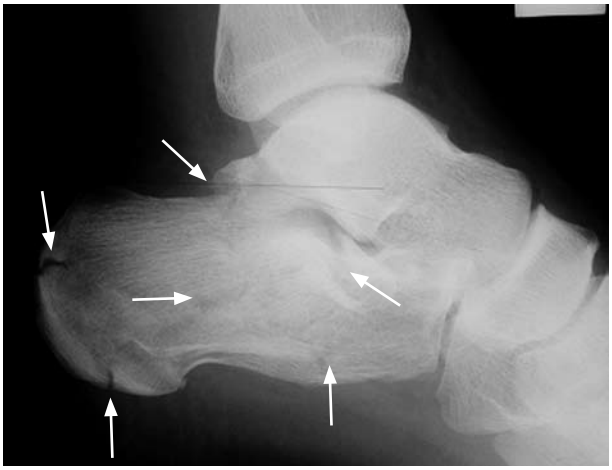
A 28-year-old male presented with a subtalar fusion and complaints of lateral forefoot and antero - lateral ankle pain. Qualitative and quantitative biomechanical information was gathered using dynamic plantar pressure analysis to assist diagnosis and evaluate the impact of orthotic intervention. The Fscan (Tekscan Co., Boston, USA) in-shoe pressure analysis system was used to track the centre of pressure (COP) and determine increased weight bearing areas of the foot. The effected foot revealed peaked pressure over the fifth metatarsophalangeal joint at a value two times greater than the contralateral foot and with a centre of pressure curve (COPC) laterally deviated from normal. The effects of orthotic therapy was also evaluated and represented by a medial shift of the COPC and a reduction in the loading of the lateral forefoot. The changes in loading pattern and COPC correlated with a decrease in the pain value derived from a visual analogue pain scale. This case presentation highlights the importance of pre and post orthotic evaluations so that comparisons can be drawn between pressure values before and after orthotic use. It may also provide the opportunity to improve the result of a surgical procedure through additional selective therapy and reiterate the need by surgeons for appropriate surgical planning and position placement of fusion sites.

Keywords: subtalar joint, fusion; plantar pressure measure; orthoses

INTRODUCTION

A 28-year-old male was referred for podiatry assessment and treatment for lateral ankle and lateral metatarsalgia, following a subtalar fusion. The subject reported falling off a roof rafter from a height of ten feet onto his feet. He sustained a comminuted intra-articular calcaneal fracture of the left foot and a meniscus tear of his right knee. The primary fracture line ran from the plantar aspect, obliquely upwards into the lateral facet and was associated with posterior facet joint decompression (Figure 1). Treatment involved immobilisation with below knee casting and crutches for six weeks, followed by physiotherapy, above ankle boots and semi rigid cushioned orthoses. Although heel pain improved and calcaneal fractures healed (Figure 2), there was increasing pain across the lateral leg, ankle and subtalar joint with peroneal muscle spasm. Further investigation revealed traumatic degenerative arthritis of the left subtalar joint (Figure 3a and 3b). An in situ subtalar fusion was performed with significant relief of symptoms. Recently however, he experienced lateral ankle, leg and forefoot pain. His medical history involved right knee arthroscopies with removal of meniscus cyst, right medial tibial condyle bone bruise, tear of posterior horn lateral meniscus and patella chondropathy. He was not taking any medications.

Figure 1. Lateral plain x-ray view of the fractured calcaneum 1 day following the injury. Joint depression fractures typically lead to a decrease in Böhler's angle and an increase in Gissane's crucial angle indicating involvement of the posterior facet.



Australasian Journal of Podiatric Medicine
2007; Vol 41, No.3 : 47-46

Correspondence: 18 Standen Street, Murray Bridge SA 5253
Ph: (08) 8532 5744 Email: footmed@bigpond.net.au

Figure 2. Lateral plain x-ray post healing revealed traumatic arthritis of the subtalar joint. Significant joint space narrowing and subchondral sclerosis is evident.

Figure 3 (a). Comparative coronal CT Images of the posterior facet of the subtler joint. Although the calcaneal fractures have healed following closed reduction and immobilization, intra articular involvement of the posterior facet can be appreciated with significant widening, irregularity, narrowing and osteophytic lipping of the joint space. Cystic degeneration of the os calcis and traumatic arthritis is also evident.

Recent plain radiographic evaluation revealed a solid fusion of the subtalar joint held with single screw (Figure 4). Re-evaluation of past plain radiographs revealed moderate degenerative change at the ankle joint, particularly lateral margin and further degeneration at the talonavicular and calcaneocuboid articulation. These findings increase the likelihood of arthritic pain across the midfoot with further degeneration over time and the possibility of further surgery, should conservative intervention be ineffective.

Figure 3 (b). Coronal CT view revealed extensive degeneration of the posterior facet of the subtalar joint (circled). The medial facet appeared preserved (white arrow).

Figure 4. Isolated subtalar fusion with screw fixation

In the open kinetic chain state the symptomatic left foot showed restricted ankle joint range of motion with approximately 5 degrees inversion/eversion detected on subtalar joint movement, probably arising from the ankle joint. Midtarsal joint motion was available and comparable with the opposite side, although some crepitus was felt. The rearfoot appeared fixed in a varus alignment with the forefoot in varus 2-5 approximating 7 degrees and the first ray was plantarflexed 8mm. The right foot showed a combination of varus/supinatus of the forefoot. A hyperkeratosis was visible and palpable under the left fifth metatarsal head. Resting calcaneal stance was 4 degrees inverted and 3 degrees everted for the left and right foot respectively (Figure 5).

Figure 5. Posterior and anterior clinical view of the feet showed subtle structural differences following subtalar joint fusion . A false sense of foot function could be interpreted in the absence of dynamic analysis.

BACKGROUND

Essex-Lopresti was the first to acknowledge the poor prognosis following the more common intra-articular fractures of the calcaneus compared to extra articular fractures which failed to breach the subtalar joint.[1] The subtalar joint is involved 75% of the time when calcaneal fractures are sustained. An axial load generated from a motor vehicle accident or a fall from a height is typically responsible for subtalar joint decompression and damage when the talus is driven downward into the calcaneus. In this case the primary fracture lines extend predominantly from the posterior facet of the subtalar joint. The primary fracture just anterior to the posterior facet appears to have two fracture lines, one projecting obliquely to the plantar posterior aspect of the os calcis and the other more vertical (Figure 1). A secondary fracture is quite posterior in the posterior facet running somewhat more longitudinally to the posterior aspect of the calcaneum where a breach of the cortex can be well appreciated (Figure 1). The CT pictures also show involvement of the posterior facet with good preservation of the middle facet (Figure 3(a) and 3(b)) suggesting that the initial impact causing the injury was with the ankle in a more plantarflexed position. Traditionally, subtalar arthrodesis has been performed as a salvage procedure in individuals with pain and dysfunction in the talocalcaneal joint. It has been applied to individuals that have shown distinct incongruity of the subtalar joint surfaces, diminished rearfoot height, peroneal muscle spasm and tendonitis, posterior muscle group weakness, widening of the heel, isolated talocalcaneal joint coalition and calcaneofibular abutment. Techniques for fusion are twofold, the in situ fusion and fusion involving bone grafts.

The importance of avoiding a varus positioning of the arthrodesis site during isolated subtalar joint fusion was mentioned by Sharrod and Duthie and Bentley.[2,3] They recommended erring on the side of caution should doubt exist and opting for a more valgus alignment, which they deem to be more satisfactory than a varus. Gallie in Whittle recommended a posterior approach to the subtalar joint for arthrodesis.[4] His description of the procedure also included the inability to correct any varus deformity if desired through this incisional approach and that this would then lead to overload of the lateral aspect of the foot. Mann and Coughlin went on to quantify what they believed to be the most desirable position of the subtalar joint during fusion and approximated this at being 5 degrees of valgus.[5] Furthermore, they believed that more than 10 degrees of valgus would be detrimental creating lateral impingement. They elaborated that if there was a residual varus malalignment then lateral overload and a vaulting type of gait could be expected. They appreciated that such a position would prevent the transverse tarsal joint to adapt to ground variances because of the locking of this joint complex, well described by Bosjen Moller and much earlier by Elftman.[6,7] A recent study by Blackwood quantified forefoot motion as being effected by hind foot position through the talonavicular and calcaneocuboid joints.[8] The study showed that there was a significant and measurable increase in sagittal plane flexibility when the hind foot is in valgus. The findings by Blackwood et al reinforces the thoughts and practices of the aforementioned authors who advocate valgus hind foot positioning of the subtalar joint during isolated subtalar joint fusion.

On the other hand Gellman described the ill effects of an excessive valgus malalignment of the hind foot during subtalar joint fusion; being calcaneo-fibular impingement, development of hallux valgus deformity, arch pain and stress reaction along the medial side of ankle and/or knee joint.[9]

The subject in this case, can be considered fortunate, as the mechanism of injury described was often associated with injuries other than just calcaneal fracture. Bilateral calcaneal fractures occur in 5 - 9% of patients and compression fractures of the lumbar/dorsal spine occur in 10% patients with calcaneal fractures.[10] Compartment syndrome develops in 10% of calcaneal fractures; with half of these developing clawing of the lesser toes or other chronic problems such as stiffness and neurovascular dysfunction.

The centre of pressure (COP) is not a new phenomena to diagnostic biomechanics and gait analysis, with Elftman first presenting the concept in 1939.[7] More sophisticated systems have since been available to practitioners and the COP has been used successfully as a way of looking at timing and progression of plantar loading during ambulation.[11,12,13,14]

The reliability of the COP progression curve has been previously documented and found to be reliable by test-retest analysis. Pearson's r and ICC indices for reliability showed that COP measurements are highly consistent within a session and between two sessions.[15,16] Likewise the visual pain analogue scale has been proven as a reliable measure for pain.[17]

METHODOLOGY

The insole sensors where trimmed to size and then placed in the subjects own shoes. Care was taken to avoid wrinkling the sensor. The sensor was connected to the cuff unit, which was the interface between the sensor and the computer. Controlled force calibration was performed before sampling using a single limb support model. The subject's body weight was entered into the computer, which set the value according to the force generated in single limb support. The subject was familiarised with the walkway and recording equipment, which was held securely in place around the subject's ankles. The subject was instructed to walk down a 10 metre carpeted walkway at normal cadence, first with the shoes and sensors and then repeated again with the shoes and the sensors overlying the orthoses.

Each resistive sensor comprised 960 'sensel's' with a spatial resolution of 4 sensors/cm squared at a sampling rate of 165Hz. Data was stored and analysed, using F-scan software. For data processing the same left and right footsteps were extracted from the middle of each walking trial (Figure 6a and 6b), in order to avoid footsteps during acceleration and deceleration. For each footstep, corresponding regions were identified at the great toe, metatarsal heads one, two, three-four and five, the midfoot and heel. The centre of pressure line was also recorded.

Figure 6 (a). Fscan analysis pre-orthotic COPC (both feet) with no orthoses.

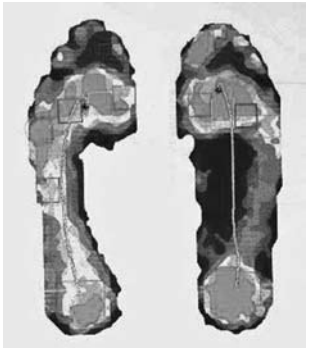
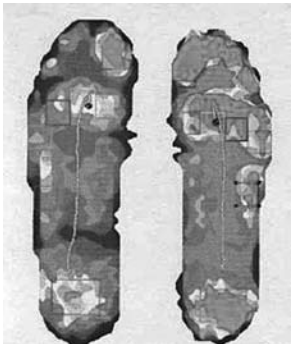


Figure 6 (b). Fscan analysis post-orthotic COPC (both feet) with orthoses.



A visual analogue scale (VAS) was used pre and post treatment as described by Miller.[17]

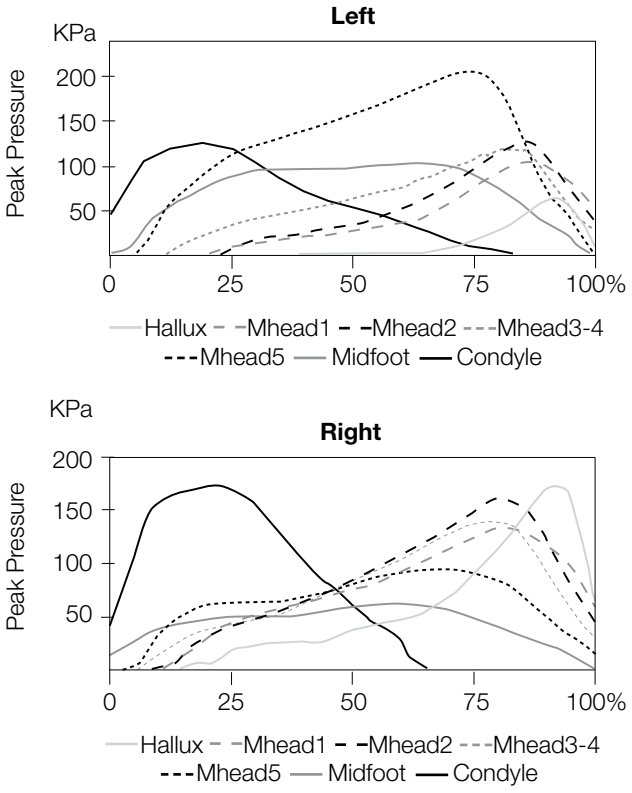
Additional information was gathered using slow motion video treadmill gait analysis. The subject was familiarised with walking on a treadmill using the same footwear for plantar pressure analysis. Frontal plane images of the rearfoot where captured and the images were slowed down frame-for-frame for more accurate visualisation.

RESULTS

The slow motion analysis revealed a varus rearfoot position at midstance affecting the left foot compared to the uninjured right foot. This occurred at a time we would be expected to see a neutral alignment, according to the traditional root model or when referencing from the unaffected, control, right foot. Also of significance was the very early heel raise affecting the left foot, due mainly to the lack of ankle joint dorsiflexion.

In the clinical setting, resistive type plantar pressure systems are more often used to identify relative areas of locally elevated pressure rather than to specifically quantify absolute values of pressure or compare pressure values between individuals.

Figure 7 (a). Peak pressure versus percentage of gait pre- orthosis. The light blue curve indicates peak pressure under the fifth metatarsal head of the right and left foot without the use of orthoses. The left fifth metatarsal head peak pressure was twice the value recorded on the right, control foot.



However, both resistive and capacitative systems demonstrate simular trends with respect to peak pressures across the metatarsal heads, great toe and heel.[18] The normal peak plantar pressure distribution formulated by Bennet and Duplock could therefore be applied with the Fscan system in relative terms. The right control foot showed normal pressure curves when using this criteria, whilst the left foot did not (Figure 7a).[19] However a restoration of plantar pressure under the metatarsal heads of the left foot, closer to normal did occur when orthoses were used (Figure 7b). That is, there was a dramatic reduction (100%) in pressure under the fifth metatarsal head and an increase in hallux pressure (110%) of the left foot when orthoses were used.

The force across the left forefoot in the shoe only, was greatest at the time of peak pressure while the contact area was decreasing. Compared to the shoe with the orthotic, although the force was higher across the forefoot, the peak pressure was lower over a decreasing, but significantly greater contact area. That is, the force/pressure are spread across a much greater

Figure 7 (b). Peak pressure versus percentage of gait post- orthosis. The light blue curve indicates the peak pressure under the fifth metatarsal head of the left and right feet when the orthoses are worn. The orthoses where shown to reduce peak pressure at the fifth metatarsal head from 200KPa to 100KPa.

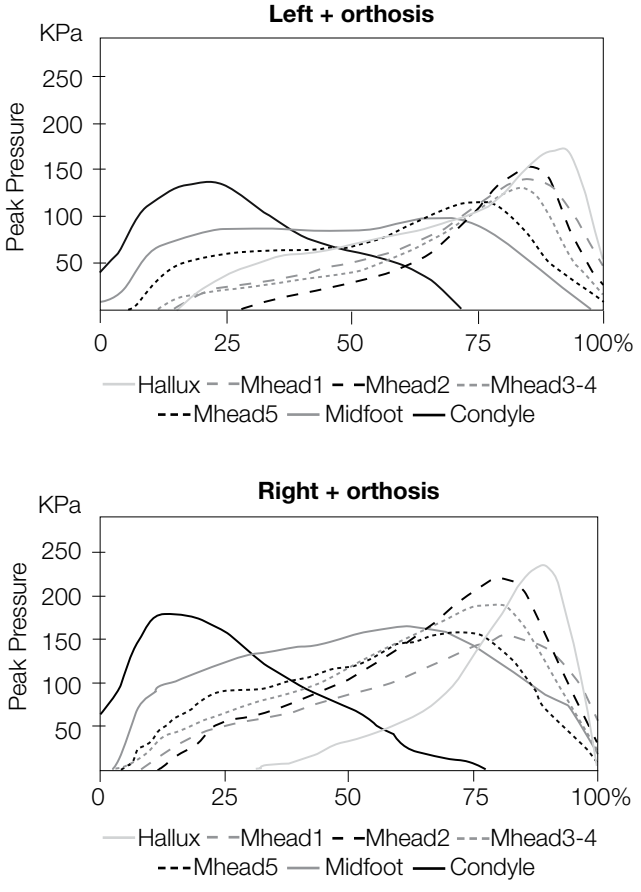
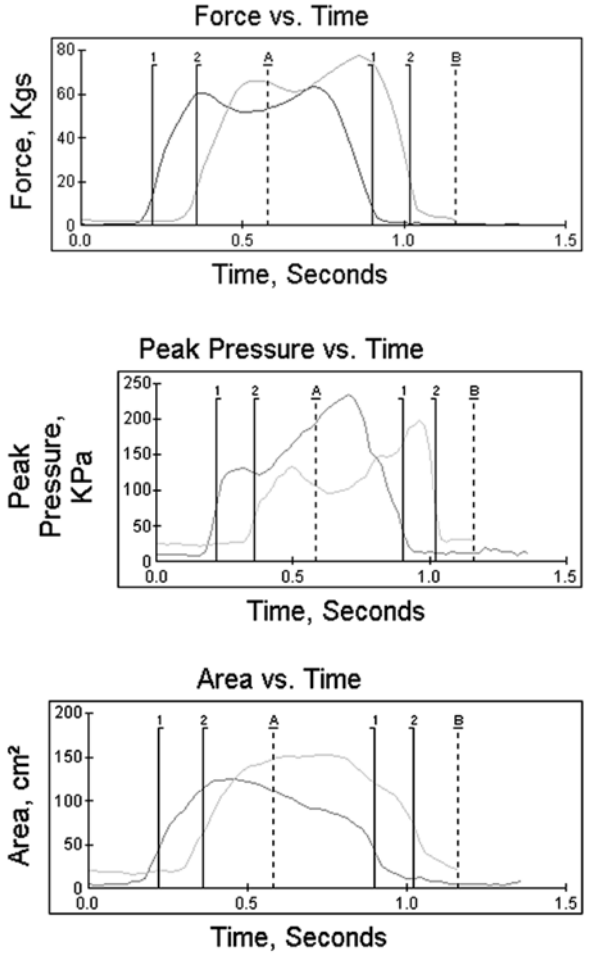


Figure 8. Comparative graph interpretation of the left foot with and without orthoses. The green curve represents the shoe with the use of the orthosis. The red curve represents use of the shoe only.



area of the forefoot in the shoe and orthosis. Also the slope of the peak pressure versus time curve after heel contact to forefoot loading was much steeper in the shoe only compared to the shoe with the orthosis (Figure 8).

The COPC is laterally deviated on the left side compared to the centrally located COPC on the control, right foot. According to Fuller's model concerning the centre of pressure and its location, this indicates that the left foot has a greater tendency toward supination with ground reaction force (Figure 6a).[20] This was consistent with clinical and gait observations. When applying the tissue stress approach to the explanation of pathology the lateral arch, ankle and leg symptomatology in this case may be explained.[21] When orthoses were used a significant shift in the location of the COPC was evident (Figure 6b), with a centralised relocation of the COPC particularly through midstance. This suggests the orthoses produced a pronatory

moment at this time on the mobile midfoot to medially shift the COP for high gear push off through the great toe.[22] The COPC from the shoe and orthosis appeared comparable with the right side.

VAS scores improved by three points out of a ten rating over a review period of four weeks, six months and 16 months suggesting a return to better function. The pre treatment score was six and the post treatment value, three.

CONCLUSION

Dynamic plantar pressure analysis involving pre and post orthotic intervention for a varus aligned isolated subtalar fusion has been presented. The F-scan in-shoe system provided qualitative and quantitative data that revealed changes in foot loading patterns and COP curves following orthotic intervention. These changes correlated with improvement in pain ascertained by visual analogue scale testing and changes towards the patterns of the non trauma foot. Plantar pressure data may not only be of value in objectively evaluating the therapeutic use of orthoses through the COP curve, but may also assist in an appropriate treatment plan to further improve surgical outcomes. The major limitation of this paper is that it is a case study and as such has a low level of scientific validity. Orthopaedic and podiatric foot and ankle surgeons have an understanding that surgical outcomes for subtalar fusion can be less than optimal if fusion site positioning is poor, but that it is possible to improve the result with adjunctive intervention if required.

REFERENCES

1. Essex-Lopresti P. The mechanism, reduction technique, and results in fractures of the os calcis. British Journal of Surgery 1996; 39:395-415.
2. Sharrord WJW. Operation for paralysis. In: David Evans, ed. Techniques in Orthopaedic Surgery. Blackwell, 1993:11:386.
3. Duthie R, Campos Da Pas Jr, Burnett S, Nomurg A. Neuromuscular effects in children In: Arnold, ed. Deformities of the foot. Mercers Orthopaedic Surgery. 1996: 7:432
4. Whittle AP. Malunited Fractures. In: Terry Canale, ed. Campbell's Operative Orthopaedics. Mosby, 2003:55:3075.
5. Mann RA. Isolated subtalar arthrodesis. Foot and Ankle International 1998; 19(8):511.
6. Bosjen-Moller F. Calcaneocuboid joint and stability of the longitudinal arch of the foot at high and low gear push off. Journal of Anatomy 1979; 129:165-176.
7. Blackwood CB, Yeun TJ, Saneorzan BJ, Ledoux WR. The Midtarsal Joint Locking Mechanism. Foot and Ankle International 2005; 26(12):1074-1080.
8. Gellman H. Selective tarsal arthrodesis: In vitro analysis of the effect on foot motion. Foot Ankle 1987; 8:127-133.
9. Nicklebur S, Dixon TB. Calcaneus Fractures [Online]. 2005; Available from: http://www.emedicine.com/orthoped/topic33.htm#section~introduction.
10. Elftman H. The transverse tarsal joint and its control. Clinical Orthopaedics 1960; 16:41-46.
11. Cornwall M, McPoil TG. Reliability and validity of centre-of-pressure quantification. Journal American Podiatric Medicine Association 2003; 93(2):142-149.
12. Lehmann JF, Condon SM, DeLateur BJ, et al. Ankle foot orthoses: effect on gait abnormalities in tibial nerve paralysis. Archives Physical Medical Rehabilitation 1985; 66:212.
13. Zernicke RE, Hoy Mg, Whiting WC. Ground reaction forces and centre of pressure pattern in the gait of children with amputation: preliminary report. Archives Physical Medical Rehabilitation 1985; 66:736.
14. Mann RA, Poppen NK, O'Konski M. Amputation of the great toe: a clinical and biomechanical study. Clinical Orthopaedics 1998; 226:192.
15. Kernozek TW, LaMott EE, Danciasak MJ. Reliability of an in shoe pressure measurement system during treadmill walking. Foot and Ankle International 1996; 17(4):204-209.
16. Tai Ryoon Han, Nam Jong Paik, Min Sik Im. Quantification of the path of center of pressure (COP) using an F-scan in-shoe transducer. Gait and Posture 1999; 10:248-254.
17. Miller M. Measurement of Subjective Phenomena in Primary Care Research. Family Practice Research Journal 1993; 13(1):15-24.
18. Quesada P, Rash G. Quantitative assessment of simultaneous capacitive and resistive plantar pressure measurements during walking. Foot and Ankle International 2000; 21(11):928-933.
19. Bennett PJ, Duplock LR. Pressure distribution beneath the human foot. Journal American Podiatric Medical Association 1993; 83(12):674-678.
20. Fuller E A. Centre of pressure and its theoretical relationship to foot pathology. Journal American Podiatric Medical Association 1999; 89:278–291.
21. McPoil TG, Hunt GC. Evaluation and management of foot and ankle disorders: Present problems and future directions. Journal Orthopaedic Sports Physical Therapy 1995; 21:38.
22. Vogler HW, Bojsen-Moller F. Tarsal Functions, movement, and stabilisation mechanisms in foot, ankle and leg performance. Journal American Podiatric Medicine Association 2000; 90(3):112-125.