**If it doesn’t work, why do we still do it? The continuing use of subtalar joint neutral theory in the face of overpowering critical research.**

Viewpoint Article Submission

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Introduction

The use of subtalar joint neutral (STJN) in the assessment and treatment of foot related musculoskeletal (MSK) symptomology is thought to be common in daily practice and education 2,6. The main pioneer of this theory was Dr Mert Root9, and it has been labelled “The Foot Morphology Theory”, “The Subtalar Joint Neutral Theory” or simply “Rootian Theory” / “Root Model” 2,3,5,6. Throughout the late 1950s and early 1960s Dr Root reported conducting hundreds of ‘biomechanical assessments’ and began to understand the importance of the subtalar joint from which he defined its 'neutral' position. From here he created a classification of foot morphology, e.g. forefoot valgus, and linked this to foot function in gait15,16,17. These core concepts are still used to underpin a common approach to MSK assessment of the foot as well as the consequent design of foot orthoses.6

The most effective method to create custom foot orthoses has been questioned and, whilst disagreements exist 2,5,19 , available literature continues to point to Dr Root’s theory as being the most prevalently utilized 8,11. Concurrently the worth of Dr Root’s STJN theory has been challenged due to issues with poor reliability 2,7,10, and more recently, limited external validity6. Inaccuracies in the interpretation and application of Dr Root’s theories have also been proposed9. This critical research spans decades and it begs the question as to why clinicians that evaluate and treat lower limb conditions still continue to utilize such a controversial approach.

This viewpoint briefly but critically reviews the main clinical areas of the STJN theory, and concludes with a possible explanation and concerns for its ongoing use. To support our view, we will discuss: 1) historical inaccuracies, 2) challenges with reliability and 3) concerns with validity.

1. **Historical Inaccuracies**

Placing the foot into STJN is used in several underpinning areas of the STJN Theory. These include assessment of the non-weightbearing rearfoot to leg angle, measurement of forefoot to rearfoot position and the position in which casts for foot orthoses prescription are taken 9,15,16,17

The process by which Dr Roots method of foot assessment is researched and utilised is worthy of historical scrutiny. In a historical review of Dr Root’s work by Lee 9 it becomes apparent that the main method employed to find STJN in the literature is not the one initially proposed by Dr Root and his co-workers. All research which has continually criticised reliability and more recently the validity of the STJN theory appear to find STJN by palpating the head of the talus and moving the STJ until articular margin congruency with the navicular is determined. This method was not proposed by Dr Root, but rather Wernick and Langer in 197118. Dr Root never endorsed this method9. Instead Dr Root proposed that:

*Open Kinetic Chain (OKC) STJN Position*

* A dell of the arc of motion of the STJ is notable when moving from the pronated to a supinated position. The position of this dell is STJN 9.
* Using bisection lines and calculating the total STJ range of motion. From there a 2:1 (inversion:eversion) ratio is applied. Moving the Calcaneum 2/3 from its maximally inverted position would detect the STJN. This method was published in 197116
* If performed correctly, Dr Root proposed that both the procedures noted above would find the same position of STJN9.

The OKC dell of motion position of STJN does not appear to have been formally published prior to Lee9, and the reference for this work is quoted as “ML Root, personal communications, 1999”. This assessment is stated to have been presented in seminars and graduate lectures through the 1950s and 60s9. However, the lack of formal documentation or publication may explain the dearth of research and apparent use of this examination technique.

*Closed Kinetic Chain (CKC) STJN Position*

Pronate and supinate the foot in bipedal stance until16:

* There is palpable congruency of the STJ
* Visual concavity of the lateral surface of the foot to the leg is apparent
* A straight line is visible in the area of the calcaneocuboid joint
* When these three observations were noted, STJN was achieved in stance and the rearfoot to ground angle recorded.

Why the CKC methodology is discarded in lieu of the talar margin palpation method proposed by Wernick and Langer18 appears less clear. The use of palpation of the talonavicular joint (in OKC and CKC) to determine STJ congruency (and so STJN) is anatomically a different position to that proposed by Dr Root and his co-workers.

Applying the STJN theory to foot orthoses prescription demonstrates further possible historical inaccuracies. Dr Root may have been developing foot orthoses in his clinical practice15 but no descriptive text on custom orthotic prescription or manufacture was ever made available. Authors have cited Dr Root in their own texts and literature on foot orthoses prescription, often using terminology such as Rootian or Modified Rootian foot orthoses 1,12. It may be unwise to assume that Dr Root would agree with the interpretation of his work. Dr Root and his co-workers gave us a theory, in a time without 3D video gait analysis and computerised plantar pressure examination, by which they believed we could ideally detect ‘normal’ and ‘abnormal’ foot function. They did not follow this up with any literature relating to the application of this theory to orthoses prescription.

1. **Challenges with Reliability**

All available research on the reliability of STJN measurements have been found to be mostly moderate (Intra-tester) to poor (inter-tester) 2, 7,10,14, including joint positions and recommended bisection line placement on the leg and foot. With regards to orthoses, the most common interpretation of the STJN theory requires a cast or impression of the foot to be taken in a non-weightbearing STJN 1,9,12,15, resulting in a ‘neutral negative cast’ of the foot. The shape of the neutral cast is of upmost importance, as it is essential to capture the correct forefoot-to-rearfoot alignment. Without beginning to introduce issues with orthotic manufacture and casting reliability, the problems with STJN position reliability immediately seem to undermine this method.

1. **Concerns with Validity**

A recent article6 has soundly questioned the validity of the foot morphology observations in Dr Root’s STJN theory relating to gait. In this only paper of its kind, none of the static examinations advocated in Dr Root’s STJN theory related to altered foot kinematics. Areas investigated included the STJN position and also the first ray position and forefoot to rearfoot angle. This is of prime importance when attempting to relate the STJN position to foot orthoses impression casting and prescription. Jarvis et al6 concluded that both the poor reliability and validity of these underpinning STJN theory cornerstones mean “the Root et al. description of foot function and the associated assessment protocol are not a sound basis for clinical evaluation of the foot nor orthotic prescription.”

Conclusion

If it doesn’t work, why is it still done?

In the light of this uncertainty into the reliability, validity and historical accuracy of the STJN theory, we propose that its use in MSK lower limb clinics should be re-evaluated. However, despite the issues noted above, the outcome of the use of foot orthoses based broadly upon this theory appears positive 5. The most recent Cochrane Library review on the efficacy of custom foot orthoses5 concluded there is a gold level of evidence for painful pes cavus and a silver level of evidence for foot pain in plantar fasciitis, rheumatoid arthritis and hallux valgus. Seven of the included 11 articles stated STJN as the position from which negative cast impressions were taken. It appears the STJN theory has become an accepted 'clinical fiction', an approach where although clinicians are not measuring or assessing what they propose, and the theory may not describe reality, the net outcome is positive13. In other words, the process which leads to treatment may work, but not in a way that the critical issues and theoretical failings actually matter.

Another explanation on the continued use of the STJN theory is that alternative foot based theories also lack large population investigations to assess their clinical relevance, and also suffer from observer reliability and theoretical validity concerns 2,4. Why should clinicians change their approach if there is no proven theory with a workable clinical assessment and treatment methodology to adopt?

However, it is important to recognise Dr Root’s STJN theory as being a clinical fiction, as the acceptance of the fiction as fact results in practitioner resistance to change and an inability to look outside of established theory. Such a situation can lead to stagnation and slow development of possibly more effective alternative ideas. With ongoing theoretical uncertainty in relation to the foot and MSK injuries, it may benefit the practitioner to be inclusive of all theories within the framework of best evidence rather than dogmatic or exclusive to historical fictional models.

**References**

1. Anthony R. *The Manufacture and Use of the Functional Foot Orthoses*. Karger. 1990
2. Harradine P, Bevan L. A review of the theoretical unified approach to podiatric biomechanics in relation to foot orthoses therapy. *J Am Pod Med Assoc*. 2009; 99:317-25
3. Harradine P, Bevan L, Carter N. An overview of podiatric biomechanics theory and its relation to selected gait dysfunction. *Physiother*. 2006; 92: 122-127.
4. Harradine PD, Bevan LJ, Carter N. Podiatric Biomechanics Part 1: Foot based Models. *Br J of Pod*. 2003; 6:5-11
5. Hawke F, Burns J, Radford J, et al. Custom-made foot orthoses for the treatment of foot pain. *Cochrane Database Syst Rev*. 2008;3
6. Jarvis H, Nester C, Bowden P, et al. Challenging the foundations of the clinical model of foot function: further evidence that the root model assessments fail to appropriately classify foot function. *J Foot Ankle Res*. 2017; 10:7
7. Jarvis H, Nester C, Jones R, et al. Inter-assessor reliability of practice based biomechanical assessment of the foot and ankle. *J Foot Ankle Res*. 2012; 5:14
8. Landorf K, Keenan A, Rushworth R. Foot orthosis prescription habits of Australian and New Zealand podiatric physicians. *J Am Podiatr Med Assoc*. 2001;91:174–83.
9. Lee WE. Podiatric biomechanics. An historical appraisal and discussion of the root model as a clinical system of approach in the present context of theoretical uncertainty. *Clin Podiatr Med Surg*. 2001; 18:555-684.
10. Menz H. Clinical Hindfoot Measurements: a critical review of the literature. *The Foot.* 1995;5:57-63.
11. Menz H, Allan J, Bonanno D, et al. Custom-made foot orthoses: an analysis of prescription characteristics from an Australian commercial orthotic laboratory. *J Foot Ankle Res*. 2017; 10:23.
12. Michaud T. *Foot orthoses and other forms of conservative foot care*. Philadelphia: Lippincott Williams and Wilkins; 1993
13. Payne C. The role of theory in understanding the midtarsal joint. J Am Pod Med Assoc. 2000; 311-319.
14. Picciano AM, Rowlands MS, Worrell T. Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. J Orthop Sports Phys Ther. 1993; 18:553-8.
15. Root ML. How was the Root functional orthotic developed? *Perspectives in Podiatry*. Podiatry Arts Lab lnc. Fall 1981
16. Root ML, Orien WP, Weed J, et al. Biomechanical Examination of the Foot, Vol 1. Clinical Biomechanics Corporation. 1971.
17. Root ML, Orien WP, Weed J. Clinical Biomechanics Vol II. Normal and Abnormal function of the Foot. Clinical Biomechanics Corporation. 1977
18. Wernick J, Langer S*: A Practical Manual for a Basic Approach to Biomechanics*. New York, Langer Acrylic Laboratory. 1971.
19. Williams AE, Martinez-Santos A, McAdam J, Nester CJ. 'Trial and error...','...Happy patients' and '...An old toy in the cupboard': a qualitative investigation of factors that influence practitioners in their prescription of foot orthoses. *J Foot Ankle Res*. 2016; 9:11.