A comparison study of custom foot orthotics versus manual therapy for lateral column equinus

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Introduction

Lateral column equinus is a poorly represented pathomechanical pedal anomaly. It is similarly inadequately described in literature. It is however evident in many people with various clinical manifestations, all of which have very little epidemiological commonality.

When identified in a clinical setting, the treatment paradigms are varied and depend on presentation, clinical history, patient complaint and practitioner bias – informed by scope, training, experience and preference.

This study looked at the comparison of managing lateral column equinus in patients with a simple and common visual clinical manifestation with custom foot orthotics and various manipulations and manual therapies targeting the pedal lateral column.

Methodology

A comparison study looked at three cohorts of ten patients each (n=20), randomly placed using specific inclusion and exclusion criteria. Each group was assigned a treatment option for lateral column equinus, looking at quantitative, qualitative and patient reported reduction of pain and symptoms for 5^{th} metatarsal head heloma durum, a common clinical manifestation of lateral column equinus.

Inclusion criteria

1. Adult, male and female
2. Lateral column equinus, confirmed by the presence of a heloma durum on the plantar aspect of the 5^{th} metatarsal head, unilateral or bilateral, that is correlated with clinically confirmed osseous position of the lateral column in relation to the medial column in the sagittal plane and without dorsiflexion of the column
3. First time seeking treatment
4. Correctible fore-foot varus

Exclusion criteria

1. Children
2. Co-morbidities that necessitate exclusion based on urgency to treat, such as diabetes, ulceration, neuropathy.
3. Surgical intervention on kinetic chain
4. Irreducible fore-foot varus

Consent was obtained prior to all treatment.

Group 1 treatment

Sharp debridement and enucleation of heloma durum(s). Casting in STJ neutral. Manufacture of thermo-plastic shell, standard heel cup, 5^{th} metatarsal cut-out and metatarsal accommodation pad with # 5 cut-out.

Group 2 treatment

Cuboid, talus, ankle and fibula head adjustment. Peroneal and pedal intrinsic manual therapy massage.

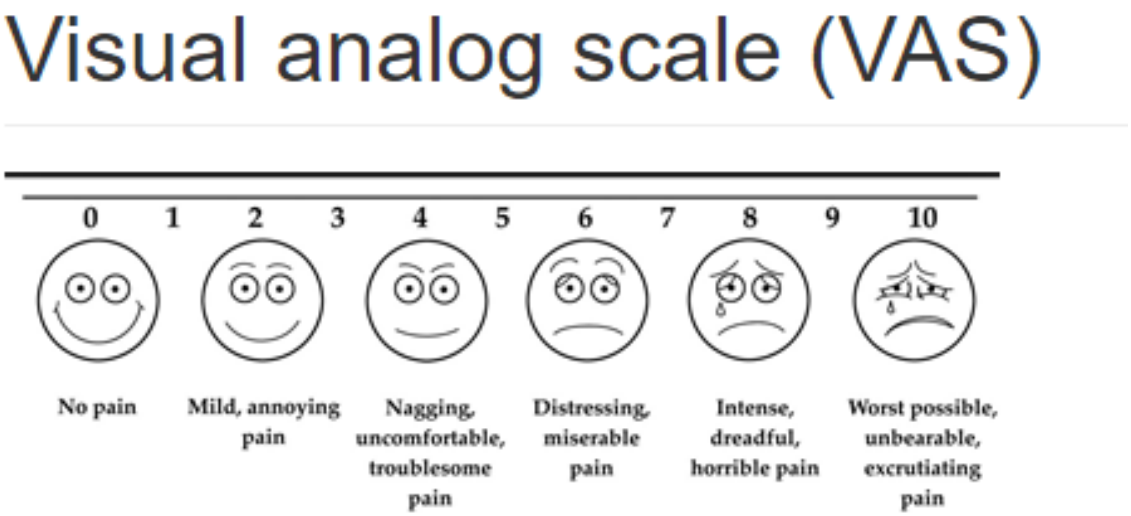
Group 3 treatment

Combination of both treatment interventions of group1 and group 2.

Additional comments

In the case of group 1 and 3, all participants were followed up as per orthotic dispensing and follow-up criteria and were advised on wearing-in protocols. Each was re-seen at 3 and then at 6 weeks for review of orthotic fit and compliance. No participant in either group 1 and 3 required modification to the orthotic.

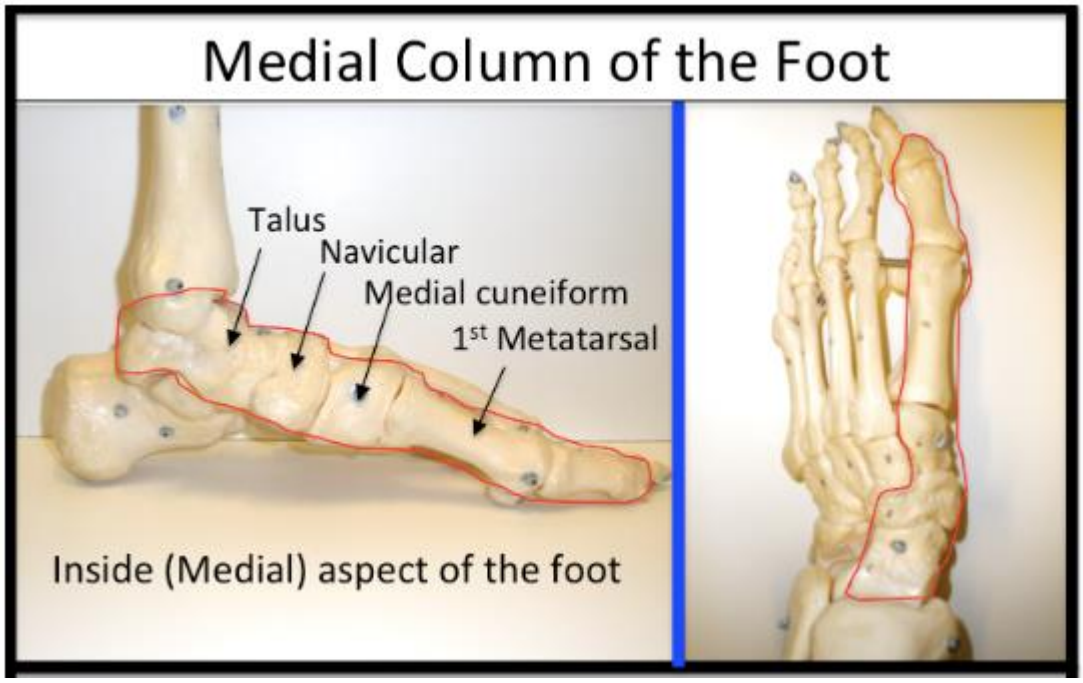
All three groups were reviewed at 6 weeks and again at 10 weeks for assessment of recurrence, pain and compliance in the case of group 1 and 3. Tools such as the visual analog scale were used where the patient was asked to mark their position from one to ten relative to pain, recurrence and satisfaction/ expectation.

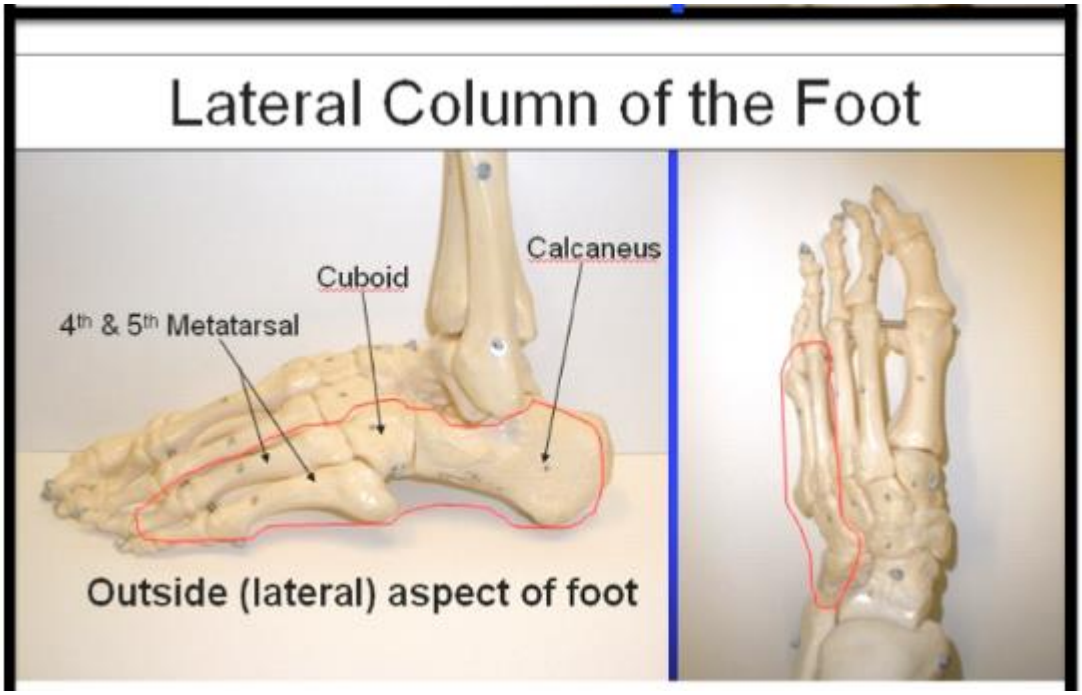


Example of VAS scale used to determine patients experience regarding pain at 6 and 3 weeks.

Lateral column equinus

It is common amongst health care professional in the care of the foot and ankle to describe the foot as having either two or three columns. Medial and lateral, or medial, central and lateral. In both of the above descriptions, the medial column is the more mobile of the columns and consists of the talus, navicular, medial cuneiform, 1st metatarsal and the hallux. The lateral column is significantly stiffer and is comprised of the calcaneus, cuboid, 4th and 5th metatarsals and their phalanges.





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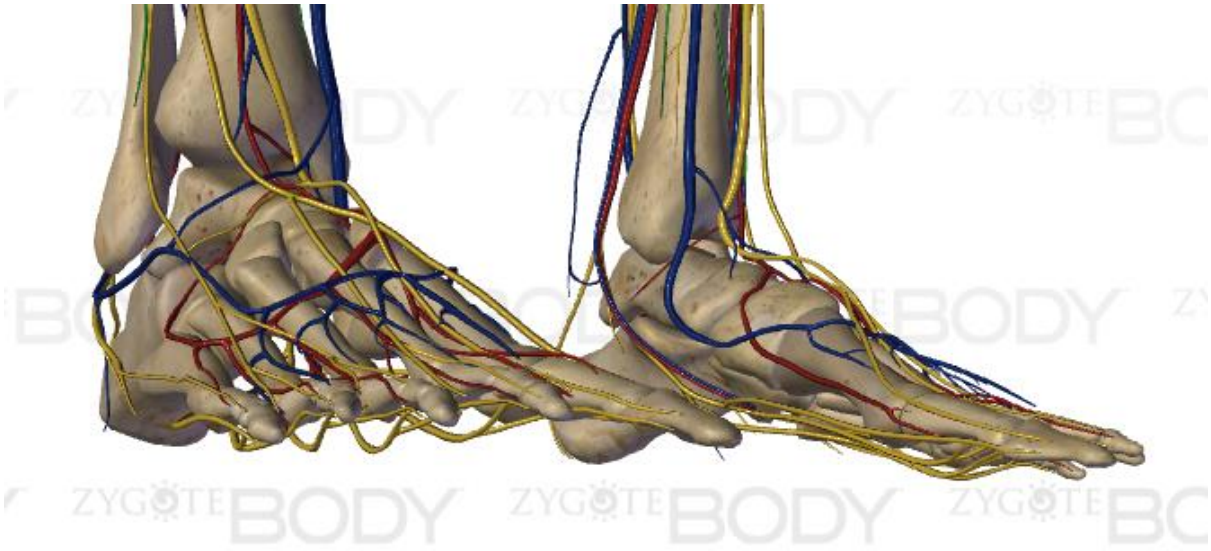
Of vital anatomical purpose is the position of the lateral column relative to the medial column. The lateral column supports the medial column from underneath. In other words, the lateral column sits on top of the lateral column.

The lateral column is responsible for stability through the gait cycle and allows an augmented base upon which the medial column can adapt to various surfaces, allowing for shock attenuation, absorption and propulsion.



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The lateral column is in equinus when the distal region is in a plantar-grade position relative to its proximal region that has been identified relative to the medial column and in a non-weight bearing examination of the foot. Further, the mobility of the lateral column is reduced in the absence of osseous pathology or trauma. Dorsiflexion at the articulation of the base of the 4th and 5th metatarsal – cuboid joint, in particular will be compromised.

Lateral column equinus is therefore evident when as a result of this plantar-grade position with reduced dorsiflexion, ground reaction force at late stage stance phase and through propulsive phase of the gait cycle, compensatory mechanics are evident with the supposition of commensurate symptoms. Pathology at the base of the 5th metatarsal head being common.

Lateral column equinus clinical manifestations

Jacob et al. (2010) reported on patients having undergone surgical lateral column lengthening with resultant increased lateral column pain, found significantly increased measures of average mean pressure, peak pressure and maximum force. The authors used force plates to ascertain these loads after excluding for differences in skeletal variations from radiographic data. These increased load-causing incidents of distal lateral column loading, corroborated by Thordarsen et al. in 2020, were prominent in the plantar 5th metatarsal head.

In a 2016 study, Koldenhoven and colleagues, looking at surface electromyography and plantar pressure during walking in young adults with chronic ankle instability, listed a limited list of pathological manifestations of lateral column equinus. This included 5th metatarsal head bursitis, hyperkeratosis, heloma durum formation, synovitis and Tailor's bunion. They did focus in reporting their results, supported by Burnfield et al. (2003), on lateral column pain being the primary complaint of lateral column equinus.

Custom foot orthotics

History

Fred Thompson, in his 2019 article, states that the first reported orthotic were pieces of wool inserted under foot nearly 2000 years ago. He goes on to state that the first recorded arch support was in 1865 by Everret Dunbar of Massachusetts, who inserted leather strips under the soles of his shoes to support his arch.

In 1905 an orthopaedist named Royal Whitman developed the Whitman Brace which was a high flanged structure that did very well to relieve foot pain and discomfort. Dr Scholl's Foot Easer followed in 1906 with a stronger and lighter metal foot support.

Following both world wars and the devastating Polio epidemic of the late 1940's and 1950's, the US Government sponsored a massive research collaboration of research and innovation into orthotic design, fabrication and development. Between 1945 and 1976, the Veterans Administration, along with Universities, military and private companies conducted numerous experiments on orthotic research projects. The result was an unprecedented surplus of over 1000 different brands of health shoes on the market, with fierce competition between brands. Eventually the Federal Trade Commission was forced to issues cease and desist orders, causing the near collapse of the corrective shoe industry for a time.

It wasn't until the early 1960s that modernisations in prosthetic and orthotic designs were influenced by adapting industrial techniques for vacuum forming sheet plastics. The National Academy of Sciences National Research Council began to promote many disciplines of scientific research initiatives into human locomotion, biomechanics and the conception of new materials and devices. Orthotics gained new purchase as materials have become lighter, more flexible and stronger.

Custom foot orthotics form an integral management tool within the scope of many health-care professionals. As new materials and fabrication methods are being employed in the manufacture of orthotics, the corresponding addition of research and pathology-specific designs become more evident.

Similarly, CAD design tools have slowly become the method of choice by centralised orthotics labs globally.

Research

A Medline, Google Scholar and PubMed search for the term 'foot orthotic' revealed between 1910 and 1950, seven results into the effect of foot orthotics on some form of gait or pathology. Similarly the same search criteria from 1950 to 2000, resulted in 4 830 results. Between 2000 and 2020, 17 000 results.

It is clear that foot orthotics have cemented their place in modern practice of medicine dealing with human locomotion, vocation and non-communicable diseases and the research output supports and proves it.

Indications for lateral column equinus

In the specific focus of 5th metatarsal head heloma durum formation resulting from lateral column equinus, Paul Scherer, in his 2011 article speaks of the relationship between off-loading and deflecting the distal 5th ray/ lateral column. Ki and colleagues in a 2008 study highlighted adding minimal cast dressing to orthotics in the treatment of lateral column loaded lesions. The study highlights for every Newton of force added to the mid-foot of the orthotic, a Newton of force is removed from the fore-foot. Similarly, for the addition of eversion/ inversion moments added to the orthotic, the differing eversion/ inversion moment is created in the foot – changing the centre of pressure and reducing peak loads, where required.

The more common forms of orthotic design for lateral column equinus is a 5th ray cut-out, 5th cut-out from an added metatarsal accommodation pad, cuboid notch, lateral skive and valgus moment to a rear-foot post.

Manual therapy

Manual therapy has an extended history within the profession of physical therapy, osteopathy and deep tissue massage, and therapists have momentously contributed to the current diversity in manual therapy approaches and techniques. Mechanical and physical elucidations were historically used to explain the mechanisms by which manual therapy interventions worked, new research reveals involved neurophysiologic mechanisms are also at play and the beneficial psychological effects of providing hands-on examination and intervention should not be ignored.

The International Federation of Orthopaedic Manipulative Physical Therapists defines manual therapy techniques as: "Skilled hand movements intended to produce any or all of the following effects: improve tissue extensibility; increase range of motion of the joint complex; mobilise or manipulate soft tissues and joints; induce relaxation; change muscle function; modulate pain; and reduce soft tissue swelling, inflammation or movement restriction."

According the American Academy of Orthopaedic Manual Physical Therapists Description of Advanced Specialty Practice, orthopaedic manual physical therapy is defined as: any “hands-on” treatment provided by the physical therapist.

Treatment may include moving joints in specific directions and at different speeds to regain movement, muscle stretching, passive movements of the affected body part or having the patient move the body part against the therapist’s resistance to improve muscle activation and timing. Selected specific soft tissue techniques may also be used to improve the mobility and function of tissue and muscles.

Lateral column

By extension of the pedal lateral column, the lateral column of the leg in locomotion consists of the fibula and its associated soft tissue structures, including the peroneal musculature and illio-tibial band. Proximal to this is the high hip and pelvis structures defining not only the origins of the illio-tibial band but the pathophysiological forces and tension loading influencing the gluteus medius and the origin of the illio-tibial band.

In a number of pathomechanical states, when loading the torsional force is applied to the lateral column, the articulations of the fibula head, lateral ankle mortise and cuboid-calcaneus, cuboid-lateral cuneiform and the cuboid-base of 4^{th} and 5^{th} metatarsals, have the opportunity to, and in many cases, do shift, resulting in altered kinematics through mid-stance of the gait cycle.

Techniques

Various professions have demonstrated a number of techniques in manipulating and mobilising joint articulations pertaining to the lateral column. Of primary importance are those methods that combine soft tissue manual therapy that address largely aetiological change, and changes to articulations which seem to be secondary, as corroborated by Dananberg (2000).

The high velocity-low amplitude (HVLA) technique of manipulation was used, in which the provider provides a high velocity beneficial force of a short duration that travels a small distance (low amplitude) within the anatomic range of motion of a joint and occupies a restrictive barrier in one or more planes of motion to elicit the release of restriction. This is a generally accepted osteopathic technique employed by manual osteopaths, physical therapists and chiropractors, globally.

Joint Manipulation - A passive, high velocity, low amplitude thrust applied to a joint complex within its anatomical limit with the intent to restore optimal motion, function, and/ or to reduce pain.

Joint Mobilisation: A manual therapy technique comprising a continuum of skilled passive movements to the joint complex that are applied at varying speeds and amplitudes, that may include a small-amplitude/ high-velocity therapeutic movement (manipulation) with the intent to restore optimal motion, function, and/ or to reduce pain.

For this study, a combination of joint manipulation/ mobilisation and HVLA were employed to ensure focus on primary and secondary causative factors and to ensure parity across the test subjects.

Joints manipulated/ mobilised and measurable gains

- Fibula head- tibia

    - Mobility in full knee extension of the proximal fibula through its tibial articulation
    - Peroneal strength testing pre and post manipulation
- Ankle mortise
    - Foot dorsiflexion with extended leg =>10°
    - Mid-line of foot correction to tibial crest
    - Anterior and posterior muscle strength testing pre and post manipulation
- Dorsiflexion through priming of 4^{th} and 5^{th} rays
    - Equidistant dorsiflexion/ plantarflexion of lateral column with focus on discernible change in dorsiflexion

HVLA manual therapy

- Illio-tibial band release
- Peroneal longus and brevis release
- Abductor Digiti Minimi
- Flexor Digiti Minimi Brevis

Study results

Group 1 – debridement and orthotic manufacture

10 patients were all made a pair of orthotics. Advice was given on dispensing and follow up. All patients were followed up as per study protocols. No patients required adjustment or modification of orthotic.

Key study criteria

- Recurrence
- Pain
- Compliance (group 1 only)

Review at week 6

Recurrence

- 1 patient did not attend week 6 follow up
- 6 patients showed no recurrence

Pain

- 5 patients reported reduced VAS

Compliance

- 9 patients demonstrated 100% compliance following instructions given at dispensing

Review at week 10

Recurrence

- 10 patients attended
- 8 patients showed recurrence

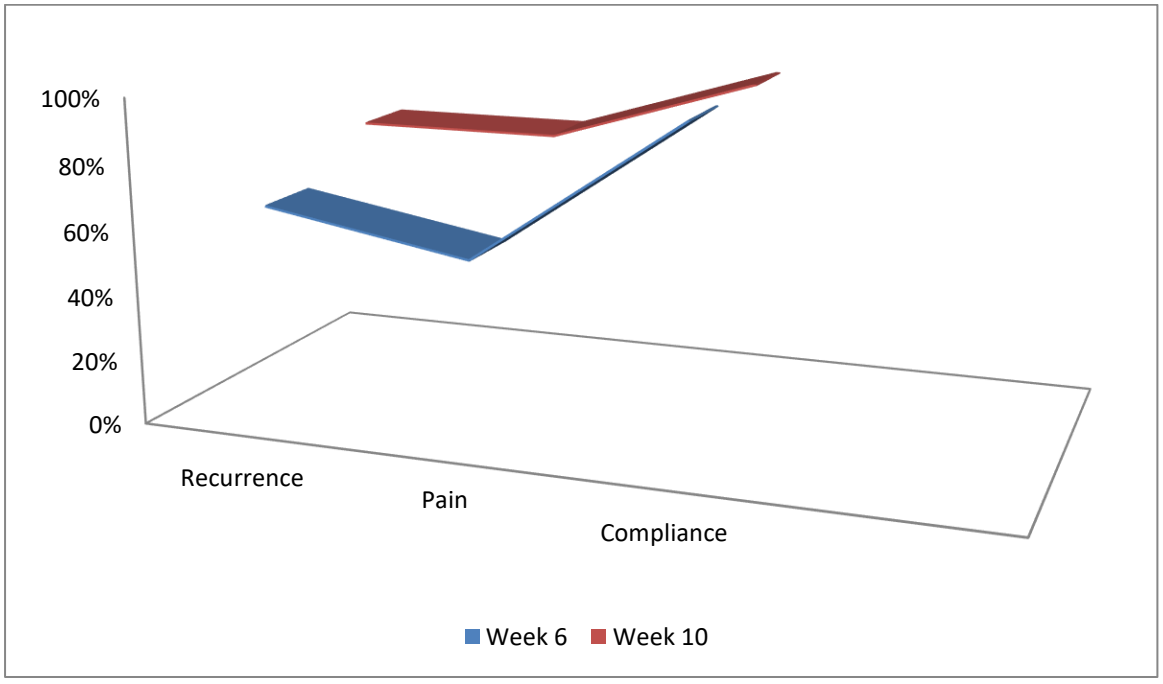
Pain

- Initial 5 patients reporting reduction in VAS scores, reported increased VAS but reduced relative to study enrolment, plus 3 others

Compliance

- 10 patients demonstrated 100% compliance

6 week follow up – 9/10	**Key study criteria**	**10 week follow up – 10/10**
6 (66%)	**Recurrence**	8 (80%)
5 (55%) ↓	**Pain**	8 (80%) ↑
9 (100%)	**Compliance**	10 (100%)



Group 2

10 patients enrolled into this group underwent manual therapy as previously described. They were followed up at week 6 and week 10 and measured against the same criterion as in group 1; recurrence and pain.

Review at week 6

100% of participants followed up at this point.

60% showed no recurrence

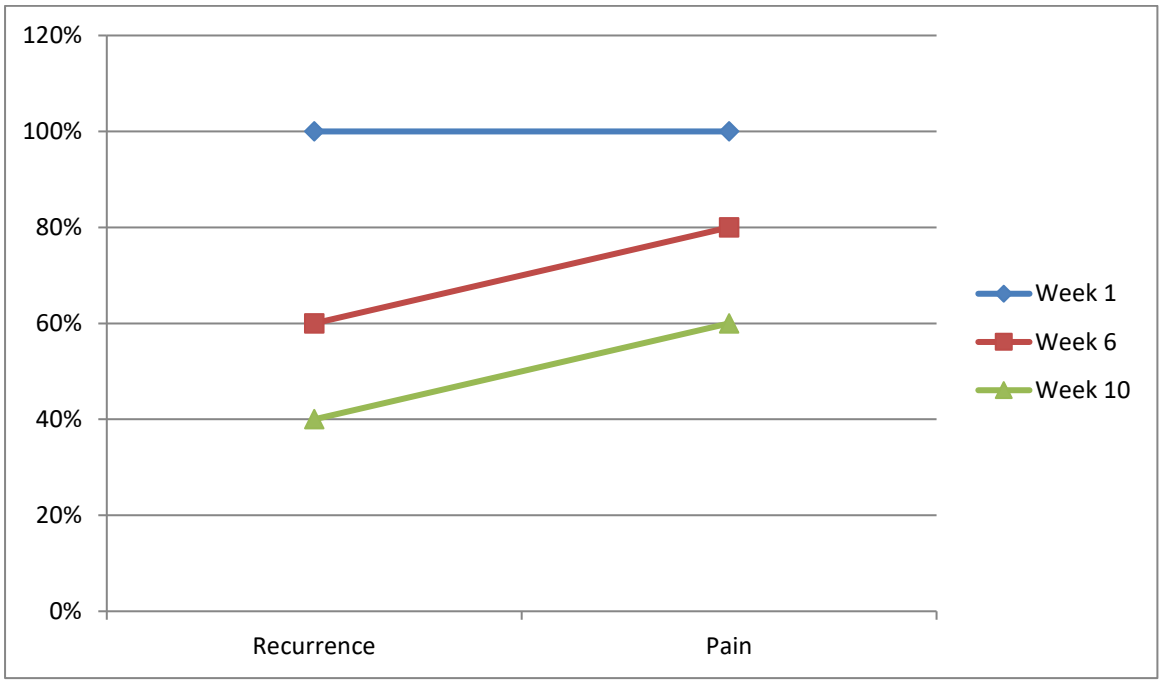
80% revealed marked reduction in VAS scores marking pain

Review at week 10

100% of participants followed up at this point.

40% showed no recurrence

60% revealed marked reduction in VAS scores marking pain



Group 3

10 patients were enrolled into this group and had both treatments applied.

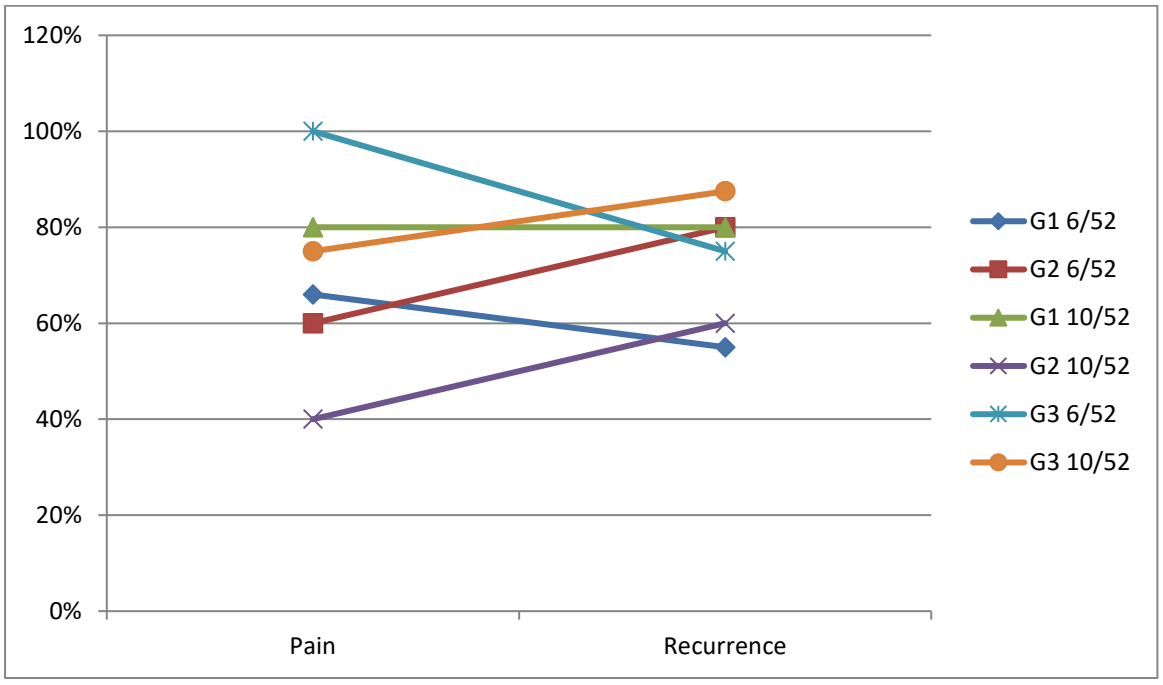
8 participants followed up at both 6 and again at 10 weeks. 2 participants (husband and wife) left for overseas. This group was then benchmarked at 8 participant's total.

All 8 enrolees demonstrated marked improvements in recurrence and pain. 6 participants (75%) had no recurrence at week 6 and at week 10.

Pain was similarly marked. At week 6, all 8 participants highlighted marked reduction in pain scores using the VAS score and 7 at week 10.

Summary table of results

	6 Week Group 1	**6 Week Group 2**	**6 Week Group 3**	**10 Week Group 1**	**10 Week Group 2**	**10 Week Group 3**
Recurrence	6/9 (66%)	6/10 (60%)	6/8 (75%)	8/10 (80%	4/10 (40%	6/8 (75%)
Pain	5/9 (55%)	8/10 (80%)	8/8 (100%)	8/10 (80%)	6/10 (60%)	7/8 (87.5%)



Discussion

The results obtained following the two interventions revealed that at week 6, the recurrence of the heloma durum's, were 66% vs 60% respectively, following one group 1 participant not following up at this point. At week 10 follow up, a marked difference was observed in that 80% reported a reduction of pain versus 60% in the group 2 subjects.

Subjective pain scores, obtained by patient-oriented VAS scoring, established significant differences at week 6 and week 10 in group 1. 55% at week 6 versus 80% reduction in pain at week 10. Group 2 went the other way, in that 80% reported a reduction in pain at week 6 compared to only 60% at week 10.

These data suggest that 6 weekly interventions show a significant improvement in group 2 subjects that were comparable in recurrence to group 1. It is also clear that a combination of both interventions (Group 3) may offer the better long term results than each individual one.

Conclusion

Lateral column equinus is a common presenting pathology but poorly defined in the literature. Many people are afflicted by various clinical manifestations and are managed by various healthcare professionals in their clinical scope and healthcare practice. It is clear that lateral column equinus is best managed by a combination of methods that target both the skeletal changes that occur along the proximal lateral column and the distal pedal lateral column, as well as the soft tissue structures that align with and support and attenuate its physiological function.

Future research is required to identify primary aetiological factors and to recognise, classify and define secondary pathological patterns.

Reference list

Brugh, A.M., Fallat, L.M. and Savoy-Moore, R.T. (2002). Lateral column symptomatology following plantar fascial release: A prospective study. *The Journal of Foot and Ankle Surgery*, [online] 41(6), pp.365–371. Available at: https://pubmed.ncbi.nlm.nih.gov/12500787/ [Accessed 30 Jan. 2021].

Burnfield, J.M., Few, C.D., Mohamed, O.S. and Perry, J. (2004). The influence of walking speed and footwear on plantar pressures in older adults. *Clinical Biomechanics*, [online] 19(1), pp.78–84. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0268003303002171 [Accessed 19 Mar. 2021].

Custom Prescription Foot Orthotics Brantford, Ontario - Thompson Health Services. (2019). *The Origins And Evolution of Orthotics: How Ergonomic Footwear Began*. [online] Available at: https://www.thompsonhealthservices.ca/origins-of-orthotics/#:~:text=In%201905%20Whitman%20Brace%20developed,the%20device%20on%20Whitman's%20behalf.&text=Prosthetic%20shoes%20guaranteed%20to%20prevent,of%20foot%20and%20mobility%20issues. [Accessed 28 Jan. 2021].

Dananberg, H. (2000). Sagittal plane biomechanics. American Diabetes Association. *Journal of the American Podiatric Medical Association*, [online] 90(1), pp.47–50. Available at: https://pubmed.ncbi.nlm.nih.gov/10659532/ [Accessed 11 Jan. 2021].

Ellis, S.J., Yu, J.C., Johnson, A.H., Elliott, A., O'Malley, M. and Deland, J. (2010). Plantar Pressures in Patients with and without Lateral Foot Pain After Lateral Column Lengthening. *The Journal of Bone and Joint Surgery-American Volume*, [online] 92(1), pp.81–91. Available at: https://journals.lww.com/jbjsjournal/Abstract/2010/01000/Plantar_Pressures_in_Patients_with_and_without.11.aspx [Accessed 7 Feb. 2021].

Elsevier (2021). *Clinical Biomechanics of the Lower Extremities - 1st Edition*. [online] Elsevier.com. Available at: https://www.elsevier.com/books/clinical-biomechanics-of-the-lower-extremities/valmassy/978-0-8016-7986-5 [Accessed 10 Apr. 2021].

Gupton, M., Akul Munjal and Kang, M. (2020). *Anatomy, Bony Pelvis and Lower Limb, Fibula*. [online] Nih.gov. Available at: https://www.ncbi.nlm.nih.gov/books/NBK470591/ [Accessed 27 Feb. 2021].

Hammell, L. and Null, M. (2020). *Osteopathic Manipulative Treatment: HVLA Procedure - Thoracic Vertebrae*. [online] Nih.gov. Available at: https://www.ncbi.nlm.nih.gov/books/NBK562143/#:~:text=High%20velocity%2Dlow%20amplitude%2C%20or,one%20or%20more%20planes%20of [Accessed 11 Apr. 2021].

Ifompt.org. (2020). *IFOMPT - The International Federation of Orthopaedic Manipulative Physical Therapists*. [online] Available at: https://www.ifompt.org/ [Accessed 9 Mar. 2021].

Ki, S.W., Leung, A.K.L. and Li, A.N.M. (2008). Comparison of plantar pressure distribution patterns between foot orthoses provided by the CAD-CAM and foam impression methods. *Prosthetics & Orthotics International*, [online] 32(3), pp.356–362. Available at: https://pubmed.ncbi.nlm.nih.gov/18677672/ [Accessed 10 Jan. 2021].

Koldenhoven, R.M., Feger, M.A., Fraser, J.J., Saliba, S. and Hertel, J. (2016). Surface electromyography and plantar pressure during walking in young adults with chronic ankle instability. *Knee Surgery, Sports Traumatology, Arthroscopy*, [online] 24(4), pp.1060–1070. Available at: https://link.springer.com/article/10.1007%2Fs00167-016-4015-3 [Accessed 1 Apr. 2021].

Lower Extremity Review Magazine | Rehabilitation • Trauma • Diabetes • Biomechanics • Sports Medicine. (2011). *Orthotic intervention for metatarsalgia relief | Lower Extremity Review Magazine*. [online] Available at: https://lermagazine.com/article/orthotic-intervention-for-metatarsalgia-relief#:~:text=Using%20the%20previously%20cited%20data,the%20first%20ray%20plantar%20flexed. [Accessed 5 Apr. 2021].

OrthoPaedia. (2021). *Anatomy, Foot & Ankle: Musculoskeletal Medicine*. [online] Available at: https://orthopaedia.com/page/Anatomy-of-the-Foot-Ankle#:~:text=Columns%20of%20the%20Foot,the%204th%20and%205th%20metatarsals. [Accessed 17 Mar. 2021].

Physiopedia. (2021). *Massage image.jpg*. [online] Available at: https://www.physio-pedia.com/File:Massage_image.jpg [Accessed 11 Apr. 2021].

Thordarson, D.B., Schon, L.C., de Cesar Netto, C., Deland, J.T., Ellis, S.J., Johnson, J.E., Myerson, M.S., Sangeorzan, B.J. and Hintermann, B. (2020). Consensus for the Indication of Lateral Column Lengthening in the Treatment of Progressive Collapsing Foot Deformity. *Foot & Ankle International*, [online] 41(10), pp.1286–1288. Available at: https://journals.sagepub.com/doi/abs/10.1177/1071100720950732 [Accessed 10 Apr. 2021].

Zygotebody.com. (2012). *Zygote Body 3D Anatomy Online Visualizer | Human Anatomy 3D*. [online] Available at: https://www.zygotebody.com/#nav=2.24,-5.84,40.34,0,0,0,0&sel=p:;h:;s:;c:0;o:0&layers=0,1,5851 [Accessed 10 Apr. 2021].