THE ASSOCIATION BETWEEN PLANTAR FASCIITIS AND ISOLATED GASTROCNEMIUS TIGHTNESS

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Declaration

I Ngenomeulu Tufikifa Nakale, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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…**05th**……day of …**June**….20**18**…….in **Park town, Johannesburg**……

Dedication

This research report is dedicated to my wife, parents and siblings for all their patience and understanding.

Presentations

Podium presentation at the South Africa Orthopaedic Association 66th Annual Congress: 4 – 7 September 2017, Port Elizabeth, South Africa.

Publications

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Abstract

Background: Plantar fasciitis is a painful inflammatory condition affecting the plantar aponeurosis of the foot. An association between plantar fasciitis and isolated gastrocnemius tightness has been postulated in published literature; however there have been few studies to prove this relationship. The aim of this study was to determine the association between plantar fasciitis and isolated gastrocnemius tightness.

Material and Methods: This was a prospective cross-sectional cohort study over a three-month period comprising three groups: 45 patients with plantar fasciitis, 117 patients with foot and ankle pathology other than plantar fasciitis and 61 patients without foot and ankle pathology. Patients were examined for the presence of isolated gastrocnemius tightness using the Silfverskiöld test. The data were analysed using STATA version 14. Statistical tests included the chi-square test, Student's t-test and analysis of variance (ANOVA). Statistical tests were two-sided at $\alpha = 0.05$.

Results: Overall, 101/223 (45.3%) patients had isolated gastrocnemius tightness, 36/45 (80%) in the plantar fasciitis group, 53/117 (45.3%) in the other foot and ankle pathology group and 12/61 (19.7%) in the group without foot and ankle pathology. The difference in the prevalence of isolated gastrocnemius tightness amongst the three groups was statistically highly significant at $p < 0.001$. The prevalence of isolated gastrocnemius tightness was similar between acute and chronic symptoms of plantar fasciitis at 78.9% and 80.6%, respectively.

Conclusion: There is a very strong association between plantar fasciitis and isolated gastrocnemius tightness, OR 16.3, 95% CI (6.1 – 42.5); $p < 0.001$ as well as a strong association between foot and ankle pathology other than plantar fasciitis and isolated gastrocnemius tightness, OR 3.4, 95% CI (1.6 – 7.0); $p = 0.001$ using the group without foot and ankle pathology as reference.

Level of Evidence: Level 2, Cross-sectional Cohort Study

Key words: Plantar fasciitis, Silfverskiöld test, Isolated gastrocnemius tightness

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Nomenclature

ACPS	Achilles-Calcaneus-Plantar System
ANOVA	Analysis of Variance
BOTOX	Botulinum Toxin
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
CI	Confidence Interval
ESWT	Extra- corporeal Shockwave Therapy
F & A	Foot & Ankle
HREC	Human Research Ethics Committee
ICU	Intensive Care Unit
IGT	Isolated Gastrocnemius Tightness
IQR	Interquartile Range
OR	Odds Ratio
PF	Plantar Fasciitis
PRP	Platelet Rich Plasma
SD	Standard Deviation

1 Introduction and Literature Review

1.1 Background

Plantar Fasciitis(PF) is defined as a localised inflammation and degeneration of the proximal plantar aponeurosis.[1] The plantar fascia or aponeurosis is a dense fibrous structure that originates from the calcaneus, it runs under the fat pad and progresses distally to form five slips that inserts to each toe. The inflammation typically occurs at the point of origin near the medial tuberosity of the calcaneus, with histological appearance of a fibro fatty degeneration with associated micro tears and collagen necrosis. PF is a common problem, with a reported incidence of 11 -15% of all consultations at foot and ankle units amongst adults.[2,3] Acute PF is diagnosed in patients presenting with symptoms for a duration less than nine months whereas chronic PF refers to presence of symptoms longer than nine months. The diagnosis of PF is generally a clinical one, based on typical history and clinical findings. The patient presents with foot pain worse in the morning with the first step or after a prolonged period of rest. The pain improves after mobilisation but may worsen if mobilisation is prolonged or is strenuous. The location of the pain can also be highly suggestive, typically located on the plantar-medial aspect of the foot at the origin of the plantar fascia from the medial calcaneal tubercle. Passive dorsiflexion of the toes, the windlass test, reproduces the pain.[4]

The plantar fascia is an important part of the normal foot and ankle biomechanics, serving to sustain the arch of the foot whilst also stabilising the joints of the foot. Together with the other structures in the foot, they form an arch-like triangular structure or truss. The arch of the truss is formed by the calcaneus, mid tarsal joints and

metatarsals, whilst the plantar fascia acts like a windlass between the calcaneus and phalanges, tightening like a rope when toes are lifted on a weight bearing foot. This is called the windlass mechanism as initially described by Hicks.[5]

Studies have shown that there is an anatomic, histologic, mechanical and functional link between the plantar fascia and the Achilles tendon through the calcaneal tuberosity. [6,7,8] The extent of the connection and the duration remains a topic of debate. Arandes and Viladot (1953) postulated that the connection is primarily present in childhood up to the age of seven years when the secondary ossification centre appears inside the fibres that connect the Achilles tendon and the plantar fascia.[9] Other authors have presented evidence in support of the idea that this anatomic connection could vary with the plantar fascia in neonates which is lost in adults and absent in the elderly.[10,11] The concept of an independent functional unit, the Achilles-Calcaneus-Plantar System (ACPS), described in earlier texts was popularised by Arandes and Viladot (1953).[9] The ACPS's main function is to transmit Achilles tendon force to distal structures that will add to the short flexors.

Another model, the sagittal foot model presented by Kirby (2009) demonstrates the mechanical connection of the gastrocnemius muscle by means of the Achilles tendon as well as the plantar fascia. This model divides the forces acting on the foot and ankle into external forces (gravity and ground reaction forces) and internal forces (Achilles tendon and plantar fascia tensional forces) to explain the mechanical behaviour of the foot and ankle.[12] Achilles tendon tensional force leads to hindfoot plantar flexion and forefoot dorsiflexion with an associated increase in ground reaction forces which naturally tends to flatten the arch of the foot. The flattening force is counteracted by tension of the plantar structures, particularly the plantar fascia, preventing arch collapse. Kirby's model has been widely supported by various cadaveric and finite

element analysis studies.[13,14,15] It stands to reason that increased tensional forces in the Achilles tendon, leads to increased tensile forces on the plantar structures, particularly the plantar fascia, predisposing to the development of PF.

1.2 Literature Review

Various authors have demonstrated that increased tensional forces in the Achilles tendon are translated to the plantar structures, particularly the plantar fascia.[13, 14,15, 16,17,

Huerta (2014) described gastrocnemius tightness as increased ankle joint stiffness in a dorsiflexion direction, clinically manifesting as an inability to dorsiflex the foot beyond neutral and is primarily as a consequence of contracture of the gastrocnemius-soleus complex.[6] The gastrocnemius muscle is the significant contributor to gastrocnemius-soleus contracture since it crosses the knee, ankle and subtalar joints.[18]

Gastrocnemius-soleus contracture can be congenital or acquired and various factors have been noted to result in this condition ranging from prolonged resting posture (supine, prone) e.g. in patients with prolonged Intensive Care Unit (ICU) stay[6,19] to continuous use of high heels.[6]

It is crucial to differentiate between the origins of the tightness being either isolated gastrocnemius tightness (IGT) or combined gastrocnemius-soleus tightness as this has clinical implications, and will help guide correct management. With IGT, management options can be aimed at addressing the gastrocnemius alone rather than the gastrocnemius-soleus complex, reducing procedure-related morbidity to the patient. The Silfverskiöld test, originally described by Nils Silfverskiöld in 1924, is a

clinical test utilised to make this differentiation.[20] The test is performed with the patient sitting or lying spine on the examination couch. The examiner's one hand is placed at the heel, whilst the other hand is positioned around the midfoot to stabilise the talonavicular joint. The hindfoot is locked in varus and the ankle pushed into maximal dorsiflexion. The maximal dorsiflexion of the ankle is compared with the knee extended and the knee flexed. If the maximal dorsiflexion improves when the knee is flexed, as compared to extended, then the test is deemed positive.[21]

IGT is defined as maximal ankle dorsiflexion that is less than 5° with the knee in full extension that corrects when the knee is flexed to 90°; a positive Silfverskiöld test. Gastrocnemius-soleus tightness is present when there is less than 10° of maximal dorsiflexion regardless of knee position.[21]

There are few published studies where the authors assessed the relationship between gastrocnemius tightness and PF.

Kibler *et al*. (1991) assessed 43 athletes' feet with PF. Thirty-seven of the forty-three patients showed reduced range of ankle dorsiflexion in the affected limb compared with the unaffected side.[22]

DiGiovanni *et al*. (2002) confirmed a connection between patients with forefoot and midfoot pathology and decreased ankle dorsiflexion. The Silfverskiöld test was performed in 34 patients with midfoot/forefoot pathology and a similar number without foot and ankle pathology as the control group.[21] They found that patients with forefoot and/or midfoot symptoms demonstrated more IGT (61%) compared to the control group (24%). The study then concluded that IGT contributes to the development of forefoot and/or midfoot conditions in the normal population.

Patel *et al*. (2011) published what is believed to have been the first study to prospectively evaluate the association between PF and IGT. This study evaluated 254 patients diagnosed with acute and chronic PF to see whether they had associated limited ankle dorsiflexion or not. The findings were that 83% of the study group had limited ankle dorsiflexion of which 57% had a positive Silfverskiöld test, 26% had gastrocnemius-soleus contracture and 17% did not have limited dorsiflexion. This study concluded that reduced ankle dorsiflexion, and in particular IGT, is a common occurrence in patients with PF.[23]

More recently, Bolivar *et al*. (2013) found significant differences between a group of 50 patients with PF and a control group for the tests used to evaluate tightness of posterior lower limb muscles, which included the Silfverskiöld test ($p < 0.001$). The Silfverskiöld test was found to be 100% sensitive and 96% specific as a diagnostic test for posterior muscle tightness.[19] The findings of this study were in keeping with earlier studies and demonstrated tightness of the posterior muscles associated with PF.

1.3 Study Aim & Objectives

The aim of this study was to determine the association between PF and IGT. The hypothesis was that there is an association between IGT and PF.

Objectives:

- To compare the prevalence of IGT in patients with PF, other foot and ankle pathologies and in patients with no foot and ankle pathology.
- To determine some of the risk factors associated with PF.

2 Methodology

2.1 Study Design

This was a prospective cross-sectional cohort study consisting of three groups of patients. Group 1, Group 2 and Group 3 comprised patients with a clinical diagnosis of PF, patients with foot and ankle pathology other than PF, and patients with no foot and ankle pathology respectively. This study was performed between 01 August and 31 October 2016. The patients in Group 1 and 2 were recruited from the University of the Witwatersrand (Wits) Orthopaedic Foot and Ankle Unit at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) and Netcare Linksfield Private Hospital in Johannesburg, South Africa. The third group (Group 3) of patients without foot and ankle pathology were recruited from the upper limb orthopaedic clinic at CMJAH.

Ethics approval for this study was obtained from the Wits Human Research Ethics Committee (Medical) (Reference: M160601) (see Appendix A).

The inclusion and exclusion criteria for the three groups are outlined in the Table below:

Table 2.1: Inclusion and Exclusion criteria

	Group 1	Group 2	Group 3
Inclusion criteria	• Diagnosis of PF • Age ≥ 18 years	• Diagnosis of foot and ankle pathology other than PF • Age ≥ 18	• No foot ankle pathology • Age ≥ 18
Exclusion criteria	• Previous gastrocnemius recession • PF and other associated foot and ankle pathology		

2.2 Sample size estimation

A sample size and power estimation performed utilising STATA (Version 14), assuming an IGT prevalence of 60% for the PF group and 20% for the group with no foot pathology, determined a total sample size of 46, with at least 23 examinations in each group in order to detect a prevalence difference between the groups.

Similarly, assuming an IGT prevalence of 45% for the other foot pathology group and 20% for the no foot pathology group, sample size and power estimation performed utilising STATA (Version 14) determined a total sample size of 108 patients with at least 54 examinations in each group to detect a prevalence difference between the groups.

2.3 Materials and Methods

PF was diagnosed clinically with the exclusion of other causes of heel pain. The Silfverskiöld test was performed as described in the literature review. The test was deemed to be positive if the difference in range of dorsiflexion was more than 10°.

A total of 45 patients were included in group 1, of which five had bilateral pathology. Only one side was considered for the study, the more symptomatic side. Group 2 included 117 patients with other foot and ankle pathology, whereas in group 3, 61 patients without foot and ankle pathology were assessed.

2.4 Data Collection

The data were collected by the principal investigator and the supervisors, using a data collection form (see Appendix C).

2.5 Statistical Analysis

The data were analysed using STATA (Version 14) statistical software (STATA Corporation, College Station, TX USA).

The following variables were included in the analysis:

- Age
- Gender
- Foot examined (Left /Right /both)
- Presence of isolated gastrocnemius
- Presence of PF
- Other foot or ankle pathologies
- Duration of symptoms for PF
- Occupation.

Exploratory data analysis of categorical and continuous variables included frequency tables and histograms of continuous variables to determine the distribution of the data.

Simple descriptive statistics were used to characterise the study population. Normally distributed continuous data were summarised by mean and standard deviation (SD), and non-normally distributed continuous data by median and interquartile range (IQR). Categorical data were summarised as a number and proportion. Statistical tests included the chi-square test, the Student's t-test for the comparison of means between two groups and Analysis of variance (ANOVA) for more than two groups. Logistic regression was used to determine the association between IGT and PF, age and gender were considered as potential confounding variables and adjusted for in this analysis. Statistical tests were two-sided at $\alpha = 0.05$.

3 Results

The study population comprised 223 patients across the three groups. The mean age of the 223 patients was 52.8 years (SD 15.0) and 153/223 (68.6%) were female. Group 1 comprised of 45/223 (20.2%) patients, group 2 comprised of 117 (52.5%) patients whilst group 3 had 61 (27.3%) patients.

More females than males were included in this study i.e. 153/223 (68.6%). There was no statistically significant difference in the gender proportions across the three groups with 34/45 (75.6%) females in the PF group, 79/117 (67.5%) in the other foot/ankle pathologies and 40/61 (65.6%) in the no foot/ankle pathologies; $p = 0.513$. The mean age was similar across the three groups, 52.4 (SD 11.4) in group 1, 53.1 (SD 16.3) in group 2 and 52.3 (SD 14.8) group 3; $p = 0.621$. These findings are tabulated in Table 3.1.

Table 3.1 : Baseline characteristics: Prevalence of IGT

Summary statistics of the prevalence of IGT and its association with PF, adjusted for the possible effect of gender and age				
Variable	All	Group 1: PF	Group 2: Other Foot/ankle Pathology	Group 3: No Foot/ankle Pathology
Total	223	45 (20.2%)	117 (52.5%)	61 (27.3%)
Gender				
Male	70 (31.4%)	11 (24.4%)	38 (32.5%)	21 (34.4%)
Female	153 (68.6%)	34 (75.6%)	79 (67.5%)	40 (65.6%)
Age				
Mean (SD)	52.8 (15.0)	52.4 (11.4)	53.1 (16.3)	52.3 (14.8)
IGT	101 (45.3%)	36 (80.0%)	53 (45.3)	12 (19.7%)

Overall 101/223 (45.3%) patients had a positive result for IGT, 36/45 (80.0%) in the PF group, 53/117 (45.3%) in the other foot/ankle pathology group and 12/61 (19.7%) in the no foot/ankle pathology group (see Figure 3.1 and Table 3.2); this was a statistically highly significant result ($p < 0.001$).

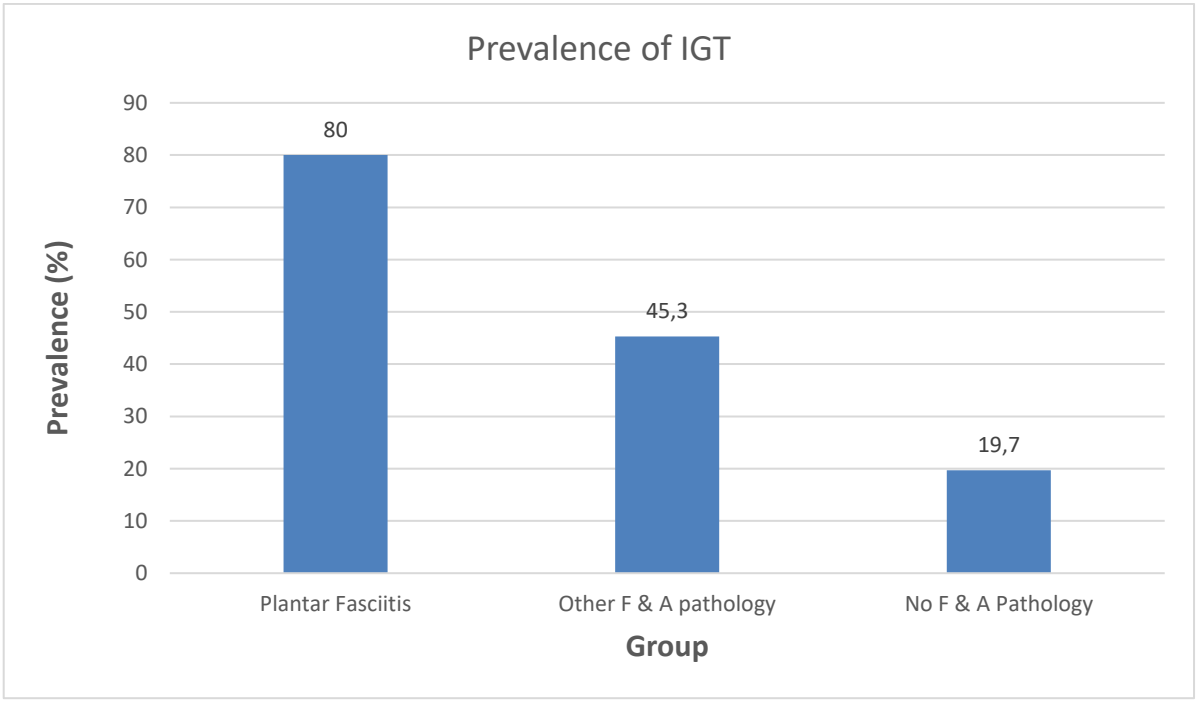

Figure 3.1: Prevalence of IGT amongst the three groups expressed as a percentage

Table 3.2: Univariate association between IGT, PF and other characteristics

UNIVARITE ASSOCIATION BETWEEN (IGT), PF AND OTHER CHARACTERISTICS				
	All N = 223	IGT N = 101 (45.3%)	No IGT 122 (54.7%)	P value
Gender				
Male	70 (31.4%)	28 (27.7%)	42 (34.4%)	0.283
Female	153 (68.6%)	73 (72.3%)	80 (65.6%)	
Age				
Mean (SD)	52.8 (15.)	53.5 (13.7)	52.1 (15.1)	0.500
Foot/ankle Pathology				
PF	45 (20.2%)	36 (80.0%)	9 (20.0%)	<0.001
Other Foot/ankle Pathology	117 (52.5%)	53 (45.3%)	64 (54.7%)	
No Foot/ankle pathology	61 (27.3%)	12 (19.7%)	49 (80.3%)	

The median duration of symptoms in the PF group was 12 months (interquartile range (IQR) 7 – 24 months). Thirty-eight (38) % of the cases presented with acute symptoms, i.e. less than nine months duration whereas 62% presented with chronic symptoms. The prevalence of IGT was similar between patients with acute and chronic symptoms at 78.9% and 80.6%, respectively.

The top five most prevalent diagnoses in the group 2 were osteoarthritis 15 (12.8%), hallux valgus 13 (11.1%), tendinopathy 12 (10.3%), pes plano-valgus 12 (10.3%) and neuromas 11 (9.4%) (see Figure 3.2). The other less prevalent diagnoses were combined in one group, and represented 19.7% of all cases in group 2. These other diagnoses are tabulated in Table C.1 in Appendix C.

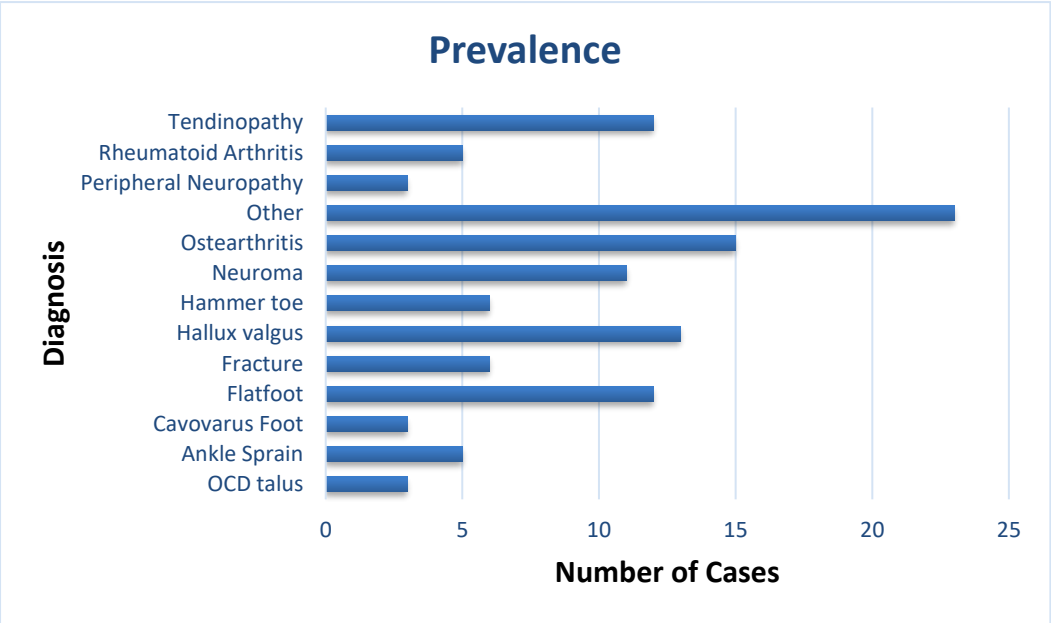

Figure 3.2: Prevalence of other foot and ankle pathology (group 2)

In the patients with a positive result for IGT, the prevalence was similar in the left foot compared to the right foot; 3/101 (3%) were positive in both feet, 50 (49.5%) were positive in the left foot and 48 (47.5%) in the right foot.

The multivariate analysis adjusted for the effect of age and gender shows that there is a very strong association between PF and IGT, OR 16.3 95% CI[1] (6.1 – 42.5); $p < 0.001$ and a strong association between other foot/ankle pathologies and IGT, OR 3.4 95% CI (1.6 – 7.0); $p = 0.001$, using the group with no foot pathology as the reference (see Table 3.3).

[1] CI = confidence interval

Table 3.3 : Multivariate association between IGT and PF

MULTIVARIATE ASSOCIATION BETWEEN IGT and PF					
	All N = 223	IGT N = 101 (45.3%)	No IGT 122 (54.7%)	OR[2]	P value
Gender					
Male	70 (31.4%)	28 (27.7%)	42 (34.4%)	0.8 (0.4 – 1.5)	0.479
Female	153 (68.6%)	73 (72.3%)	80 (65.6%)	Reference	
Age					
Mean (SD)	52.8 (15.0)	53.5 (13.6)	52.0 (15.9)	1.0 (0.9 – 1.0)	0.460
Foot/ankle Pathology					
PF	45 (20.2%)	36 (80.0%)	9 (20.0%)	16.3 (6.1 – 42.5)	<0.001
Other Foot/ankle Pathology	117 (51.5%)	53 (45.3%)	64 (54.7%)	3.4 (1.6 – 7.0)	0.001
No Foot/ankle pathology	61 (27.3%)	12 (19.7%)	49 (80.3%)	Reference	

[2] OR = odds ratio

4 Discussion

This study achieved the aims and objectives which were to determine the association between PF and IGT by comparing the prevalence of IGT across the three groups. This study was adequately powered to detect differences in the prevalence between the three groups (PF, other Foot/ankle pathology and No Foot/ankle pathology). Statistical analyses showed that differences in gender and age across the three groups were not statistically significant.

The average age of patients with PF was 52.4 years. This falls within the reported peak age range for this condition, which is 40 – 60 years[24,25,26] with almost two thirds of the affected patients being female (74%). The left and right foot were equally affected and no differences were found between chronicity of symptoms and IGT.

The results indicate a very strong association between IGT and PF. Possible risk factors for developing PF identified in this study include gender (female), middle age (41-64), and reduced ankle dorsiflexion, some of which were identified in previous studies. [27,28,29,]

The strong association between PF and IGT is not surprising, as previous studies have demonstrated the embryonic and functional connection between the plantar fascia and the gastrocnemius-soleus complex.[6, 7, 8, 12, 18] Increased tensional forces on the Achilles tendon, e.g. due to gastrocnemius tightness will result in increased transmission of forces on the plantar fascia in the stance phase of walking, causing PF.

The results also confirm a strong association between patients with other foot and ankle pathology and IGT, with a prevalence of 45.3% in this group. Patients without

foot and ankle pathology are less likely to have IGT, with a prevalence of IGT in this group of 19.7% compared to the other two groups.

These findings are consistent with existing evidence, and support the notion that IGT is a strong risk factor for PF and contributes to the development of other foot and ankle pathology. Patel *et al.* (2011) reported an incidence of 83% of reduced ankle dorsiflexion in their study, looking at patients with PF, of which 57% had IGT.[23] Similarly, DiGiovanni *et al*. (2002) found a prevalence rate IGT of between 65 - 83% in patients with other foot and ankle pathology.[21] This current study shows that IGT does not invariably produce foot or ankle pathology as 19.7% of patients without foot and ankle pathology will have a positive Silfverskiöld test.

Evidence suggests that a good proportion of patients with PF improve over time with conservative management alone. Therefore, for the management of PF, non-operative options must be exhausted prior to proceeding to operative techniques. The non-operative options have been well described in literature and range from patient-oriented modalities particularly, rest, activity modification, ice packs and analgesia to physical modalities such as stretching and foot orthotics. Orthotics commonly employed in the management of PF include night splints, viscoelastic heel cups, arch supports etc. Failure to respond to these modalities can be followed by injections with steroids[30], Botulinum-toxin (Botox)[31,32] or Platelet Rich Plasma (PRP)[33,34], casting[35,36] or extra corporeal shockwave therapy (ESWT).[37,38, 39]. However, there will still be a subset of patients that fail to satisfactorily respond to the non-surgical modalities and subsequently develop chronic, recalcitrant symptoms that requires surgical intervention. Surgical options include plantar fasciotomy or gastrocnemius soleus

complex lengthening done by either lengthening both the gastrocnemius and the soleus muscles or the gastrocnemius muscle alone. Based on the findings of this and previous studies that most patients with PF display IGT, a gastrocnemius muscle release alone will seem to be adequate to allay the symptoms, possibly with reduced procedure related morbidity. This view is supported by Aronow *et al*. (2006).[18] Taking it a step further, Abbassian *et al*. (2012) advocated for the proximal release of the medial head of gastrocnemius alone.[40] The authors argue that the medial head contributes a greater deal to generating plantarflexion power compared to the lateral head, and its release alone achieves satisfactory correction.

With the findings of this study and previous studies showing a strong association between IGT and PF, it will be interesting to find out how IGT status changes over time as PF resolves. Therefore, future studies could assess the improvement of the Silfverskiöld test over time as PF resolves.

A limitation of this study is a relatively small study population even though it was adequately powered. A larger cohort would have been more representative. This study also did not assess some of the risk factors known to contribute to PF, e.g. body mass index, occupation and foot morphology like cavovarus foot and pes planovalgus.[41]

The implications of the findings of this study suggest that IGT should be actively sought out early and treated, whether non-operatively or operatively when managing PF and other pathologies.

5 Conclusion

This study suggests a very strong association between IGT and PF, as well as a strong association between IGT and other foot and ankle pathology. This study also points to female gender and middle age (41 – 64) as additional risk factors for PF.

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Appendix A: Postgraduate title approval letter

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
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Reference: Mrs Sandra Benn
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06 January 2017
Person No: 773145
PAG

Dr NT Nakale
P.0 Box 217
Bergbron
1712
South Africa

Dear Dr Nakale

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *The association between plantar fasciitis and isolated gastrocnemius tightness* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix B: HREC (Medical) Ethics Clearance Certificate

R14/49 Dr Tufikifa Ngenomeulu Nakale et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160601

NAME: (Principal Investigator)	Dr Tufikifa Ngenomeulu Nakale et al
DEPARTMENT:	Orthopaedics Charlotte Maxeke Johannesburg Academic Hospital Prof Nick Saragas's Private Practice - Foot and Ankle Unit
PROJECT TITLE:	The Association between Plantar Fasciitis and Isolated Gastrocnemius Tightness
DATE CONSIDERED:	24/06/2016
DECISION:	Approved
CONDITIONS:	Providing written permission to conduct the study from Netcare Ethics Committee
SUPERVISOR:	Dr Andrew Strydom
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	05/08/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004, 10th floor, Senate House/2nd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in June and will therefore be due in the month of June each year.

Principal Investigator Signature

Date 20/02/2018

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Data Collection Form

The association between plantar fasciitis and isolated Gastrocnemius tightness

Data Collection form

1. Patient Identification

Study Code _____ Case Number _____

2. Demographic Data

Age ☐

Gender (Mark with X) Male ☐
Female ☐

Occupation _____

3. Study Data

Affected side (Study Group/Control Group 1)

Right ☐
Left ☐
Both ☐

Diagnosis (Control Group 1)

_____

Ankle Dorsiflexion (Study and Control Groups)

	Knee Flexed	Knee Extended
Dorsiflexion Right	☐	☐
Dorsiflexion Left	☐	☐

Appendix D: Summary of other foot & ankle pathology

Table C.1: Summary of other foot & ankle pathology

Table

foot/ankle pathology h	Freq.	Percent	Cum.
OCD talus	3	2.56	2.56
ankle sprain	5	4.27	6.84
cavovarus foot	3	2.56	9.40
flat foot	12	10.26	19.66
fracture	6	5.13	24.79
hallux valgus	13	11.11	35.90
hammer toe	6	5.13	41.03
neuroma	11	9.40	50.43
osteoarthritis	15	12.82	63.25
peripheral neuropathy	3	2.56	85.47
rheumatoid arthritis	5	4.27	89.74
tendinopathy	12	10.26	100.00
Ankle Instability	2	8.70	8.
Ankle fracture malunion	1	4.35	13.04
Freiberg Infraction	2	8.70	21.74
Gouty arthritis	1	4.35	26.09
Hallux rigidus	1	4.35	30.43
Heel Fat pad contusion	2	8.70	39.13
Lesser toe deformities	1	4.35	43.48
Ligament sprain	1	4.35	47.83
Lisfranc Injury	1	4.35	52.17
Peroneus brevis tear	1	4.35	56.52
Peroneal enthesopathy	1	4.35	60.87
Peroneal subluxation	1	4.35	65.22
Plantar Fibromatosis	2	8.70	73.91
Posterior ankle impingement	1	4.35	78.26
Shin pain	1	4.35	82.61
Subluxating Peroneal tendons	1	4.35	86.96
Tibialis posterior impingement	1	4.35	91.30
Tibialis Anterior Tendinitis	1	4.35	95.65
Venous Insufficiency	1	4.35	100.00
Total	117	100.00	

Appendix F: Article

Article

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2018, Vol. 39(3) 271–277

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Association Between Plantar Fasciitis and Isolated Gastrocnemius Tightness

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Abstract

Background: An association between plantar fasciitis and isolated gastrocnemius tightness (IGT) has been postulated in the literature; however, there have been few studies to prove this relationship. This prospective cross-sectional cohort study was aimed at determining the association between plantar fasciitis and IGT.

Methods: Three groups comprising 45 patients with plantar fasciitis (group 1), 117 patients with foot and ankle pathology other than plantar fasciitis (group 2), and 61 patients without foot and ankle pathology (group 3) were examined for the presence of IGT using the Silfverskiöld test. Statistical tests included chi-square test, Student t test, and analysis of variance.

Results: Of the patients, 101 (45.3%) had IGT: 36 (80%) in group 1, 53 (45.3%) in group 2, and 12 (19.7%) in group 3. The difference in IGT prevalence between the groups was statistically significant at $P < .001$. The prevalence of IGT was similar between acute and chronic plantar fasciitis at 78.9% and 80.6%, respectively.

Conclusion: There was a very strong association between plantar fasciitis and IGT using group 3 as a reference. This study suggests that IGT should be actively sought out and managed in patients with plantar fasciitis.

Level of Evidence: Level II, cross-sectional cohort prospective study.

Keywords: plantar fasciitis, isolated gastrocnemius tightness, Silfverskiöld test

Plantar fasciitis is a common diagnosis, with a reported incidence of 11% to 15% of all consultations at foot and ankle units among adults.[33,41] Plantar fasciitis is defined as a localized inflammation and degeneration of the proximal plantar fascia.[29] The plantar fascia has an important function in normal foot and ankle biomechanics, serving to sustain the arch of the foot while also stabilizing the joints of the foot. Studies have shown that there is an anatomic, histologic, mechanical, and functional link between the plantar fascia and the Achilles tendon through the calcaneal tuberosity.[23,28,46] The extent of the connection and the duration remains a topic of debate. Achilles tendon tensional force leads to hindfoot plantarflexion and forefoot dorsiflexion with an associated increase in ground reaction forces, which naturally tends to flatten the arch of the foot. Increased tensional forces in the Achilles tendon mainly lead to increased tensile forces on the plantar structures, particularly the plantar fascia, predisposing to the development of plantar fasciitis, which has been suggested by various authors.[6,10-12,50]

Huerta[23] described gastrocnemius tightness as increased ankle joint stiffness in dorsiflexion, clinically manifesting as an inability to dorsiflex the foot beyond neutral and is primarily a consequence of contracture of the gastrocnemius-soleus complex. The gastrocnemius muscle is the major contributor to gastrocnemius-soleus contracture since it crosses the knee, ankle, and subtalar joints.[4]

In assessing patients with gastrocnemius-soleus complex tightness, it is crucial to differentiate between the origin of the tightness being either isolated gastrocnemius tightness (IGT) or combined gastrocnemius-soleus tightness as this has clinical implications and will help guide correct management. In the Grand Rapids Arch Collapse Classification proposed by Anderson et al,[3] IGT is described as the first of 5 stages (type 1) of a cascade of events leading to a progressive collapse of the arch. This type 1 is a precollapse deformity that can initiate conditions such as Achilles tendinopathy, plantar fasciitis, metatarsalgia, and arch pain.

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Table 1. Inclusion and Exclusion Criteria.

	Group 1	Group 2	Group 3
Inclusion criteria	• Diagnosis of plantar fasciitis • Age ≥18 y	• Diagnosis of foot and ankle pathology other than plantar fasciitis • Age ≥18 y	• No foot ankle pathology • Age ≥18 y
Exclusion criteria	• Previous gastrocnemius recession • Concurrent diagnosis of plantar fasciitis and other foot and ankle pathology		

With IGT, management options can be aimed at addressing the gastrocnemius alone rather than the gastrocnemius-soleus complex, reducing procedure-related morbidity to the patient. The Silfverskiöld test, originally described by Nils Silfverskiöld in 1924, is a clinical test used to make this differentiation.[45] IGT is defined as maximal ankle dorsiflexion that is less than 5 degrees with the knee in full extension that corrects when the knee is flexed to 90 degrees, a positive Silfverskiöld test. Gastrocnemius-soleus tightness is present when there is less than 10 degrees of maximal dorsiflexion regardless of knee position.[17]

There are limited published studies in which the authors assessed the relationship between IGT and plantar fasciitis, most of which demonstrated a relationship between IGT and plantar fasciitis.[7,17,26,40] IGT has a reported incidence of between 24% and 44% among the normal population without foot and ankle pathology.[17] The aim of this study was to determine the association between plantar fasciitis and IGT and to compare the prevalence of IGT in patients with plantar fasciitis, other foot and ankle pathologies, and patients with no foot and ankle pathology. Our hypothesis was that there would be a marked association between IGT and plantar fasciitis.

Methods

This prospective cross-sectional cohort study consisted of 3 groups of patients. Group 1, group 2, and group 3 comprised patients with a clinical diagnosis of plantar fasciitis, patients with foot and ankle pathology other than plantar fasciitis, and patients with no foot and ankle pathology, respectively. This study was performed between August 1, 2016, and October 31, 2016. Patients for group 3 were recruited from the orthopedic upper limb trauma clinic. Ethics approval for this study was obtained from our institution's ethics committee (medical) prior to the commencement of data collection, and informed consent was obtained from all patients. The inclusion and exclusion criteria for the 3 groups are outlined in Table 1.

The study population comprised 223 patients across the 3 groups. The mean age of the patients was 52.8 (range, 21 to 82) years. Group 1 was composed of 45 (20.2%) patients, of which 5 had bilateral pathology. Only 1 side was considered for the study, the more symptomatic side. Group 2 was composed of 117 (52.5%) patients, and group 3 had 61 (27.3%) patients. Women accounted for 68.6% (153) of the patients. There was no statistically significant difference in the gender proportions across the 3 groups, with 34 (75.6%) women in group 1, 79 (67.5%) in group 2, and 40 (65.6%) in group 3; $P = .513$. The mean age was similar across the 3 groups, 52.4 (SD, 11.4) in group 1, 53.1 (SD, 16.3) in group 2, and 52.3 (SD, 14.8) group 3; $P = .621$. These findings are tabulated in Table 2.

Plantar fasciitis was diagnosed clinically with the exclusion of other causes for heel pain. Although there have been reports on the usefulness of magnetic resonance imaging (MRI) in diagnosing plantar fasciitis,[1] clinical diagnosis remains key,[21] and MRI is often indicated only in cases of recalcitrant plantar fasciitis and to rule out other pathologies.[13,49]

The Silfverskiöld test was performed with the patient supine, assessing the range of ankle dorsiflexion with the knee in full extension and in 90 degrees of flexion. The test was deemed to be positive if the difference in range of dorsiflexion was 10 degrees or more using a goniometer.

Statistical Analysis

The data were collected by the principal investigator and the supervisors. The data were analyzed using STATA (version 14) statistical software (STATA Corporation, College Station, TX). Exploratory data analysis of categorical and continuous variables included frequency tables and histograms of continuous variables to determine the distribution of the data. Simple descriptive statistics were used to characterize the study population. Normally distributed continuous data were summarized by mean and standard deviation (SD), and nonnormally distributed continuous data by median and interquartile range (IQR). Categorical data were summarized as a number and proportion. Statistical tests included the chi-square test, Student t test for the comparison of means between 2 groups, and analysis of variance for more than 2 groups. Logistic regression was used to determine the association between IGT and plantar fasciitis; age and gender were considered as potential confounding variables and adjusted for in this analysis. Statistical tests were 2-sided at $\alpha = .05$.

Table 2. Baseline Characteristics: Prevalence of Isolated Gastrocnemius Tightness (IGT).[a]

Variable	All	Group 1: Plantar Fasciitis	Group 2: Other Foot/ Ankle Pathology	Group 3: No Foot/Ankle Pathology
Total	223	45 (20.2%)	117 (52.5%)	61 (27.3%)
Gender				
Male	70 (31.4%)	11 (24.4%)	38 (32.5%)	21 (34.4%)
Female	153 (68.6%)	34 (75.6%)	79 (67.5%)	40 (65.6%)
Age, mean (SD)	52.8 (15.0)	52.4 (11.4)	53.1 (16.3)	52.3 (14.8)
IGT	101 (45.3%)	36 (80.0%)	53 (45.3)	12 (19.7%)

[a]Summary statistics of the prevalence of IGT and its association with plantar fasciitis, adjusted for the possible effect of gender and age.

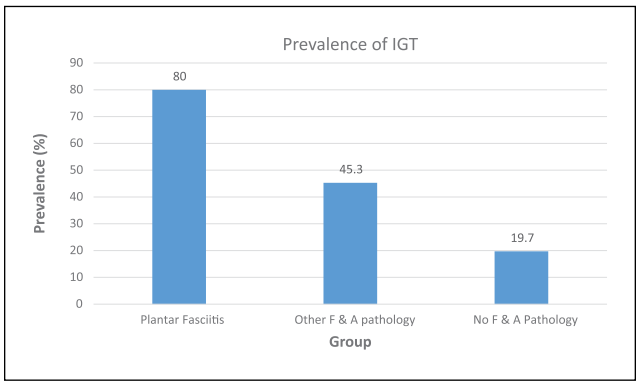

Figure 1. Prevalence of isolated gastrocnemius tightness among the 3 groups expressed as a percentage.

A sample size and power estimation was calculated using STATA (version 14). To determine a statistically significant difference in the proportion positive for IGT in group 1 compared with group 3, a prevalence of 60% was assumed for group 1 and 20% for group 3. STATA calculated that we would need a total sample size of 46, with at least 23 examinations in each group ($\alpha = .05$, delta = 0.4, and power = 0.8). Similarly, to determine a statistically significant difference in the proportion positive for IGT in group 2 compared with group 3, a prevalence of 45% was assumed for group 2 and 20% for group 3. STATA calculated that we would need a total sample size of 108, with at least 54 examinations in each group ($\alpha = .05$, power = 0.8, delta = 0.25).

Results

The primary outcome variable was presence of IGT as measured by the Silfverskiöld test. Overall, 101 (45.3%) patients had a positive Silfverskiöld test, 36 (80.0%) in group 1, 53 (45.3%) in group 2, and 12 (19.7%) in group 3 (Figure 1; Table 3). The difference in the 3 groups was statistically significant ($P < .001$).

The median duration of symptoms in the plantar fasciitis group was 12 months (IQR, 7 to 24 months). Thirty-eight percent of cases presented with acute symptoms (ie, less than 9 months' duration), whereas 62% presented with chronic symptoms. The prevalence of IGT was similar between patients with acute and chronic symptoms at 78.9% and 80.6%, respectively.

The top 5 most prevalent diagnoses in group 2 were osteoarthritis in 15 (12.8%), hallux valgus in 13 (11.1%), tendinopathy in 12 (7 Achilles, 3 peroneal, 2 tibialis anterior; 10.3%), pes planovalgus in 12 (10.3%), and neuromas in 11 (9.4%; Figure 2). The other less prevalent diagnoses were combined into one group and represented 19.7% of all cases in group 2.

In the patients with a positive test for IGT, the prevalence was similar in the left foot compared with the right foot; 3 (3%) were positive in both feet, 50 (49.5%) were positive in the left foot, and 48 (47.5%) in the right foot.

The multivariate analysis adjusted for the effect of age and gender shows that there was a very strong association between plantar fasciitis and IGT (odds ratio [OR], 16.3; 95% confidence interval [CI], 6.1 to 42.5; $P < .001$) and a strong association between other foot/ankle pathologies and IGT (OR, 3.4; 95% CI, 1.6-7.0; $P = .001$) using the group with no foot pathology as the reference (Table 4).

Discussion

The association between IGT and plantar fasciitis has previously been reported in the literature. Authors have also compared the prevalence of IGT between patients with plantar fasciitis and patients with other foot and ankle pathologies. To our knowledge, our study is the first to compare the prevalence of IGT between 3 groups as described earlier. The results indicate a very strong association between IGT and plantar fasciitis. Possible risk factors for developing plantar fasciitis identified in this study include gender (female), middle age (41 to 64 years), and IGT, some of which were identified in previous studies.[43,47,52] The strong association between plantar fasciitis and IGT is not surprising, as previous studies have demonstrated the embryonic and functional connection between the plantar

Table 3. Univariate Association Between Isolated Gastrocnemius Tightness (IGT), Plantar Fasciitis, and Other Characteristics.

	All, N = 223	IGT, n = 101 (45.3%)	No IGT, n = 122 (54.7%)	*P* Value
Gender				
Male	70 (31.4%)	28 (27.7%)	42 (34.4%)	.283
Female	153 (68.6%)	73 (72.3%)	80 (65.6%)	
Age, mean (SD)	52.8 (15.)	53.5 (13.7)	52.1 (15.1)	.500
Foot/ankle pathology				
Plantar fasciitis	45 (20.2%)	36 (80.0%)	9 (20.0%)	<.001
Other foot/ankle pathology	117 (52.5%)	53 (45.3%)	64 (54.7%)	
No foot/ankle pathology	61 (27.3%)	12 (19.7%)	49 (80.3%)	

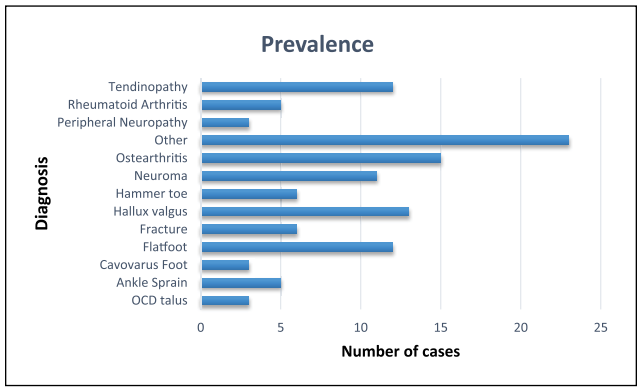

Figure 2. Prevalence of other foot and ankle pathology.

fascia and the gastrocnemius-soleus complex.[4,23,27,28,46] Increased tensional forces on the Achilles tendon (eg, due to gastrocnemius tightness) will result in increased transmission of forces on the plantar fascia in the stance phase of walking, causing plantar fasciitis.

The results also confirm a strong association between patients with other foot and ankle pathology and IGT, with a prevalence of 45.3% in this group. Patients without foot and ankle pathology were less likely to have IGT, with a prevalence of only 19.7% in this group. This prevalence is similar to the reported incidence of IGT in the normal population (24%-44%).[17]

The average age of patients with plantar fasciitis in our study was 52.4 years. This falls within the reported peak age range for this condition, which is 40 to 60 years,[8,9,38] with almost two-thirds of the affected patients being female (74%). The left and right feet were equally affected, and no differences were found between chronicity of symptoms and IGT.

The 80% IGT prevalence in our study is consistent with the existing literature and supports the notion that IGT is a strong risk factor for plantar fasciitis and may contribute to the development of other foot and ankle pathology. Patel et al[40] reported an incidence of 83% of reduced ankle dorsiflexion in their study, looking at patients with plantar fasciitis, of which 57% had IGT. Similarly, DiGiovanni et al[17] found a prevalence of IGT between 65% to 83% in patients with other foot and ankle pathology. In a cohort of 46 athletes with plantar fasciitis, Kibler et al[26] found a prevalence of 86% reduced ankle dorsiflexion, but they did not determine the origin of the tightness. This current study shows that IGT does not invariably produce foot or ankle pathology as 19.7% of patients without foot and ankle pathology had a positive Silfverskiöld test. DiGiovanni et al[17] reported an IGT prevalence of between 24% and 44% among the normal population without foot and ankle pathology.

Evidence suggests that a good proportion of patients with plantar fasciitis improve over time with conservative management alone. Therefore, when managing plantar fasciitis, nonoperative options must be exhausted prior to proceeding with operative techniques. The nonoperative options have been well described in literature and range from patient-oriented modalities such as rest, activity modification, ice packs, and analgesia[52] to physical modalities such as stretching[15,16,24,31,52] and foot orthotics.[36,42] Recently, Engkananuwat et al[20] found that simultaneous stretching of both the Achilles tendon and the plantar fascia resulted in complete relief of plantar fasciitis symptoms after 4 weeks of treatment in 56% of their cohort. Orthotics commonly employed in the management of plantar fasciitis include night splints, viscoelastic heel cups, arch supports, and so forth. Failure to respond to these modalities can be followed by injections with steroids,[35] Botulinum-toxin (Botox),[2,19] or platelet-rich plasma[37,51]; casting[22,48]; extracorporeal shockwave therapy[34,39,44]; or low-level laser therapy.[25,30] However, there will still be a subset of patients who fail to respond to the nonoperative modalities and subsequently develop chronic, recalcitrant symptoms that require operative intervention. Operative options include plantar fasciotomy or gastrocnemius soleus complex lengthening, done by either lengthening both the gastrocnemius and the soleus muscles or the gastrocnemius muscle alone. Based on the findings of this and previous studies that most patients with plantar fasciitis display IGT, a gastrocnemius muscle

Table 4. Multivariate Association Between Isolated Gastrocnemius Tightness (IGT) and Plantar Fasciitis.

	All, N = 223	IGT, n = 101 (45.3%)	No IGT, n = 122 (54.7%)	OR	*P* Value
Gender					
Male	70 (31.4%)	28 (27.7%)	42 (34.4%)	0.8 (0.4-1.5)	.479
Female	153 (68.6%)	73 (72.3%)	80 (65.6%)	Reference	
Age, mean (SD)	52.8 (15.0)	53.5 (13.6)	52.0 (15.9)	1.0 (0.9-1.0)	.460
Foot/ankle pathology					
Plantar fasciitis	45 (20.2%)	36 (80.0%)	9 (20.0%)	16.3 (6.1-42.5)	<.001
Other foot/ankle pathology	117 (51.5%)	53 (45.3%)	64 (54.7%)	3.4 (1.6-7.0)	.001
No foot/ankle pathology	61 (27.3%)	12 (19.7%)	49 (80.3%)	Reference	

release alone will seem to be adequate to allay the symptoms, possibly with reduced procedure related morbidity.

This view is supported by Aronow et al.[4] Gastrocnemius recession has been noted to have a very high level of patient satisfaction in patients with isolated foot pain, 86% of whom had plantar fasciitis with grade B recommendation for midfoot problems including plantar fasciitis.[14,32] Duthon et al[18] reported that when a gastrocnemius recession was performed for isolated Achilles tendinopathy, the strength between the 2 legs was equal at 1 year. Abbassian et al[1] even advocated for the proximal release of the medial head of gastrocnemius alone. The authors argued that the medial head contributes a greater deal to generating plantarflexion power compared with the lateral head, and its release alone achieves satisfactory correction.

With the findings of this study and previous studies showing a strong association between IGT and plantar fasciitis, it will be interesting to find out how IGT status changes over time as plantar fasciitis resolves. Therefore, future studies could assess the improvement of the Silfverskiöld test over time as plantar fasciitis resolves.

A limitation of this study is the relatively small study population even though it was adequately powered. A larger cohort would have been more representative. This study also did not assess some of the risk factors known to contribute to plantar fasciitis (eg, body mass index, occupation, and foot morphology such as cavovarus foot and pes planovalgus).[5]

Conclusion

This study suggests a very strong association between IGT and plantar fasciitis and a strong association between IGT and other foot and ankle pathology. This study also points to female gender and middle age (41 to 64 years) as additional risk factors for plantar fasciitis. The findings of this study suggest that IGT should be actively sought out early and treated, whether nonoperatively or operatively, when managing plantar fasciitis and other foot and ankle pathology.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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