A SERIES OF SIX CASES FOR THE
SIR ROBERT JONES PRIZE
FOR ORTHOPAEDIC SURGERY,
1955.

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B.Sc. Hons.
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INTRODUCTION

This series of six cases was selected by kind permission of Professor Walter Mercer from his Wards in the Royal Infirmary, Edinburgh. It consists of conditions affecting the foot, varying in incidence and severity, all of which disable their victims.

Interest has been centred mainly on the underlying disordered anatomy and functional mechanics rather than on routine case management. Owing to the difficulty in obtaining illustrations from the actual cases, the figures have been supplemented from the literature. In no instance was permission asked as the series is not for publication.

A list of major references has been added. Information was obtained from the Central Medical Library, Edinburgh University, from the Cohen Library, Liverpool University and from the Round Library, City of Liverpool.

It was thought fitting to write a brief account of the Life and Work of Sir Robert Jones whose memory is perpetuated in this award.
ROBERT JONES
(1857-1933)
ROBERT JONES

Robert Jones was born at Rhyl, North Wales on June 28th, 1857, the son of a journalist. He was educated at Sydenham College London until sixteen years of age. In 1873 at the invitation of his uncle Hugh Owen Thomas, he left the Metropolis to study medicine at Liverpool. During his medical student days he lodged at the now famous address of his uncle, 11, Nelson Street. Not only had he his studies to contend with but also the infinitely more arduous task of helping "H.O.T." He saw the tireless enthusiasm, the lightning diagnosis and the fantastic technical skill of Thomas. He was given a thorough grounding in the mechanics of orthopaedics for his uncle was no mean engineer and was equally at home at the operating table, at his lathe or in his smithy fashioning splints.

In 1881 the Stanley Hospital appointed Robert Jones Honorary Assistant Surgeon and seven years later he was made Consulting Surgeon to the Manchester Ship Canal Company, an appointment which brought him an unrivalled variety of patients.

The year 1889 saw him Honorary Surgeon and Dean of the Clinical School at the Royal Southern Hospital, Liverpool.

After the untimely death of his uncle in 1891, Robert Jones was left virtually alone at the head of British Orthopaedics. Was he to continue in the footsteps of his uncle? A career in General Surgery offered every attraction
HUGH OWEN THOMAS
(1834-1891)
but he felt compelled to make the decision which has since meant so much to many.

So it was that with Nurse Hunt (now Dame Agnes Hunt) he founded a small hospital in the village of Baschurch, Shropshire.

Hardly had this tiny centre become famous than the First World War broke out. After rapid promotion Robert Jones became Inspector of Military Orthopaedics. Of his work during that War alone a book has been written; honours were heaped upon him including a Knighthood in 1917 and Knight of the British Empire and Companion of the Bath in 1918.

The death of Lady Jones at the end of the War was a great sorrow but his spirit could not be broken and shortly afterwards it was under his direction that the original Orthopaedic Hospital System was set up in Great Britain - the first of the many specialist services we enjoy today.

It would be impossible to give a complete list of his distinctions which included the Liston, Victoria Jubilee and Cameron Prizes as well as the elected Fellowship of the Royal College of Surgeons and a Baronetcy in 1926.

At the age of 76 his end came quietly in the familiar countryside of his native Wales.

So much tells us very little about Robert Jones, for his contribution to surgery was only part of his life. His
overwhelming personality and intense humanity born of a complete lack of selfish pride or ambition won the hearts of all who met him. He had a great sense of humour and a fine physique and talked to every man as his friend and equal. Of him Lord Moynihan said, "It is impossible to tell truly of the love his patients bore him." How seldom is our Profession blessed with such character and ability in one man.

The tribute which he might best have liked is that inscribed in the Chapel of the Shropshire Orthopaedic Hospital, now renamed The Robert Jones Agnes Hunt Orthopaedic Hospital:

"To the Glory of God and in Loving Memory of Robert Jones, Great Surgeon and Greater Man. Who devoted his life to the healing of the maimed and the cheering of the desolate."
CASE 1.

HAGLUND'S DISEASE

Miss Patricia Messer, aet. 17.

41, Parkhead Drive, Edinburgh.

Recommended by Dr. Sellars.

Admitted 26.1.55, discharged 3.2.55.

Complaint - a painful, occasionally inflamed swelling at the back of the right heel for more than 2 years.

History - this patient first attended the Orthopaedic Out-Patient Department on 25.4.52 with a painful swelling on the left heel of 4 months duration. She was given conservative advice at that time. Since then the pain has become worse. It is particularly severe first thing in the morning and shoots up the back of her leg into the calf with every step. Walking and cold weather both aggravate the pain. The skin of the right heel has been purple since the onset of symptoms, and has itched and burned like a chilblain during cold weather. The overlying skin has never broken nor has there even been any discharge. The pain is of equal intensity whether flat or high-heeled shoes are worn and prevents the wearing of ladies boots. Her left heel has occasionally given slight pain but not recently. She did not notice that walking uphill intensified the pain.

Her previous health has been excellent, a sprained wrist
2 years ago being the only outstanding disease in her memory. She was recommended to undergo a minor operation on the right heel to cure her symptoms.

**Physical examination.**

A very healthy looking, intelligent girl (a telephonist), well-nourished with no morbid features.

The right heel is swollen and tender posteriorly with an accentuation of the supero-lateral eminence at the back of the calcaneum. This feels hard on palpation. The overlying skin is thickened and of a bluish-red colour but not broken or frankly inflamed.

The left heel shows a similar but less marked swelling which is not tender.

Movements at both ankle joints are unimpaired.

**Cardiovascular system.**

Radial pulse - 78, wave normal, vessel wall not palpable.

Heart - sounds closed in all areas, no murmurs or thrills present.

No cyanosis oedema or venous distension.

**Respiratory system.**

Chest expansion good.

Percussion note resonant throughout.

Breath sounds vesicular; no accompaniments.

**Other systems**  N.A.D.
X-ray examination, 27.1.55. Both heels appear normal. There appears to be a bilateral os trigonum.

Treatment.

Operation 28.1.55 "Removal of exostosis from Right calcaneum."

A curved incision was made lateral to the tendo calcaneus insertion. The bursa and subcutaneous tissues were dissected clear of the insertion of the tendo calcaneus and the exostosis removed with an osteotome. The subcutaneous tissues were sutured with catgut and the skin closed with silk. A padded bandage was applied.

Progress. Post-operative condition excellent. After early ambulation the patient was discharged on 3.2.55.

Discussion

First to describe this condition, now often referred to by his name was Haglund in 1928 (1). Synonyms include "Winter Heel" and "Tendo Achillis Bursitis".

Haglund attributed the symptoms to a congenital malformation of the upper calcanean border posteriorly, causing pressure on and inflammation of the "supra-calcaneal" bursa. Recently the situation has been explored in more detail (2). The inflammation of the tendo Achillis is of an aseptic type due to pressure as Haglund suggested, but it seems unlikely that an actual malformation of the calcaneum is present.
Fig. 1

Posterior view of ankle. 1 - area for insertion of tendo calcaneus, 2 - supero-lateral border of posterior calcaneal surface, 3 - posterior and transverse inferior tibio-fibular ligaments, 4 - fibula, 5 - tibia, 6 - talus, 7 - deltoid ligament, 8 - posterior talo-calcaneal ligament.

Fig. 2

Lateral view of ankle. 1 - supero-lateral border of posterior calcaneal surface, 2 - fibula, 3 - tibia, 4 - cuneiform bones, 5 - cuboid, 6 - area for supra-calcaneal bursa, 7 - area for insertion of tendo calcaneus.
The normal calcaneum when viewed from behind is not symmetrical; the supero-lateral part of the posterior surface is always more prominent than the supero-medial border. This is more easily appreciated from diagrams (Figs. 1 & 2).

There are 2 bursae in this region; a subcutaneous one over the prominence in question (not always present) and the supra-calcaneal bursa, situated between the back of the calcaneum in its upper third and the adjacent anterior surface of the tendo (Fig. 2). Either or both of these bursae may be involved in this condition.

Nisbet (2) describes an articular facet between the tendo and the calcaneum. In the Dissecting Rooms, I have been unable to find such a facet and certainly none exists on the macerated bone. It appeared rather that the tendo Achillis bursa simply eliminates friction between tendon and bone during flexion and extension at the ankle joint. The existence of a facet or otherwise is of no practical importance.

This condition is more common in women and is especially prevalent during cold weather. As regards the sex incidence, the only possible explanation for this lies in the footwear as there is no record of a significant difference in morphology between male and female calcanei. The most important factors in the footwear include the height of the shoe sides at the heel, the fit of the shoe and the texture of the materials from which it is made. The worst offenders are those shoes
with a rim coinciding with the level of the supra-calcaneal bursa and related eminence, which fit badly, either rubbing or constantly compressing this region, and those made from stiff material unwilling to mould itself to the shape of the heel. These factors may seem of a trifling nature, but in this condition they outweigh anatomical considerations in importance. Men's shoes on the whole have higher backs thus avoiding contact of the rim in the region of the bursa and allowing a snug fit round the heel. Furthermore, the vast majority have a lace-up arrangement over the front of the foot which effectively prevents the shoe moving in relation to the foot during the whole life of the shoe. When men do experience pain in this region it is usually due to direct pressure from a new shoe not yet adapted to the contours of the heel. Rarely is it due to rim pressure or chafing.

Consideration of the seasonal incidence shows that this really concerns any spell of cold weather rather than an absolute peak incidence in Winter per se. Perhaps a chilblain type of disturbance is set up in the region, friction on which draws increased attention with the all too familiar itching and burning sensations. It seems unlikely that cold weather could cause symptoms unless pressure factors were already present.

This patient suffered pain shortly after rising from bed - probably due to the rather obvious reason of putting on shoes. Another feature of the condition is increased pain when walking
uphill - this patient was unable to confirm this finding. The disease is often bilateral and from the clinical findings in this case it seems probable that this young lady will have further trouble on her left side in the near future.

**Treatment.**

Mild cases respond to conservative measures such as rest, the avoiding of much walking and the fitting of sorbo rubber pads in the shoe heel. Of course all cases must be advised on the matter of footwear, but often sensible advice on this subject is unwelcome or ignored in female patients.

More severe cases need surgical treatment as in this case. Essentially it consists of removing the supero-lateral eminence of posterior calcaneal border with an osteotome and the supra-calcaneal bursa as well. While such an operation is simple and curative and weight-bearing may begin in the immediate post-operative period, one cannot help being left with a feeling of dissatisfaction that such a procedure to adapt the normal anatomy to a badly designed shoe should be necessary. Throughout the study of orthopaedics in the foot one is struck by the total inadequacy and bad design of modern footwear in almost every respect.
CASE 2.

ONYCHO-CRYPTOSIS

David Scott, aet. 16.
38, West Pilton Park, Edinburgh, 4.
Recommended by Dr. Down.
Admitted 10.1.55, discharged 5.2.55.

Complaint - pain in left big toe of 2 months duration.

History. This boy first came to the Orthopaedic Out-patient Department on 13.5.53 with a painful left hallux. The nail was then removed under general anaesthesia as an out-patient on 27.5.53 with temporary relief from pain. The trouble has recurred over the past 2 months and the patient was sent for a specialist's opinion on 23.12.54. It was decided that he should have a second operation and he was asked to come as an in-patient on 10.1.55.

Previous Health - Good apart from scarlet fever with renal complications in 1953. He admits to tearing his toe nails in bed and bites his finger nails badly.

Physical examination - A healthy looking boy of average intelligence. Very nervous and highly strung, distinctly of a worrying type. Palms and axillae sweating freely and speech hesitant and strained. Nutritional state good with no morbid signs.
The left foot has a markedly ingrowing toe nail on the hallux. The ingrowth is particularly marked on the medial side and in that region paronchychia exists. There is no evidence of lymphangitis or palpable nodes in popliteal fossa or groin. Examination of the other nails shows a deeply buried nail on the right hallux with a similar but less marked condition in all the other toe nails. All nails are torn across their anterior free margin revealing the nail bed in some cases. The corners of the nails are rounded off by tearing and the nail folds rise up as if to enclose them. The toes and feet are broad and spade-like as if from constant vertical compression and are perspiring freely.

**Cardiovascular system.**

Radial pulse - 82, regular, wave normal vessel wall not palpable.

Heart - apex beat 5th space within M.C.L. sounds closed in all areas and no murmurs or thrills present. No oedema venous congestion or cyanosis.

**Respiratory system.**

Chest expansion good.

Percussion note resonant.

Breath sounds vesicular without accompaniments.

**Other systems** N.A.D.
**Treatment.** Bed rest and local hygiene to control paronychia before operation.

Operation 17.1.55 "Excision of nail bed from Left Hallux".

After application of a local tourniquet a longitudinal incision was made on either side of the nail and its folds and bed excised. The upper half of the distal phalanx was removed and the distal half amputated. The lower skin flap was then turned back and sutured with interrupted nylon. A tulle gras dressing was applied.

**Progress.** Post-operative condition satisfactory. Complaining of a lot of pain in the toe. Slight discharge from stitch wounds but no frank infection present. Has some pain in the dorsium of the left foot when walking. At one time he complained of pain in the right great toe nail. Stitches removed - no pain in left hallux now. Patient discharged 5.2.55.

**Discussion**

This condition of ingrowing toe nail is very common but not in young boys. Women are affected more than men in the ratio of 3:1 due largely to abuse and misuse of their feet (3). Much of the blame for the condition must again be laid on the modern shoe. Pointed shoes compress the toes into a cramped space and particularly does the pressure from the vamp drive the nail into the soft tissues round the terminal phalanx. This compresses the terminal pulp compartment and impairs local
Cross sections of terminal phalanx of hallux

A - non-weight bearing.

B - excessive compression of terminal pulp compartment with upriding nail folds.
circulation. The nail folds more upwards and inwards as if attempting to cover the nail (Fig. 3). This is facilitated by the nails being torn off short and torn back at the corners as in this boy. Eventually a groove is created between the nail and its fold in which infection flourishes giving rise to paronychia and often lymphangitis. In more serious and especially in chronic cases, the formation of fissures and warty growths is occasionally seen.

Another predisposing factor is the wearing of stockings too small for the free movement of the toes - often of the shrunken woollen variety which compresses the toes. High-heeled shoes are major offenders. They eliminate the normal weight bearing sequence in the sole during walking and standing, and compress the toes. In addition they cause excessive weight bearing on the toe pulps and metatarsal head regions by partially blocking the support of the posterior pillar of the longitudinal arch. The rigid insole of modern shoes further induces pulp compression and impairs the normal gripping mechanism of the toes on the ground which can only function properly in bare footed peoples.

Of course as in many other conditions, prolonged periods of standing (nurses, waiters, housewives, conductresses etc.) and obesity play a part in producing this condition. Sometimes pregnancy tips the scales in favour of ingrowing nails if other conditions are ripe.
Fig. 4

Diagrammatic sectional view of a terminal phalanx. 1 - horny portion of nail fold, 2 - stratum lucidum, 3 - lunule, 4 - eponychium, 5 - stratum corneum, 6 - germinal zone, 7 - fibrous septum, 8 - medulla of phalanx.
The local anatomy is important (4, 5). (Fig. 4) Many people are unaware of their duty in maintaining the normal anatomy in the foot by correct choice of footwear, local cleanliness and the proper trimming of toe nails. The trimming should always be done at right angles to the axis of the toe and should be carried across the whole breadth of the nail. This avoids the occurrence of horny spicules of untrimmed nail at the edge, which continue to grow forwards and embed themselves in the depths of the nail fold anteriorly and lead to infection. Convex trimming of the nails renders the toe less able to withstand the weight bearing strains of normal life and allows the nail fold to flow upwards over the nail more freely. This results in an impacted rather than an ingrowing nail which is however equally disabling and often proceeds to ingrowth later.

The natural protection afforded to the nail fold is by a condensation of stratum corneum in its depths, homologous with the eponychium (Fig. 4). This normally prevents embedding of the nail into its fold.

It is of interest to note that in the hand where compression strains on the distal phalanges are only slight and of temporary duration, ingrowing of the nails is uncommon. Most people intentionally trim their nails to a convex outline and often the horny stratum corneum mentioned above is removed as well at manicure, with no ill effects.
In summary, the most important factors in this boy's case are obviously nail-tearing and the wearing of faulty footwear, while excessive sweating has softened his skin. This together with rather questionable cleanliness has helped the setting up of paronychia.

Treatment. This case did not respond to the more conservative measures and it was decided to perform a radical curative operation rather than allow additional useless suffering. However, in milder cases conservative treatment has its place. It includes daily antiseptic footbaths with thorough drying of the feet and powdering of the toes. Correct trimming of the nails is insisted on and nail tearing and picking is forbidden. A critical review of footwear, including socks and stockings is indicated, also treatment of obesity should it exist and possibly advice on occupation. Finally sedation and psychotherapy have their place in nervous nail meddlers. Some advocate the use of local measures to prevent the nail embedding, such as tin foil or cotton wool soaked in oil of cloves inserted gently under the nail edge.

In many cases, social conditions make much of the above advice idealistic and often the patient cannot afford to miss work. Such cases are best treated radically as follows. Any infection is controlled pre-operatively by hot baths, poultices, elevation and antibiotics. The operation may be done under a local nerve block at the base of the toe, but is
Operative procedures for ingrowing toe-nail.

A - skin incisions for radical operation.

B - nail bed removed and distal phalanx filleted and its terminal half amputated.

C & D - sutures inserted and tied.

E - side view after operation.

F - wedge resection, a less radical alternative operation.
more satisfactorily performed under a general anaesthetic. In all cases a bloodless field is obtained by a local tourniquet. The types of radical operation are as follows:

1. Simple excision of the nail - this often allows the new nail to grow in good position without ingrowth but was of no avail here.

2. Wedge resection of one or both nail edges (6). This is a good operation in many cases (Fig. 5).

3. Complete excision of the nail bed. This has the distinct advantage of guaranteeing a cure, carries no post-operative disability and is not unsightly (7). It is important to remove all the germinal tissue of the nail bed. The filleting of the terminal phalanx is rendered necessary by its intimate contact via fibrous tissue with the nail bed.

The accompanying diagrams illustrate the main features of these operations (Fig. 5). Excision of the nail bed without shortening of the distal phalanx and the application of a whole-thickness skin graft may be employed as an alternative (6).
CASE 3.

BILATERAL HALLUX VALGUS

Miss Francis McCraig, aet. 43.
31 Howard Place, Edinburgh, 4.
Recommended by Dr. Watt.
Admitted 8.2.55, discharged 15.2.55.

Complaint. Painful bunion on left foot for 25 years, causing much more pain during the last 2 years. Right foot causes much less pain.

History. This lady was sent to the Orthopaedic Out-Patient Department on 13.1.55 with the above complaint. She attributes the start of her trouble to the wearing of high heeled shoes several sizes too small for her at the age of 16. She has always had much pain with new shoes until they were broken in. She has worn her correct shoe size (six) now for many years - mostly of the flat-heeled variety. For the past 2 months the bunion on her left foot has been very inflamed and has throbbed in bed preventing sleep on occasions. It has never broken down or discharged. The right bunion, although well marked has never caused actual pain - discomfort was her description. She expressed a desire to have operative treatment.

Previous History - pneumonia and oophorectomy.
Physical Examination.

A healthy intelligent woman (doctor's secretary), well nourished and without morbid signs.

On examining the feet, both transverse and longitudinal arches are present. A moderate degree of hallux valgus is present on both sides, to an extent of about 25 degrees on the right and 30 degrees on the left. Large bunions are present on both sides, the left one being very tender and inflamed. Flexion and extension excursion is limited to 25 degrees on both sides, but no crepitus is felt on manipulating the first metatarso-phalangeal joints. A degree of primary metatarsus varus is present on both sides.

Cardiovascular system.

Radial pulse 86, regular, normal wave, vessel wall not palpable.

Heart - apex beat in 5th space within M.C.L.

sounds present and closed in all areas. No murmurs or thrills present.

Respiratory system.

Slight cough.

Chest expansion good.

Percussion note resonant.

Breath sounds vesicular with occasional crepitations.

Other systems N.A.D.
X-ray - Bilateral hallux valgus of moderate degree (Fig. 6).

Treatment. "Bilateral Keller's Arthroplasty".

Operation 9.2.55.

After exsanguination a dorsal incision was made along the proximal phalanx. The deep fascia was divided, the periosteum elevated and the proximal portion of the proximal phalanx excised. The osteophytic growths on the metatarsal head were removed with an osteotome and the deep fascia brought into the new joint by a purse-string suture. The skin was closed with interrupted nylon. A similar operation was performed on the other side and padded bandages applied.

Progress. Post-operative condition satisfactory, physiotherapy was begun on the day after operation and toe movements were good especially on the left side. The patient was discharged a few days later.

Discussion

It is now generally agreed that the condition of hallux valgus falls into three groups; a rare congenital form, those secondary to developmental abnormalities in the forefoot and lastly an acquired type. This patient's condition appears to be a mixture of the "forefoot" and "acquired" types.

A note on the functional anatomy of the foot has been included in the section on Morton's Disease with a description of some anomalies.
The main predisposing condition to hallux valgus is the forefoot anomaly of primary metatarsus varus. The position of the first metatarsal bone in the human foot is in itself an interesting study. In the foetus at the time of skeletal differentiation in the limbs, the metatarsal (and metacarpal) axes diverge in a distal direction. This divergence is reduced during intra-uterine life until the metatarsals lie parallel to each other. The last bone to come into line is the first metatarsal and occasionally it fails to fall alongside its fellows. Primary metatarsus varus is then the result. Metatarsal parallelism is an outstanding feature of specialization in the human foot consequent upon the adoption of permanent orthograde posture and loss of prehensile ability. Such ability is only possible when the first and second metatarsal axes are divergent. This creates a free field of movement for the first metatarsal and allows the characteristic movement of the prehensile limbs to take place, namely opposition.

This movement is well seen in the human hand, an exceedingly primitive and unspecialised structure compared to the foot. The condition of primary metatarsus varus is physiological in the apes giving them varying degrees of prehensile ability. Its occasional presence in Man therefore must be regarded as an atavistic feature. Other forms of this atavism in the human foot are recognised. They include
the so-called "Atavistic metatarsus" in which lengthening of
the first metatarsal relative to the others does not occur
(another Simian feature) and "Hypermobile Metatarsus". All
such conditions are of course atavistic and are remnants of
the arboreal existence of earlier Primate stock. Metatarsus
varus was a feature in this lady's case. As regards the pre-
disposition to hallux valgus, only the medial deviation of the
first metatarsal axis is important in two ways; normally the
tendon of m. extensor hallucis longus lies roughly along the
great toe-metatarsal axis, but in varus displacement of the
metatarsal, the tendon is shifted laterally. Thus it gains
a lateral moment of leverage on the hallux and pulls it
laterally - hallux valgus. Once such displacement has
occurred, the use of the foot as a weight bearing organ
aggravates it and the deformity becomes fixed by musculo-
tendinous and ligamentous contracture. Secondly, as modern
footwear does not tolerate any degree of hallux varus, the
medially deviated great toe axis is pushed into valgus, thus
adding an acquired element to the condition so well illustrated
by this lady's history.

The poor shape of modern shoes, particularly their
pointed toes, is yet another item in their long list of faults.
Sir Herbert Barker was among the first to attempt re-education
of the public in the matter of physiologically designed foot-
wear. Unfortunately his well-meant intentions have resulted
in shoes bearing his name being put in a price range beyond the pocket of the man in the street. Perhaps the most important single feature of a good shoe is the presence of a dead straight inner border. Nearly all modern shoes push the big toe laterally to a greater or lesser extent even in the absence of metatarsus varus. There appears to be a reason for slavish adherence to symmetry about the "mid-line" of the foot, perhaps dictated by fashion, which is in complete opposition to the bilateral symmetry dominating animal life except in its most primitive forms. It is interesting to note the shape of an infant's foot with its perfectly straight medial border and the rarity of hallux valgus among barefooted peoples.

Some of the anatomical readjustments secondary to valgus displacement of the hallux have been mentioned, others include the stretching of medial structures, especially the metatarso-phalangeal joint capsule, the lateral shift of the sesamoid bones related to it and the shortening of laterally related ligaments. Other changes in more chronic cases consist of thickening and sclerosis of the first metatarsal head with callus and exostosis formation in response to shoe pressure. The formation of a subcutaneous bursa medially completes the well-known entity of the bunion, prone to aseptic inflammation and often acutely tender as in this case. The chronic subluxation of the first metatarso-phalangeal joint its
Fig. 6

Moderate bilateral hallux valgus - patient's X-rays.

Note - hallux valgus, metatarsus varus, short first metatarsal, laterally displaced sesamoids and some exostosis formation on left first metatarsal head.
consequently impaired function often give way to osteoarthritic changes: destruction of the articular cartilage with eburnation loss of joint space and painful osteophyte formation in the region.

The characteristic radiological findings include valgus deformity, loss of joint space, displaced sesamoids and splaying of the foot due to collapse of the transverse arch. This is usually associated with a short first metatarsal as part of Morton's Syndrome (8) (Fig. 6).

It is interesting to note that a similar condition affects the little toe, its phalanges being displaced medially and the metatarsal head appearing as a prominence (with subcutaneous bursa formation) on the lateral border of the foot. This is an acquired condition usually and is known colloquially as "Tailor's Bunion," (1).

To sum up, the main features in this lady's case are bilateral primary metatarsus varus with hallux valgus displacement aggravated by the wearing of small, badly shaped and high-heeled shoes at an early age.

Treatment.

A degree of hallux valgus sufficiently severe to cause pain and disablement does not respond to conservative treatment. An inflamed bunion is rarely the source of all the pain and in any case such treatment as cutting of the shoes does not affect complications which often co-exist e.g. displacement and
hindrance of function in the other toes, and is unsightly.

As regards surgical treatment, about 60 different operations have been used - the first was by Hueter in 1877. Modern procedures include those of Keller, McBride, Peabody and Erlacher (9). The Keller operation is simple and most successful and was employed in this case. It gives excellent results especially on serious degrees of valgus. The operation consists of removing $\frac{1}{2}$ to $\frac{1}{2}$ of the base of the proximal phalanx of the hallux and excision of any osteophytes on the related metatarsal head i.e. it is an anthroplasty of the first metatarso-phalangeal joint. This fact should be borne in mind when assessing function post-operatively. Cleveland and Winant (10) give a figure of 93% of patients as having good or excellent function after the Keller procedure in their series of 193 cases. But they issue a warning against weight bearing before the 14th post-operative day and stress the fact that a long convalescence is needed. Such recommendations are of necessity drastically modified in view of the waiting lists and limited hospital accommodation available. A range of 40 degrees of movement is to be expected after operation in most cases (30 degrees extension and 10 degrees flexion). This is more than adequate for everyday needs. In cases without osteophytic outgrowths, the MacBride operation or a modification of it is to be preferred. Of course no operative treatment is complete without adequate supervision afterwards, particularly on the matter of footwear.
CASE 4.

PES CAVUS

David Ballantyne, aet. 34.
20 Spittal Street, Edinburgh.

Recommended by Dr. Neilson.

Admitted 25.9.51.
Re-admitted 30.3.55.
Discharged to N. General Hospital for convalescence 13.4.55.

Complaint. Pain along the inner side of the left foot for 12 years with painful callosities on sole for 17 years. Pain along outer side of right foot for 3 years.

History. In 1934 this patient suffered a compound fracture of the left tibia and fibula near the ankle joint. He was treated in Ward 13 R.I.E. with 9 weeks immobilization. Following this he developed clawing of the left toes and corns on the ball of his foot. His feet and toes were sore on walking. He managed quite well until 1939 when the left foot became painful and swollen after exercise. He was seen 2 years later in Ward 2. Tenotomy of the plantar fascia was carried out with immobilization in plaster for 6 weeks. He had little further trouble until 1943, when in the Army he developed pain along the inner side of the left foot and plantar callosities. The Medical Board in the Army said that he did not need operative treatment at that time. In 1949 he developed pain along the
inner side of the right foot and the pain in the left foot became worse. He attended Ward 2 R.I.E. again and his right foot was manipulated. He was placed on the waiting list for operation.

He now complains chiefly of pain along the outer border of the right foot and some pain along the inner side of the left foot with swelling of the left ankle at night. He can walk 2 miles only and this interferes with his work as a gas-fitter.

Previous Health. Childhood complaints only with no complications.

Physical Examination.

A slim patient, rather worried looking of average intelligence and co-operative.

His gait is awkward and he uses the ball of his left foot to bear weight while the heel is raised.

Left foot. Marked per cavus deformity with clawing of the toes. These are typically shaped being hyperextended at the metatarso-phalangeal joints and flexed at the inter phalangeal joints. The hallux is a well-marked hammer and its overlying skin is inflamed. The extensor tendons stand out on the dorsum of the foot. The toes barely reach the ground during walking and there are tender callosities under the metatarsal heads. There is scarring of the skin over the lateral malleolus.
Movements - Extension of foot - free.

Flexion " " - full - makes extensor tendons taut.

Flexion of toes limited and painful.

Right foot. Arches well formed. Slight clawing of the toes. The terminal phalanx of the 5th toe is flexed and everted and is abnormally mobile. There is a central callosity over the middle of the anterior arch.

Movements - Extension of foot - free.

Flexion " " - free.

Inversion \( \{ \) limited and painful.

Eversion \( \} \)

Other joints N.A.D.

Cardiovascular system.

Pulse 86, regular in time and force.

Heart - sounds closed in all areas, no murmurs.

B.P. 140/86.

No cyanosis oedema or venous congestion.

Respiratory system.

Chest expansion good and symmetrical.

Breath sounds vesicular with a few crepitations at right apex.

Other systems N.A.D.
Treatment.

On his first attendance a metatarsal bar on the insole of his shoe was suggested. His present attendance was for operative treatment in view of pain and swelling of both feet.

Operation. "Lambrinudi fusion of left toes", 1.4.55.

A dorso-lateral incision was made over the interphalangeal joint of the hallux. This was deepened and the joint exposed. The articular cartilage was removed from both joint surfaces and the tendon of m. extensor hallucis longus was lengthened. A dorso-medial incision was made over the interphalangeal joints of the remaining toes and the joints erased. A dorsal capsulotomy of the metatarso-phalangeal joints was carried out and the extensor tendons divided. The skin incisions were closed with interrupted silk sutures without drainage.

X-ray report. The right side is fairly normal. The left side shows well marked pes cavus, with clawing of the toes. Some hallux valgus deformity is present. On both sides the first metatarsal is unduly short.

Discussion

Although claw foot or pes cavus ("Hollow Foot") is an easily defined and identified clinical entity, in most cases the precise etiology cannot be ascertained. In this patient there is a definite history of trauma to the left leg and on this side the pes cavus is certainly more marked. However, no
damage was suffered on the right side yet pain, hammer toes and well marked longitudinal arches indicating a mild degree of incipient claw foot are present on that side also.

Pes cavus is characterised by a marked accentuation of the longitudinal arches with flattening of the anterior arch and hammer toe deformity. All these features are well illustrated by this patient: the great toe displacement almost amounting to a dorsal subluxation of the metatarsophalangeal joint.

This patient would appear to belong partly to the post-traumatic group of claw foot and partly to the idiopathic variety. In some cases claw foot is of congenital origin - here heredity plays a large part (by direct transmission to offspring of the same sex in a single family group) while many congenital cases have a neurological lesion such as spina bifida occulta or a myelo-dysplasia. Rarely, congenital syphilis has been associated with the deformity.

Among the acquired types poor posture, bad footwear (especially high heels), poliomyelitis, spastic paralysis, arthritis, post-inflammatory contracture of plantar fascia and neurological lesions such as Friedreich's Ataxia and progressive peroneal atrophy are possible causes. This patient exhibits none of these features and as suggested above, his deformity is probably a mixture of bilateral idiopathic claw foot precipitated in a moderately severe form on the left side only by trauma.
More recently it has been suggested that this large group of idiopathic claw foot (which includes the majority of cases) is caused by neuro-muscular inco-ordination, causing weakness of the extensor muscles of the toes and weakness of the intrinsic foot muscles, especially the lumbrical group. In some cases absence of the latter muscle group has been shown. The lumbrical muscles have an interesting dual function and an importance quite out of proportion to their size. They are inserted into the extensor expansion on the dorsum of the proximal phalanges. This enables them to flex the metatarsophalangeal joints and to extend the interphalangeal joints. Thus they splint the toes and prevent them buckling excessively during strong contraction of the long flexors in the thrusting, propulsive movement as the forefoot leaves the ground. Absence or weakness of these tiny muscles allows the long flexors to act unopposed, thus the toes are flexed. Furthermore extension is allowed at the metatarso-phalangeal articulation. In the normal foot the "splinted" toes give the long flexors a relatively fixed insertion, tension in them is thus high and they are able to sling up the corresponding metatarsal heads. Unopposed toe flexion prevents this sling action, the metatarsal heads drop, the anterior arch is eliminated and painful callosities develop in the region as in this man. According to Hoke (11) this dropping of the forefoot is really plantar angulation at the naviculo-cuneiform joints.

Once its mechanisms are set in motion, claw foot is a
progressive condition. In this way it resembles hallux valgus. It may be subdivided into several stages according to severity and these are of importance in planning treatment. Eventually the deformity becomes "fixed" by musculo-tendinous and ligamentous contracture; the digital extensors, the dorsal part of the metatarso-phalangeal joint capsule and the plantar aponeurosis are important in this way. In cases of great severity, shortening of the tendo calcaneus and adduction of the forefoot may be found. In all cases painful callosities develop due to poor function in the foot arches, tiredness on standing and walking and incapacity result as shown in this patient. He gave a typical history of having difficulty in fitting new shoes due to his "high instep". In children with clawfoot, often the parents complain of the rapidity with which shoes are worn out, this taking weeks rather than months. Pain is not a prominent feature in juvenile cases as a rule.

The pain experienced by this patient along the inner side of his left foot is due to ligamentous strain in the plantar aponeurosis and long plantar ligament. These shorten as described and normal weight bearing causes excessive tension in these tiebeams. Laterally placed pain in the sole is due to excessive weight bearing and callosity formation in that region. It is noteworthy that at the time of operation this patient's pain was chiefly on his right side. It is a feature of early claw foot that ligamentous pain exists before clinical deformity. Steindler (1) points out that such pain has well-marked "trigger"
Lambrinudi's sole plate.

The fused toes are splinted by sling sutures passing round the five metal rods.
points of value in diagnosis e.g. at the attachments of the plantar ligaments and fascia and over the sinus tarsi. Treatment.

This depends on the severity of the deformity. Mild-to-moderate cases often respond to such measures as exercises for the intrinsic foot muscles and/or a metatarsal bar (which must be correctly placed behind but only just behind the metatarsal heads). In all fixed cases, operative treatment is essential, as in this patient. The Lambrinudi operation (12) was used for this case, its object being to splint the toes by arthrodesis of their interphalangeal joints, thus replacing the action of the weak or absent inlumbricales. The long flexors of the toes regain their fixed insertion and can increase their tone support the metatarsal heads and restore the anterior arch. Arthrodesis is effected by excision of the articular cartilage. Splinting of the digits can be ensured by a number of means. Originally, Lambrinudi used intramedullary ivory pegs while more recently Selig introduced intramedullary wires. Another alternative is the use of a sling suture passing over the dorsium of the proximal phalanx and secured to the Lambrinudi sole plate, (Fig. 7). Arthrodesis is followed by extensor tendon tenotomy. The extensor hallucis longus may be lengthened, as in this case or tenotomised and threaded through a hole bored in the neck of the corresponding metatarsal. Dorsal metacarpo-phalangeal capsulotomy is
performed to allow good positioning of the toes. Arthrodesis will be complete in 8-10 weeks in this patient and he will then be given exercises to re-educate his foot. It is axiomatic that the other muscles of his limbs will be kept in good shape by quadriceps drill etc.

Other operations for pes cavus include stripping of the calcaneum (13), extensor tendon tenectomy and tendon transplant without arthrodesis, and extensor tendon transplant through the medial and lateral cuneiform bones (Hibbs). These soft tissue procedures are sometimes insufficient by themselves and bony operations such as anterior tarsal wedge osteotomy, mid-tarsal fusion, triple fusion arthrodesis of Naughton Dunn (14) and Hoke's Naviculo-cuneiform fusion (11) have all been recommended. Rarely is it necessary for the foot to be radically modified by operations such as astragalectomy and forefoot amputation or Syme's amputation (15) since the recent improvements in tarsal fusion procedures.

Results depend largely on the severity and fixity of the original deformity. This patient's condition was of only moderate severity and should respond to the Lambrinudi operation. It is possible that his right foot may need a similar operation, at least on the lateral four toes, at a future date. Blockway (16) recommends prolonged plaster immobilization, vigorous foot exercises and proper supervision of footwear in order to avoid failures after soft tissue operations especially. Occasionally repeated operations and manipulations are needed.
even in mild cases as deformities tend to recur. Even then a tarsal fusion may be ultimately necessary.

**Prognosis.** This patient is a good co-operative type and should regain good function in his left foot within six months. He should be able to resume his occupation as a gas-fitter shortly afterwards. As regards his right foot, one is inclined to be more guarded in giving an opinion. Hammer toes rather than a frank pes cavus might develop on that side in the future.

**History.** This lady first attended the Orthopaedic Out-Patient Department on 23.1.50 with the above complaint. Only the left foot was causing symptoms, tiredness on standing being particularly troublesome. She has tried both low and high-heeled shoes but none lessened the pain, indeed high heels make it much worse. She has worn a metal arch support of proprietary make in the left shoe for many years and that has given some relief. She now feels that she is walking on her heel. Some years ago her left ankle swelled and became stiff; this was not associated with trauma. At no time has her right foot caused trouble and her general health is excellent.

**Physical examination.**

The patient is an intelligent middle-aged woman, well nourished with no obvious skeletal appearances. Superficially the feet appear to be in good condition.
**CASE 5.**

**CALCANEO-NAVICULAR SYNOSTOSIS**

Mrs Marjory Kilpatrick, aet. 44.

39, Allan Park Road, Edinburgh.

Recommended by Dr. Millar.

Admitted 15.1.55, discharged 11.2.55.

Complaint. Pain, stiffness and tiredness on walking in left foot for 18 years.

History. This lady first attended the Orthopaedic Out-Patient Department on 23.1.50 with the above complaint. Only the left foot was causing symptoms, tiredness on standing being particularly troublesome. She has tried both low and high-heeled shoes but none lessen the pain, indeed high heels make it much worse. She has worn a metal arch support of proprietary make in the left shoe for many years and that has given some relief. She now feels that she is walking on her heel. Some years ago her left ankle swelled and became stiff; this was not associated with trauma. At no time has her right foot caused trouble and her general health is excellent.

Physical examination.

The patient is an intelligent middle-aged woman, well nourished with no obvious morbid appearances.

Superficially the feet appear to be in good condition.
On closer examination, the longitudinal arch of the right foot is rather shallow and almost absent in the left foot. The head of the talus and the navicular and medial cuneiform bones are prominent on the left side. The left forefoot is held in a permanently everted position and when the patient walks, the lateral displacement of the foot on the tibia is exaggerated. On testing the movements, the range is limited at the ankle joint as is eversion and inversion at the subtaloid and mid-tarsal joints. No pain is experienced or crepitus felt during these manoeuvres. The foot is not swollen.

Similar features are present on the right side but to a much lesser degree.

**Cardiovascular system.**

Radial pulse 86, regular, wave normal vessel wall not palpable. B.P. 130/78. No venous distension cyanosis or oedema. Heart - apex normal sounds present and closed in all areas - no murmurs or thrills.

**Respiratory system.**


**Other systems** N.A.D.
X-ray examination. There appears to be a bar of bone between calcaneum and navicular on both sides.

Treatment.

On 23.1.50, conservative treatment in the form of sorbo rubber arch pads and foot exercises from the physiotherapists were given. It was felt that the rigidity of the condition contra-indicated the use of metal devices. This treatment did not relieve symptoms and the patient was again referred for a specialist opinion. It was decided that a fusion operation was necessary to eliminate pain and produce a stable foot. Operation was performed on 18.1.55.


The left lower limb was exsanguinated and a pneumatic tourniquet applied to the left thigh. A sandbag was placed behind the left buttock and behind the left tendo calcaneus. A curved incision was made over the tarsus and the bones exposed after division of the peroneal tendons and forward reflexion of m. extensor digitorum brevis. The sinus tarsi was small and no movement was possible at the sub-taloid or talo-navicular joints. The cancakeo-cuboid and naviculo-cuneiform joints together formed the mid-tarsal joint. This was very mobile, but there was no evidence of soft tissue initiation or joint degeneration. This mid-tarsal joint was then erased and approximation of the rawed surfaces maintained
by means of a staple bridging across the calcaneo-cuboid junction. The m. flexor digitorum brevis was replaced and the peroneal tendons repaired. The subcutaneous tissues and skin edges were sutured. A well-padded plaster cast was applied from toes to knee and the tourniquet removed.

**Progress.** Post-operative condition excellent. Two days after operation the patient was moving her toes well. On 21.1.55, the padded plaster was removed and the wound inspected. Healing was satisfactory and the stitches were removed and a new plaster applied. It was found difficult to mould a longitudinal arch or to completely correct the eversion of the forefoot.

**Discussion**

The subject of flat foot is a wide and difficult one and much of the underlying pathology is unknown. The condition may be congenital or acquired but this patient appears to be a difficult mixture of the two. Of course the element of calcaneo-navicular fusion is of congenital origin, but symptoms were only present from the middle twenties of the patient's life. Presumably before that, the stigmata of acquired flat foot were developing on a basis of impaired tarsal function, muscular hypotonicity and ligamentous strain, possibly aggravated by poor posture, gait and footwear and long periods of standing. Thus the stages of flat foot as
visualised by Perkins (17) succeeded each other in this patient (modified by the synostosis) namely potential flat foot, mobile, temporary and eventually fixed flat foot deformity. Other types of bony pathology apart from calcaneo-navicular fusion and related anomalies can give rise to rigid flat foot e.g. talo-calcanean bridge, lipping of the head of the talus, talo-navicular lipping (possibly a form of talo-navicular os) and arthritis of the tarsal joints leading to peroneal spasm.

A flaccid variety of flat foot also exists but rarely if ever proceeds to a rigid deformity.

Before 1921 it was thought that rigid flat foot was caused solely by either peroneal spasm or disordered tarsal function, toxic synovitis secondary to an infective focus, long hours of standing and abnormalities of the talo-navicular ligament. All these factors can and do produce flat foot but it was not until 1921 that Sloman (18) directed attention to bony anomalies of congenital origin in the tarsus. This patient is a case of flat foot secondary impaired tarsal function due to calcaneo-navicular anomaly. Such anomalies were missed initially because of the difficulty in spotting them on ordinary X-ray views such as a straight lateral film. Sloman advocated the use of an oblique inverted position of the foot during exposure to show the calcaneo-navicular gap more clearly.

The connection between the navicular concerns the posterolateral process of the navicular and the anterior process of the
Fig. 8
Sketch of calcaneo-navicular bar of left foot viewed from the medial aspect. (Mercer).

Fig. 9
Calcaneo-navicular synostosis in right foot. Normal lateral view with an obscure shadow.
Fig. 10

Calcaneo-navicular synostosis in left foot. Showing how the anomaly may be overlooked. Features similar to those of Fig. 9.

Fig. 11

Calcaneo-navicular synostosis. Oblique view by Sloman's technique showing a well defined bar.
Fig. 12
Calcaneo-navicular synostosis.
Oblique view, left foot.

Fig. 13
Oblique view, right foot of the same case as Fig. 12.
Fig. 14

Accessory calcaneum.
Showing the os in characteristic position.

Fig. 15

Diagrammatic medial and lateral views of foot showing sites of some accessory bones.
1 - os trigonum, 2 - accessory calcaneum, 3 - dorsal talo-navicular ossicle, 4 - intercuneiform os, 5 - inter-metatarsal os, 6 - os of Vesalius, 7 - external tibial os, 8 - sustentacular os.
calcaneum. The gap between these processes is subject to a number of interesting variations which are not excessively rare. The variations concern the organisation of the foetal mesoderm in that region. A complete bony bar may rigidly unite navicular and calcaneum as in this case or a fibrous cord may take its place (Figs. 8, 9, 10, 11, 12, 13). Overgrowth of the postero-lateral pointed process of the navicular has been personally observed in a number of dried specimens. The other forms of anomaly include the presence of a small bony nodule in the calcaneo-navicular gap (Fig. 14). In two series by Laidlaw (19) and Pfitzner (20), the incidence of such a nodule was as high as 1-2% respectively. Several examples of such a nodule are now on record - Laidlaw (19), Pfitzner (20), Dwight (21) and Mercer, 1931 (22). This bone which Gruber has named the "Accessory Calcaneum" is one of the series of accessory bones occasionally found in the foot. The illustration shows some of these bones (Fig. 15). They are not sesamoids and may be separate and articulated. The accessory calcaneum may articulate with or be fused to either the calcaneum or the navicular. It is obvious that these anomalies represent varying degrees of ossification in the region.

From the clinical point of view, such structures vary in their production of symptoms. A case of complete calcaneo-navicular synostosis went through military training in Canada
without symptoms, while others such as this lady suffer serious impairment of inversion and eversion movements. Strain is thus put upon the mid-tarsal joint or whatever joint acts as that joint and pain is the result. Rarely symptoms may arise from trauma to the anomalous structure e.g. fracture of a bony bridge or tearing of a fibrous band. In this case a progressive rigid flat foot deformity has resulted, illustrating yet another possible associated symptom complex.

Treatment.

Conservative treatment of flat foot secondary to tarsal anomalies does not give good results. Arch supports, strapping and shoe modifications such as metatarsal bar are of little use. Occasionally a symptomless anomaly may be fractured and respond to immobilization becoming symptomless again after union. Such cases are rare.

Contrary to what might be expected, the mere excision of the offending structure does not restore normal function. This is due to an associated insufficiency in the muscular and ligamentous supports of the foot arches, rendered thus by long deprivation of dynamic function and with consequent atrophy and fibrous contracture. This is well shown by many cases of so-called peroneal spastic flat foot, the spasm being really disuse contracture.

Thus some form of fusion operation is needed to stabilize
the foot in a good functional position and eliminate painful ligamentous strain. A large number of procedures is in use including sub-talar and talo-navicular fusion. This converts the talus, calcaneum and navicular into a solid block of bone thus eliminating strain on any calcaneo-navicular connection. In this patient the hypermobile "mid-tarsal" joint was erased. Naviculo-cuneiform fusion is a useful procedure in flat foot with plantar angulation at the naviculo-cuneiform joint. This was first pointed out by the late Mr Jack (23). Thirty-eight of his series of forty-six cases of flat feet from various causes were thus rendered symptom-free. Such sagging is detected by the great toe raising test which corrects the flat foot only if angulation is anterior to the talo-navicular joint.

These fusion operations are contra-indicated in growing patients otherwise a disturbance of endochondral ossification would result due to the intentional elimination of articular cartilage. In such cases, manipulation and plaster fixation under general anaesthesia and/or arch supports will generally tide the patient over until a fusion can be undertaken if need be. In some severe cases fusion may have to be performed before growth has ceased.
CASE 6.

MORTON'S METATARSALGIA

Mr John Pinkerton.

7, Calder Medway, Sighthill, Edinburgh.

Recommended by Dr. Dodson.

Admitted 29.1.55, discharged 7.2.55.

Complaint. Pain in the left 4th toe region of 6 weeks duration.

History. This patient was a drill instructor in the Cameron Highlanders during World War II. He has always been proud of his feet which never gave any trouble until early 1952. He then noticed a tired feeling in the left foot only. It became gradually worse and he reported to his M.O. as his work on the parade ground became unbearable. He was allowed to wear civilian shoes which eased the discomfort until his demobilization in September 1952. His present occupation is that of an attendant in the National Portrait Gallery, Queen Street, and it involves much walking and standing. For about 12 weeks he has had pain on top of his left 3rd and 4th toes which often compelled him to remove the shoe, this together with bathing alleviated the pain. He has no pain in the sole of his left foot and at no time has his right foot caused any symptoms.

Previous History. His health has always been good. He has a slight early morning cough. While serving in the Highlanders
he was captured and as a P.O.W. he endured a forced march of about 1,000 miles in Germany. His feet gave him no trouble even after this ordeal. His left knee was damaged by shrapnel in France 1940 but was successfully repaired by a French surgeon and is now "as good as new". He developed a right inguinal hernia in 1943 which was repaired by a German surgeon.

**Physical examination.**

A pleasant co-operative patient of average intelligence inclined to be introspective. He is well nourished and of a strong "wiry" type.

The right inguinal and left knee scars are exceedingly neat and well healed. The right foot looks normal. The left has a moderate degree of hammer toe deformity in the 3rd and 4th toes and a slight hallux valgus. The left metatarsal heads are prominent in the sole. On compressing the forefoot laterally he experiences a sharp shooting pain in the 3rd cleft. Tactile sensation is diminished in this region and the foot is tender on pressure over the plantar aspect of the 3rd and 4th metatarsal head region. Movements of the toes are unimpeded.

**Cardiovascular system.**

Radial pulse 88, wave normal and regular, vessel wall not palpable.
Fig. 16.

Fig. 17
Morton's Metatarsalgia. Lateral view of left foot. Note claw toe deformity.
Fig. 18


Fig. 19

Heart sounds closed in all areas - no murmurs or thrills - apex beat normal. No cyanosis oedema or venous congestion.

Respiratory system.

Slight smoker's cough in mornings, with some mucoid sputum. Never any pain, breathlessness or haemoptysis.

Chest expansion good.

Percussion note resonant.

Breath sounds vesicular with a few low rhonchi and crepitations at the bases. Resonance normal.

Other systems N.A.D.

X-ray examination. Slight left hallux valgus otherwise N.A.D. (Figs. 16, 17, 18, 19.)

Treatment. Excision of plantar digital neuroma from 3rd left intermetatarsal space.

Progress. The day after the operation, the patient was comfortable, but strangely suffered no loss of sensation in the 3rd cleft. After a few days the patient was discharged ambulant.

Operation. Notes on the operation were not available at the time of writing.

"Excision of plantar digital neuroma in left foot."
Mechanics of weight-bearing in the foot.
A - weight-bearing sites and their sequence.
B - transverse arch - non-weight-bearing.
C - anatomical but not functional elimination of transverse arch during weight-bearing.
Discussion

For many years the "diagnosis" of metatarsal pain (metatarsalgia) was made without the underlying pathology being defined. This was largely due to a lack of information on the pathology and particularly on the mechanics of this region. An understanding of the functional mechanics is an essential precursor to a consideration of the differential diagnosis of metatarsal pain.

The concept of the foot as an intricate, highly specialised support developed following Man's adoption of the orthograde posture is largely due to anatomists and comparative anthropologists such as Wood Jones and Sir Arthur Keith. The foot is not merely a static base upon which the body weight rests, but is rather a combination of arches, each having its component pillars, keystone and tiebeam apparatus. These arches are not rigid structures but cushion shocks applied to them by means of associated ligaments and muscles.

Essentially the foot consists of three arches; two longitudinal, a lateral and a medial having a common posterior pillar in the calcaneum, and a transverse arch in the region of the metatarsal heads. As it has an important bearing on this case the transverse arch will be considered in more detail.

This transverse (or "anterior") arch is only anatomically present when the sole of foot is not under pressure. Weight bearing obliterates it anatomically but not functionally (Fig. 20)
Fig. 21

Lateral view of foot.

A - Tiebeam action of m. peroneus longus and the intrinsic muscles of the sole in direction "A" during voluntary muscle tensing.

B - Sling action of m. peroneus longus and m. tibialis posterior in direction B.

Continuous line - during contraction.

Broken line - during relaxation.

Note depression of longitudinal arch during relaxation.
the intrinsic mechanisms of the arch are still present and include the plantar ligaments between the metatarsal heads, the digital flexors and the tendon of m. peroneus longus. The ligaments are static and deficient function in the muscles causes pain due to permanent flattening of the arch and ligamentous stretching (Fig. 21). Such deficiency of function occurs in the deformity of pes cavus, with relative shortening of the digital extensors and hammer toe formation completing the picture of claw foot seen to a slight extent in this patient. Deficient muscle function in the foot also occurs in feet with an abnormal metatarsal formula. The most usual mutation is a relative shortening of the first metatarsal with backward displacement of its related sesamoids. This results in weight bearing on the second metatarsal which is unequipped for the task. This is collectively known as Morton’s Syndrome (24).

It is unnecessary to describe the muscles and ligaments in more detail but a brief picture of functional dynamics of the foot in action may not be out of place (Fig. 20). The heel strikes the ground first, then as the forefoot approaches the ground, the weight is transmitted along the lateral longitudinal arch. The anterior arch meets the ground last and bears the full weight with the aid of the toe flexor mechanism. The final movement is a propelling of the body forward by a sudden increase in plantar pressure on the pulps of the toes.
The figures illustrate the arch mechanisms discussed above.

These mechanisms and disordered function in them account for the majority of cases of metatarsalgia, the differential diagnosis of which will now be considered.

1. Pain may be due to ligamentous strain in the transverse arch as outlined above.

2. In 1875 Morton (24) suggested that forefoot pain was caused by the flattened anterior arch allowing compression of the plantar digital nerve between the heads of the 3rd and 4th metatarsals and the ground. He added that this explained the reference of pain to adjacent sides of the 3rd and 4th toes. As proof he pointed out that the pain may be reproduced by lateral compression of the forefoot which squeezes the same plantar digital nerve. This test was well illustrated by this patient and in the absence of other pathology e.g. a march fracture, is strongly in favour of plantar digital neuroma (see later).

3. More recent investigations have shown that in many cases of forefoot pain a neoplasm of the plantar digital nerve in the 4th space is the cause (following its compression).


5. Thrombo-angiitis obliterans causes pain due to local muscle ischaemia. Other forms of arteritis in the foot are rare.
6. Local bursitis - bursae occasionally exist over the plantar aspects of the metatarsal heads and the metatarso-phalangeal joints (25).

The precise localising signs in this patient made a diagnosis of plantar digital neuroma fairly certain. However from the clinical picture it seems doubtful whether this alone accounted for his symptoms. The claw foot deformity which he had in mild degree undoubtedly allowed undue pressure on the plantar digital nerve in the 3rd intermetatarsal space, and it is noteworthy that his right foot although local signs of a neuroma could be demonstrated, the virtual absence of claw foot on that side allowed good transverse arch and toe gripping function thus preventing undue compression of the neuroma and pain. It is suggested that the marked hammer toe deformity in his left foot caused local toe pain by direct shoe pressure and by referred pain along the toes from neuroma compression. It is impossible to say which of these factors was predominant - both were, of course, relieved by removal of the shoe. This was volunteered in the history. The very slight degree of hammer toe on the right side was presumably of an extent too small to cause pain by interphalangeal joint pressure dorsally.

**Plantar digital neuroma**

Although the name "Morton's Metatarsalgia" is now often given to the above condition, Morton himself never suspected the presence of a neuroma in his patients and never recorded
Fig. 22

Plantar digital neuroma.
Longitudinal section showing spindle-shaped enlargement of the nerve.
(Low power).

Fig. 23

Plantar digital neuroma.
Transverse section showing gross thickening of the perineurium.
(Low power).
Fig. 24
Plantar digital neuroma.
Transverse section showing thick perineurium and slight thickening of the endoneurium. (Medium power).

Fig. 25
Plantar digital neuroma.
Showing deposition of hyaline material in perineurium and the indistinct border between the perineurium and nerve tissue proper. (High power).
such a finding. In several of his cases he attributed the pain to direct trauma, in others to compression of the plantar nerve of the 3rd intermetatarsal space. Morton operated on a case of metatarsalgia on March 22nd 1873 and later stated that pressure was the cause in that case i.e. on the medial division of the lateral plantar nerve. Presumably he did not find a neuroma in that case.

**Etiology of the tumour.**

In spite of Morton's original views, traumatic irritation of the plantar digital nerve has never been proved to exist. Certainly this nerve is more fixed than its fellows, especially posteriorly. This is due to the double derivation of the nerve from a network composed of lateral and medial plantar nerve filaments closely applied to the tendon of m. flexor digitorum brevis to the 4th toe (26).

Present day views seem to be that neuroma formation is due to a neoplastic tendency at the junction of two nerve filaments to form the plantar digital nerve and/or to the fixity of the nerve so formed rendering it susceptible to trauma of stretching and pressure types. This would account for the otherwise inexplicable selectivity of this particular plantar digital nerve to neuroma formation.

**Tumour pathology.** *(Figs. 22, 23, 24, 25.)*

The site of the tumour is fairly constant being either between or just proximal to the 3rd and 4th metatarsal heads
and at the junction of the communicating branch of the lateral plantar nerve to the lateral division of the medial plantar nerve before it bifurcates to supply the 4th cleft. The tumour is fusiform and usually small although McElvenny (27) has removed one measuring 20 x 13 x 5 m.m. In all cases the tumour is benign and in the nature of a neuro- or angiofibroma or a combination of the two. Its external coats are soft and contain much fat while the centre of the tumour is harder and more fibrous and occasionally shows cystic degeneration.

It has been pointed out that these tumours are not confined to this particular region but are common in skin, intermuscular septa and fascial sheaths. These are less frequently reported due to the cushioning effect of local tissues such as bulky muscles and subcutaneous fat which render the tumours much less liable to compression trauma.

McElvenny reports that females predominate in established cases by the ratio of 10:6, and very rarely he found other plantar digital nerves involved in the neoplastic process.

**Treatment.**

Originally Morton treated most of his patients conservatively - giving them wide shoes with firm soles embodying an excavation in the region of the 3rd and 4th metatarsal heads. He had success only in the mildest of cases, but as has been pointed out, he was apparently unaware of the local pathology.

Later many and often drastic operations were performed.
including amputation of the 4th toe and arthroplasty of the 4th metatarso-phalangeal joint.

Even today, MacMurray (7) and Steindler (1) advocate conservative treatment initially in all cases using metatarsal bars. Certainly such a regime is desirable if diagnosis of the pathology is in doubt.

Others including Speed and Smith (28) recommend immediate operation once the presence of a tumour is established. McElvenny was the first to demonstrate a tumour in June 1935, since then many operations have been performed on these neuromas. The actual approach varies; Mercer (29) recommends a dorsal incision, Steindler a plantar one. Plantar incisions may be longitudinal, transverse or web splitting. The tumour is located dorsal or the plantar aponeurosis and below the deep transverse ligaments of the sole. A wide resection of the tumour and adjacent nerve is adviseable, leaving the proximal cut end buried deeply in muscle. This obviates the risk of pressure symptoms on a terminal "neuroma".

Results.

Such an operation cures most cases dramatically. The loss of cutaneous sensation in the 3rd cleft is a trivial matter and in any case, reinervation apparently takes place from adjacent digital nerves within a few months. The persistence of sensation in this man's foot after operation is unexplained.
Thus this patient's symptoms due to the neuroma will be cured, but if his hammer toe deformity gives trouble some fusion operation may be necessary e.g. Hoffman (30) or Lambrinudi (11). In time his other foot may require excision of its neuroma should it give rise to symptoms.
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