PES CAVUS
A CLINICAL STUDY WITH SPECIAL REFERENCE TO ITS ETIOLOGY.

by

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A RECORD OF SIX CASES OF PES CAVUS.

DEFINITION.

Pes Cavus or Hollow Claw Foot is a deformity exhibiting three cardinal features (Steindler):

1. An increase in the height of the longitudinal arch.

2. A dropping of the anterior arch with plantar flexion of the front of the foot.

3. A variable amount of dorsal retraction of the toes, the claw-foot deformity proper, with hyperextension of the metatarsophalangeal and flexion of the phalangeal joints.

Cases I, II, IV and V are recorded by permission of Professor Wilkie and Mr W.A. Cochrane, Case III by permission of Miss Herzfeld and Mr Stewart Middleton and Case VI by permission of Professor Fraser.

Permission has also been given for the inclusion in an appendix of a further series of cases treated in the Royal Infirmary and the Royal Hospital for Sick Children.
CASE I. D.M. Female, age 24. (No. 36 in series)

Bilateral.

HISTORY.

The patient had been employed as a saleswoman for 8 years and for six years had suffered from pain referred to the anterior arch and the inner border of the foot. She also complained of swelling of the ankles. All these phenomena were most severe at the end of the day, and after some months produced such disability that she consulted her doctor who diagnosed an early stage of flat foot and advised her to wear a support. She also tried the effect of bandaging her ankles but while this prevented the oedema it did not relieve the pain. She wore the support regularly for two years, but her symptoms increased in spite of it, and her doctor sent her to the R.I. for advice.

EXAMINATION.

There was (bilateral) increase in the height of the longitudinal arch; in both feet the head of the first metatarsal was prominent in the sole, and could not readily be replaced by pressure, and there was marked dorsal retraction of the toes, more especially in the left foot. The skin over the ball of the feet was hardened, though callosities had/
had not yet formed; but there were corns on the dorsal aspect of the interphalangeal joints of the toes on the left foot. There was no limitation of dorsiflexion at the ankle and no additional deformity at the mid tarsal joint.

No tenderness could be elicited by palpation over the insertion of ligaments round the ankle joint, and at this time there was no oedema.

The patient's general health was good; there was no discoverable abnormality of the nervous system, and no cardiac insufficiency which might have accounted for the oedema.

**Diagnosis.** Bilateral pes cavus of 3rd degree.

**OPERATION.** 6.2.28 by Mr W.A. Cochrane.

The operation consisted of subcutaneous division of the plantar fascia in both feet, with tenotomy of the long extensors of the toes on the left side.

Both feet were wrenched to stretch the sole structures, and plaster was applied in the corrected position.

**AFTER-TREATMENT.**

After a week the plaster was bivalved to allow of massage. On removal of the plaster exercises were commenced and the patient attended an instruction class so that she might be able to carry out the treatment/
treatment at home. Unfortunately, fearing to lose her occupation she ceased attendance before the completion of the course, and without obtaining instructions about her shoes. The result was a recurrence of symptoms after she had been at work for a few weeks though the deformity was entirely corrected. As she was unable to attend the massage department for further treatment she was advised to wear a metatarsal bar on both shoes, and to persevere with remedial exercises when practicable.

COMMENTARY.

There appeared to be no reason for the development of pes cavus in this case. The patient herself could assign no cause to the condition, and was convinced that until she was 18 her feet had been perfectly normal. It appeared that her symptoms were associated with the long hours of standing which her work entailed; her shoes were not of a particularly non-anatomical shape, and except for dancing she did not wear high heels. Questioned as to her recreations she stated that she had never had much outdoor exercise; she had been fond of dancing but had never danced much, and lately had not danced at all, as although she did not notice any pain at the time she invariably suffered from an exacerbation of the symptoms after she had danced.

No further information could be obtained from the/
the patient, but later an opportunity occurred of questioning her relatives and their statements threw some light upon the etiology in this case. In infancy dorsal retraction of the toes had been observed, though its significance was not appreciated and no increase had been noted in the height of the arch. She was late in learning to walk, no attempt being made until 19 months; there was nothing else to indicate rickets. It was also difficult to provide her in childhood with well-fitting shoes, she was never comfortable until "she had worn a nest in them" the site indicated corresponding to the head of the first metatarsal.

In view of these facts it would seem probable that the deformity was in reality a congenital defect whose manifestation, as indicated by symptoms, had been long delayed.

There was no evidence of any hereditary influence. Further reference is made to this case in the discussion.

CASE II. G.B. male, aet 38 (No. in series 39) Unilateral (Left).

HISTORY.

This patient was an engineer employed in overhauling railway engines. His work entailed much standing.

For/
treatment at home. Unfortunately, fearing to lose her occupation she ceased attendance before the completion of the course, and without obtaining instructions about her shoes. The result was a recurrence of symptoms after she had been at work for a few weeks though the deformity was entirely corrected. As she was unable to attend the massage department for further treatment she was advised to wear a metatarsal bar on both shoes, and to persevere with remedial exercises when practicable.

COMMENTARY.

There appeared to be no reason for the development of pes cavus in this case. The patient herself could assign no cause to the condition, and was convinced that until she was 18 her feet had been perfectly normal. It appeared that her symptoms were associated with the long hours of standing which her work entailed; her shoes were not of a particularly non-anatomical shape, and except for dancing she did not wear high heels. Questioned as to her recreations she stated that she had never had much outdoor exercise; she had been fond of dancing but had never danced much, and lately had not danced at all, as although she did not notice any pain at the time she invariably suffered from an exacerbation of the symptoms after she had danced.

No further information could be obtained from the/
EXAMINATION.

The left foot showed a pronounced degree of pes cavus the right foot being normal. There were distinct callosities on the sole of the left foot over the site of the dropped metatarsal heads, and the latter could not be replaced by pressure. There was dorsal retraction of the toes but no corns on the dorsum of the joints.

Dorsiflexion at the ankle was limited but there was no real shortening of the tendo Achilles; the whole foot appeared to be immobile and stiff, the muscles of the leg were wasted, and the general limitation of movement together with this disuse atrophy were suggestive of chronicity. There was also a commencing functional scoliosis, and a slight tendency to varus at the midstarsal joint.

OPERATION. 25.2.28 by Mr W.A. Cochrane.

Steindler's operation was performed on the left foot; the long extensors of the toes were not divided. The foot was wrenched to straighten the arch and put up in plaster in the corrected position.

AFTER-TREATMENT.

The plaster was bivalved at the end of a week and after three weeks the casing was discarded, and remedial exercises were commenced; the faradic foot bath was also employed. The patient took a great/
great interest in the treatment and persevered with the exercises with the result that he made excellent progress. He was discharged 3 weeks after the operation with a metatarsal bar on his boot.

Five weeks later he returned to work, the condition had greatly improved and the metatarsal bar added considerably to his comfort. Correction of the deformity was not quite complete but the functional result was excellent; the patient referred to it as a "miracle", and said that for ten years he had never been able to work so well.

The absence of pain also improved his gait and this indirectly prevented a general sense of fatigue to which he had long been liable.

Three months after the operation the patient began to be troubled by a tender area on the lateral border of the sole beneath the head of the 5th metatarsal, probably associated with a persistence of the tendency to varus. He was given instructions to have the metatarsal bar heightened on the outer side of the boot to relieve pressure and correct the inclination to a varus position.

COMMENTARY.

The patient could assign no cause to the deformity, the symptoms arising from it were apparently due to the long hours of standing entailed by his occupation.

He/
He had served in the army for one year during the War but after that had worked in munitions. On one occasion a stone had lodged in the sole of his sand shoe during his army training and the patient had speculated as to its possible association with his symptoms. He agreed that it was an inadequate explanation; it had not immediately preceded the onset of symptoms and had not produced a cellulitis which through cicatrical contraction might have led to a later development of the deformity. The only other trauma recorded (a severe burn) affected his right leg, and as it occurred in 1920 the symptoms due to cavus antedated this injury.

Reference must be made to an impediment in the patient's speech. Articulation was indistinct, and occasionally his speech was unintelligible; it was hesitant and slurring and strongly suggested an association with some ataxic condition.

The nervous system presented no obvious abnormality. It was difficult to elicit the deep reflexes satisfactorily as the patient would not relax his muscles, there was however no spasticity and the plantar response was normal. There appeared to be a slight inequality of the knee jerks, the left being decreased, but it was difficult to obtain a conclusive result. Rhomberg was negative. There were no abnormal ocular phenomena, and no sphincter disturbance, neither was/
was there any intention tremor, but in walking the
gait was peculiarly unsteady.

The patient was a Cornishman by birth and the
possibility of his speech being merely a dialect
presented itself. His wife however stated that on
visits to his native town his friends commented on
"this new language", and she was of the opinion that
his speech was less distinct than it had been when
they were married in 1922.

The association of pes cavus, the speech defect,
and a slight alteration in reflexes with wasting of
the muscles of the leg and an unsteady gait is suggest-
ive of organic nervous disease and particularly of
the group of ataxias of hereditary and familial origin.
Enquiry was therefore made as to whether any other
members of the family in the same or previous genera-
tion had exhibited a similar condition. The family
history however was negative.

The clinical picture is in any case incomplete
but it seems possible that the condition in this case
is of nervous origin and that some slowly progressive
disease of the nervous system may have exhibited
already an insidious onset. The familial ataxias
develop during childhood as a rule, but delayed
manifestation is not uncommon as in the "Sanger Brown"
type, and Friedrich's ataxia may also remain latent
until after the age of 30; there is also a slight
incidence/
incidence upon the male sex, and the nervous phenomena are characteristically variable owing to the arbitrary manner in which the several columns of the cord may be attacked.

In the absence of more definite evidence it has not been thought justifiable to classify this case as of nervous origin, but there can be little doubt that the deformity had been present for more than the ten years during which symptoms had been complained of.

CASE III. V.H. female, aet 8 (No. 48 in series)

Bilateral.

In the summer of 1927 the child was wearing sandals and attention was directed for the first time to a pronounced dorsal retraction of the 5th toe of each foot, most noticeable in the left. For some years the child had complained of discomfort if her shoes were at all tight, and her mother had been careful to provide her with wide shoes. The remaining toes showed no such evident abnormality but were slightly drawn up and the child had difficulty in pointing her toes in the dancing class at school.

In November her mother took her to the Sick Children's Hospital for advice, and she was treated by/
by osteotomy and plaster but the condition did not improve to any great extent, and in May she was again admitted as an out-patient under Miss Herzfeld.

EXAMINATION.

The fifth toes of both feet were dorsiflexed acutely at the metatarso-phalangeal joint and plantarflexed at the interphalangeal joints. On the left side the toe was also adducted and had come to over-ride the fourth. The remaining toes were slightly retracted but showed no lateral displacement. In both feet the height of the longitudinal arch was increased, the metatarsal heads were prominent and the head of the first could not be replaced by pressure. There was some limitation of dorsiflexion at the ankle, but no varus deformity was present at the midtarsal joint. The skin on the ball of the foot was thickened and there was a tendency to the development of corns.

The nervous system was normal, and the child was in good health.

OPERATION. 8.5.28 by Mr Stewart Middleton.

The extensor tendon of the 5th toe was exposed by an incision on the dorsum of the foot, and was lengthened by a sliding operation. A dressing was applied and the toe was secured in position.

A metatarsal bar was advised but operative treatment for the claw foot deformity was not considered necessary at present.
COMMENTARY.

The mother stated that the patient had never been able to play as the other children did, she was easily tired and was unable to go for long walks. She had never actually complained of her feet being painful but was disinclined to walk or stand for long.

Enquiry was made as to the duration of the deformity of the toes and whether this was present in infancy. The mother stated that she had noticed that the toes looked "fat" at birth, and that the patient's feet had always seemed thick compared with the feet of the other children which were slim. She had never noticed any increase in the height of the arch, and had not attributed any of the symptoms to a painful condition of the sole, but she said that the child had always been inclined to have "walking skin", i.e. a tendency to the development of blisters. These appeared on the ball of the foot below the metatarsal heads, they were not constantly present but appeared if the child walked much. She was late in learning to walk but in this case there was indirect evidence of rickets for teething was delayed until the 9th month, and after the third month she was fed on Allenbury's food. This was afterwards changed, cows' milk being substituted and the condition of the child improved. There was no history/
history of spasmophilia, and no evidence of past rickets in the bones; the tendency was probably checked by the alteration in diet before any permanent structural damage had occurred.

The position of the toes bore a strong resemblance to the congenital hammer or "hook" finger, and there can be little doubt that the deformity of the toes was present at birth. Its association with pes cavus is interesting as although dorsal retraction of the toes is an integral part of the deformity it is unusual to find it exaggerated to so marked an extent in the little toe alone. There was no history of any familial tendency to the condition, either with regard to the foot or hand.

CASE IV. J.G.K. Male, aet 28 (No.38 in series)

Unilateral.

HISTORY.

The patient stated that he had suffered from pain in the left foot for as long as he could remember; it was always most severe at the end of a day's work and had occasionally been so bad that he was unable to keep his employment. His left foot also swelled. The pain was referred to the medial side of the foot and was dull and aching in character; it sometimes extended up the leg, the anterior tibial muscles being/
being affected most. In addition to this he had always had corns on the ball of the foot, and on the dorsum of the toes, and was subject to periodical attacks of severe cramp in the night involving the whole of the foot and passing up into the leg.

The first occasion on which he was entirely incapacitated by the pain was in 1915; he was then 14 years of age and had begun to work at the pit-head, but he had not been employed there long before his foot began to trouble him, and finally the pain was so severe that one day he had to give up work and was sent home in a van as he could scarcely walk.

He was sent to the R.I. for treatment, and was advised to wear a support in his shoe and no heels. He wore the support for a time but did not return for further treatment and as the support gave him no relief he finally gave up wearing it.

Towards the end of the War he served in the Navy for 15 months but was not sent on active service. At that time his foot was much better though he was never quite without pain and unfortunately he received a blow on the left foot at the end of his period of service which caused a recurrence of the symptoms. He was out of work for a time but recently became a bus driver. This was not a very suitable occupation as he found his left foot painful in using the clutch, and his doctor advised him to return to the Royal Infirmary for treatment and he was admitted for operation on Feb. 24th 1928.
EXAMINATION.

The left foot showed marked increase in the height of the longitudinal arch, with retraction of the toes. The anterior part of the left foot appeared broader and thicker than the right; the head of the first metatarsal was prominent in the sole and could not be replaced by pressure, and the skin over it was much thickened and callosities had formed. There were corns also on the dorsal aspect of the interphalangeal joints of the toes. The tendo-Achillis was slightly shortened, and dorsiflexion at the ankle was limited; there was no varus deformity at the mid tarsal joint.

In other respects the patient was in good health and showed no abnormality of the nervous system.

OPERATION 26.2.28 by Mr W.A. Cochrane.

Steindler's operation was performed on the left foot with division of the long extensors of the toes.

The foot was wrenched to straighten the arch and plaster was applied in the corrected position.

AFTER-TREATMENT.

Massage and exercises were carried out as described in cases 1 and 2. The patient returned to work after completing the massage course and had a metatarsal bar fitted to his boot.
The deformity was well corrected and the position of the toes was particularly satisfactory.

Ten weeks later the patient was still at work and was almost entirely free from discomfort. He had recently been promoted to drive a heavier motor and found this rather a strain upon his foot, but had not had any recurrence of the pain to date. He was very pleased with the result, and was still wearing the metatarsal bar. His only symptoms were related to the insertion of the tendo Achillis, and were probably due to constant slight stretching of the ligament resulting from the corrected position of the foot.

COMMENTARY.

Although his foot did not seriously trouble him until he began work at the age of 14 the patient said that he had never been entirely free from discomfort and was unable to play football when at school. At the age of 11 the condition was further aggravated by an injury from a heavy block of ice which fell on his left foot and crushed the toes. His mother also remembered that when he was sent to school at the age of five he was obliged to come home again on account of a sore toe which disabled him for some weeks. She attributed this to the new shoes he was wearing at the time, as they were stiff and stronger than any he had worn before, but she could find nothing in/
in the toe of the shoe to account for the injury in
the left foot alone. It had not occurred to her that
the fault might be in the child's foot, but ever since
he began to wear stiff shoes the interphalangeal joint
of the big toe always became sore and blistered and
he was never comfortable until the shoes were stretched.
The right foot never gave him any trouble, and his
mother never noticed any peculiarity in the left foot
before the age of five.

It seems probable however that some degree of
deformity had existed since birth, but it is common
experience that no attention is paid to it until
symptoms arise. In this case actual pain and dis-
ability appeared earlier than is usual, although the
symptoms were intermittent until the age of 14.

There was no family history suggestive of
hereditary influences but there can be little doubt
that the condition was a congenital defect.

CASE V. R.C., male, aet 27. (No. 45 in series)

Bilateral.

HISTORY.
The patient was a baker and for 5 years had
suffered from pain in both feet, referred to the sole
beneath the first metatarsal head, and most severe in
the right foot.
The pain was more or less constant but always became worse at the end of the day. His occupation entailed much standing.

A year ago a corn developed on the dorsal aspect of the right great toe over the interphalangeal joint, and since that date it had steadily increased in size.

Since Jan. 1928 he had also suffered from profuse sweating in both feet.

The pain in the right foot was so severe as to produce lameness and he now walks with a limp.

For many years he had been obliged to wear special shoes, but the condition had not improved.

**EXAMINATION.**

In both feet there was increase in height of the longitudinal and transverse arches.

The great toes were shorter than the second toes in each foot, and there was definite dorsal retraction of the toes.

On the dorsal aspect of the interphalangeal joint of the right great toe there was a large corn, and on the interphalangeal joint of the left great toe was a bursa.

Over the extensor digitorum brevis a slight fulness could be seen; this was present on both feet.

**OPERATION 7.4.28. by Mr W.A. Cochrane.**

Steindler's operation was performed on the right foot. The foot was wrenched, and put in plaster/
plaster in the corrected position. The patient came from the country and therefore did not attend the Infirmary for massage. Six weeks after operation he reported, and had made extremely good progress. The deformity was completely corrected, and the functional result entirely satisfactory.

**COMMENTARY.**

The patient had had a very high instep ever since childhood but did not develop symptoms until he was 22. During boyhood he had measles, chicken pox, scarlet fever and diphtheria, and in 1922, at the age of 21 he had double pneumonia.

This history of several acute illnesses in childhood is of interest in view of the observation that pes cavus may be a sequel of the specific fevers, and the case has been classified as due to these illnesses, diphtheria being most often responsible, but in this case the deformity antedated the diphtheria.

It is also noteworthy that symptoms were not developed until the age of 22, one year after he was in bed with double pneumonia. The relation of acute illness to pes cavus is considered in the discussion and the suggestion is made that an illness of this nature accentuates a preexisting condition and may in the absence of other factors determine the onset of/
of symptoms. It is quite possible that the fevers 
were not the fundamental cause of the deformity in 
this case. The arch was observed to be high in child-
hood, and as pes cavus generally becomes noticeable 
some years after an acute illness it seems very pro-
bable that the condition was present before these 
ilnesses, which no doubt added their quota to the 
development of the deformity, but were not actually 
responsible for its origin.

In the absence of more definite evidence it 
cannot however be classified as a congenital defect.

CASE VI. M.W., female age 7. (No. 46 in series) 
Unilateral.

HISTORY.

At the age of 2 yrs. 6 months the right foot 
was twisted in a fall from a go cart, and shortly 
afterwards the mother noticed that the foot was 
deformed. The child was taken to hospital and the 
foot and leg were put in plaster extending to the 
waist.

On two occasions an X-Ray photograph was taken 
but both were negative.

EXAMINATION.

The child appeared to be quite strong and 
healthy but was small for her age. She walked with 
a/
a limp but there was no pain or tenderness. The right leg was underdeveloped and the foot was in a position of equino varus with some degree of cavus. The knee jerks were increased on both sides.

Electrical Reactions. The muscles of the leg showed no abnormality but no response could be obtained with either current from the small muscles of the foot.

OPERATIONS. 7.4.28 by Prof. Fraser.

The operation consisted of fasciotomy and transplantation of the tendon of the extensor hallucis longus into the extensor hallucis brevis and the head of the first metatarsal.

8.4.28. Steindler’s operation was performed for correction of the cavus deformity.

COMMENTARY.

It appears probable that the injury only served to direct attention to a pre-existing condition. The alteration in reflexes and early development of a pronounced deformity suggest a congenital origin as the spasticity was bilateral and could not therefore be accounted for by the trauma.

The absence of response to electrical stimulation shown by the small muscles of the foot is of interest in view of the analogy to main-en-griffe which was originally suggested by Duchenne as the cause of pes cavus.
cavus, and in this case their paralysis appears to have been a factor in its production.

The association of diminished response to Faradism from the small muscles of the foot and brisk knee jerks is rather suggestive of the peroneal type of muscular atrophy, in which talipes equino-varus and pes cavus are common, but the distribution is bilateral as a rule. 24

Although this paper is primarily intended as a detailed record of five cases it was found that a proper appreciation of the points presented by these could only be obtained by the analysis of a larger number. The records of a further series of cases have therefore been investigated, the tabulated results are appended and form the basis for discussion.

An attempt has been made to discover what condition is most frequently responsible for the deformity at different age periods and whether there is any association between clinical and etiological types or a significant difference in sex or age incidence.

HISTORICAL ASOCIATION WITH OTHER ILLNESSES.

In 1889 F.R. Fisher drew attention to the prevalence of a mild degree of pes canus and to its association with specific fevers and other acute illnesses.
ETIOLOGICAL ASPECTS OF PES CAVUS.

INTRODUCTORY.

Pes cavus has long been recognised as a distinct clinical entity, but its etiology is still a controversial subject and the theories concerning its nature and significance are so numerous as to suggest that none is in itself adequate to explain the clinical facts observed.

Although this paper is primarily intended as a detailed record of six cases it was found that a proper appreciation of the points presented by these could only be attained by the analysis of a larger number. The records of a further series of cases have therefore been investigated; the tabulated results are appended and form the basis for discussion.

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HISTORICAL.

ASSOCIATION WITH ACUTE ILLNESS.

In 1889 F.R. Fisher drew attention to the prevalence of a mild degree of pes cavus and to its association with specific fevers and other acute illness.
illness. He distinguished and described two stages of the deformity, talipes arcuatus (pure cavus) and talipes plantaris, the latter being intermediate between pure and equino–cavus.

In 1927 Pes cavus was the subject of discussion at a meeting of the Orthopaedic Section of the Royal Society of Medicine.¹

Referring to the etiology of the condition Rocyn Jones considered three main types of cavus according to whether it was of postural, paralytic or traumatic origin. He also expressed the opinion that slight degrees of cavus were a frequent sequel of acute illness and Gordon Pugh stated that the prevalence of these cases was not sufficiently appreciated.

SEQUEL TO EQUINUS.

Rocyn Jones traced the development of pes cavus from an initial foot-drop, resulting from a faulty attitude due to pressure of bed clothes and associated with a transitory paresis of the tibialis anterior or extensor digitorum longus. This slight equinus lasted long enough to allow adaptive shortening of the plantar fascia. On recovery from the illness an awkward gait was sometimes observed owing to the slight degree of foot drop, but as the tone of the muscles improved the symptoms also subsided. No further immediate effects were observed, but later, perhaps/
perhaps after an interval of years, a differential growth rate came into operation, the contracted plantar fascia could no longer keep pace with the development of other structures and acted as a "taut tie-band" bringing the pillars of the long arch into apposition and forcing its convexity upwards. A cavus deformity was thus produced and it needed only some added strain or prolonged pressure to induce symptoms.

This theory did not account directly for dorsal retraction of the toes but Naughton Dunn expressed the opinion that weakness of the tibialis anterior and peroneus brevis were compensated by over-action of the extensors of the toes with the result that "dorsal dislocation" of the toes occurred in the effort to clear the foot from the ground in walking.

PERVERSION OF RECIPROCAL ACTION.

Rocyn Jones also referred to the suggestion made by C.A. Parker in 1913\textsuperscript{21} that cavus resulted from loss of the reciprocal action which normally exists between the extensors and flexors of the toes.

ANALOGY TO MAIN-EN-GRIFFE.

Percival Mills\textsuperscript{10} has recently revived the analogy to ulnar paralysis originally suggested by Duchenne as a cause of the deformity. He shows that paralysis of the intrinsic muscles supplied by the lateral/
lateral plantar nerve should cause a deformity precisely similar to claw foot, as main-en-griffe is produced in the hand.

LOSS OF NORMAL MUSCLE BALANCE.

Steindler\textsuperscript{11} on the other hand says "the increase in height of the longitudinal arch is due mainly to the unopposed or insufficiently opposed pull of the short muscles of the foot which draw the ball of the foot towards the heel;" but the muscles he specifically refers to are not the group supplied by the lateral plantar nerve.

PARALYSIS.

There is general agreement that paralytic cases are mainly due to anterior polyomyelitis and spastic paralysis. The former is productive of a very severe degree of deformity, and the latter is often of congenital origin.

CONGENITAL AND DEVELOPMENTAL ANOMALIES.

Opinions differ as to the frequency of congenital cases, and various developmental abnormalities have been suggested to account for the condition. Among these may be mentioned arrest of development or delayed medullation of nerve fibres, or incomplete medullation resulting from premature birth, spinal malformation such as spina bifida occulta, wedge vertebrae/
vertebrae etc. (these are only discovered if X-rays are employed as a routine method of examination); and a differential growth rate which may be under the control of hereditary influences. Among traumatic cases vascular lesions resulting from intra uterine or birth injury or other conditions have been suggested which might result in an ischaemic contracture, or in destruction of cortical areas.

SHOES.

The modern shoe has been held responsible by some authorities, but here again there is little unanimity of opinion. Thus Fraser⁹ associates pes cavus with high heels and the "role of the professional dancer" among acquired cases in adults, and Dudley Morton⁰ also says "shoe wearing ...... has a distinct tendency towards elevating the arch because it eliminates the retarding effect of the foot's natural flexibility. This seems to explain the greater prevalence of higher arches among the members of the white races as compared to those who are not shoe wearers." Sir Robert Jones⁸ on the other hand says "the modern shoe causes crumpling and distortion of the toes and diminishes the power of the toes to spread, the muscles of the foot atrophy and a condition is brought about which is opposed to the maintenance of the arch without strain." He therefore appears/
appears to think that such shoes produce flat foot rather than pes cavus, and the context of this statement is in reference to flat foot.

CONSIDERATION OF THEORIES ADVANCED.

The complexity of the problem is evident, and no single theory can be said to accommodate all the facts.

Mills objects to the hypothesis that paralysis of the tibialis anterior can cause claw foot because this is a recognised cause of valgus whereas pes cavus tends to be varoid, and paralysis of this muscle should actually produce flat foot.

SEQUEL OF FOOT-DROP.

Mills is still more sceptical of the suggestion that claw foot can follow paresis of all the anterior muscles of the leg as "this is invoked to explain right angled contraction and mild degrees of talipes equinus." He contends that until it can be explained how pes cavus, an entirely different deformity, can be due to a similar cause, this hypothesis is quite untenable.

Since the publication of his paper Naughton Dunn and Rocyn Jones respectively have to some extent provided this explanation and Fraser attributes pes cavus to secondary contraction of the muscles of the sole and calf following paresis of the extensors in polyomyelitis which supports this view.
ANALOGY TO MAIN EN GRIFFE.

Mills himself was unable to present conclusive evidence that his hypothesis, theoretically unimpeachable, accounted for the deformity in practice. He endeavoured to establish its validity by investigating the electrical reactions of the interossei, using the faradic bath and testing the abductor hallucis also to serve as a control. In a series of 29 cases 23 gave a normal response, 5 responded weakly and in only one was no response obtained; the abductor hallucis responded normally in every case. There was thus only slight support for his theory but he explains the large percentage giving a normal response on the grounds that at the time of examination paresis was no longer present, and he argues that this does not disprove an antecedent paralysis. There was however a history of paresis in only 9 out of 52 cases.

He refers to a case of cavus associated with progressive muscular atrophy which was classified as giving a normal response, and cites this as evidence that the electrical reactions are no criterion of the history of the case. An anomalous result may occur in some cases owing to the fact that normal and degenerate fibres are stimulated coincidently, and a "mixed reaction" is characteristic of all conditions in which the muscle wastes fibre by fibre (Collier & Adie).
A "neurotonic" reaction has also been described by Remak in certain cases of progressive muscular atrophy; it is characterised by an excessive reaction to faradism and galvanism and may be followed by slight tetanus for 10-30 secs.

It seems curious that paralysis of the quadratus plantae (flexor accessorius) and oblique head of the adductor hallucis (both supplied by the lateral plantar nerve) should be associated with an approximation of the anterior and posterior pillars of the longitudinal arch, for while these are not specifically concerned with the maintenance of the height of the arch they participate in the general shortening of the sole structures in pes cavus, and the origin of the quadratus plantae is divided in Steindler's operation for correction of the deformity. If these muscles fail to exert normal traction between the ball of the foot and the heel the reverse of an approximation of these two points should result. They might be shortened by atrophy fibrosis, but there is one clinical observation to which no reference seems to have been made, and that is the appearance of the anterior part of the foot in pes cavus, particularly noticeable where comparison can be made with the normal foot of the same individual as in a unilateral case.

There seems to be if anything a hypertrophy of the soft parts in addition to the bony prominence of the/
Third Layer of Muscles of Sole
(From Grey's Anatomy)

Tracing of Radiogram of Clawfoot showing outline of soft parts.
the dropped metatarsal heads and in excess of any thickening of skin or increase in subcutaneous fascia and fat.

The position occupied by the transverse head of the adductor hallucis (one of the muscles supplied by the lateral plantar nerve) is invariably the site of a fleshy mass projecting at the base of the toes; the remainder of the ball of the foot on the medial side is largely covered by the flexor hallucis brevis (supplied by the medial plantar nerve) but towards the mid-line the oblique head of the adductor also takes part in forming the muscular floor of the sole.

(See Diagrams)

If these were atrophic there should be clinical evidence of wasting in the situations indicated, whereas the reverse condition is strikingly noticeable.

Dudley Morton, discussing the mechanics of the foot dismisses the intrinsic muscles very briefly with the statement that in man they "are apparently undergoing an actual fibrous degeneration"; he regards them as being of slight importance in function and the maintenance of form. They serve, he says, only to increase the spring and resiliency of the foot as a whole, this being one distinction between the anthropoids and man.

If it is a fact that these muscles are actually fibroed this might account for the few cases in which a/
a weak response to faradism was obtained, and if this degenerate state becomes more prevalent as a result of civilisation through successive generations one might anticipate a coincident increase in the incidence of pes cavus if Percival Mills' solution of the problem is correct.

But according to Dudley Morton the intrinsic muscles have long ceased to bear any important function in the human foot; delicacy and accuracy of movement being unnecessary these muscles in the feet unlike their homologues in the hand have fallen into disuse, their lost function being compensated by ligamentous strength and rigidity.

It is therefore open to question whether any further decrease in their activity could produce so pronounced a deformity as claw foot, and it would seem that the intrinsic muscles of the foot can no longer be considered strictly comparable to the intrinsic muscles of the hand.

Hence the analogy to main-en-griffe must also be subject to criticism.
CLASSIFICATION.

Since etiology affords some explanation of the mechanism producing the deformity it is to be preferred, and has been adopted, as a basis for classification.

It was found that the cases fell into two large groups, according to whether the foundation for the deformity appeared to have been laid in ante- or postnatal life.

The first group includes cases in which a hereditary influence would seem to have been responsible for the condition, and those which are considered to be of congenital origin.

The second embraces cases acquired as a result of organic nervous disease, acute illness such as the specific fevers, and also cases which have been termed "postural" and include those of adolescent and compensatory types.

Cases in which the condition was exhibited during the period birth - puberty in the absence of other etiological factors are classified as congenital, and there is evidence that even in adult patients the deformity was sometimes present shortly after birth.

Congenital cases have been subdivided under the headings spastic and non-spastic. The term flaccid, as opposed to spastic, seemed inappropriate as there was no discoverable nervous abnormality at the time of examination, but non-paralytic might be equally incorrect in view of the possibility of antecedent paralysis.
Classification and Analysis of 48 Cases of Pes Cavus.

### GROUP I.

<table>
<thead>
<tr>
<th>Etiology</th>
<th>No. of Cases</th>
<th>Percentage</th>
<th>Sex Incidence</th>
<th>Pure Cavus</th>
<th>+ Equinus</th>
<th>+ Eq. Varus</th>
<th>+ Varus</th>
<th>Calcaneus</th>
<th>Laterality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereditary</td>
<td>3</td>
<td>6.25</td>
<td>M. : F.</td>
<td>2 : 1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>B2 U1 (R1 L0)</td>
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<tr>
<td>Congenital</td>
<td>21</td>
<td>43.75</td>
<td>10 : 11</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>B11 U10 (R4 L3)</td>
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<tr>
<td>(1) Spastic</td>
<td>7</td>
<td>14.3</td>
<td>3 : 4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>B4 U3 (R2 L1)</td>
</tr>
<tr>
<td>(2) Non-spastic</td>
<td>14</td>
<td>29.16</td>
<td>7 : 7</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>B7 U7 (R2 L2)</td>
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</table>

### GROUP II.

<table>
<thead>
<tr>
<th>Etiology</th>
<th>No. of Cases</th>
<th>Percentage</th>
<th>Sex Incidence</th>
<th>Pure Cavus</th>
<th>+ Equinus</th>
<th>+ Eq. Varus</th>
<th>+ Varus</th>
<th>Calcaneus</th>
<th>Laterality</th>
</tr>
</thead>
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<tr>
<td>Polyomyelitis</td>
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<td>18.75</td>
<td>M. : F.</td>
<td>6 : 3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>B3 U6 (L2 L0)</td>
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<tr>
<td>Specific Fevers</td>
<td>6</td>
<td>12.5</td>
<td>3 : 3</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>B3 U3 (R1 L0)</td>
</tr>
<tr>
<td>Postural</td>
<td>9</td>
<td>19.75</td>
<td>7 : 2</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>B4 U5 (R0 L3)</td>
</tr>
<tr>
<td>(1) Adolescent</td>
<td>3</td>
<td>16.5</td>
<td>6 : 2</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>B4 U4 (R0 L2)</td>
</tr>
<tr>
<td>(2) Compensatory</td>
<td>1</td>
<td>2</td>
<td>M.</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>B0 U1 (R0 L1)</td>
</tr>
</tbody>
</table>

In last column of table: B = Bilateral
U = Unilateral
(R) = Right
(L) = Left
where side is known.
GROUP I.

HEREDITY.

Of the three familial cases two occurred in males; the female case was characterised by absence of knee jerks and was suspected of being an example of Friedrich's ataxia. Her mother and grandmother had a similar deformity of the feet but are not known to have suffered from any disease of the nervous system.

It is unfortunate that as full family histories are not available the mode of transmission cannot be studied and it is uncertain whether this is a character conforming to Mendelian Law. It appeared that in any particular family line the condition was limited to one sex and that transmission was direct, but exceptions would probably be found if previous generations could be traced. It is of course impossible on such slight evidence to state that it was sex linked or sex limited in the strict sense of those terms. There was no record of any associated features such as spasticity or ataxia which would indicate a genetic relationship to the group of nervous disorders which are recognised to be of hereditary or familial origin.

CONGENITAL CASES.

Cases exhibiting distinctive features such as spasticity and which were clearly of congenital origin/
origin will not be considered further as their etiology is relatively obvious.

The majority (14) of the cases classified as congenital presented no evidence of any nervous abnormality and there was nothing in the history sufficient to account for the deformity.

In all other respects the child appeared to be normal and in good health, and had not suffered from any severe illness, neither was there any discoverable hereditary element in operation.

Since pes cavus commonly takes some years to develop to the extent of producing symptoms it is evident that the foundation for the deformity must have been laid very early if not actually in antenatal life.

ANALOGY TO OTHER CONGENITAL DEFECTS.

It seemed possible that a consideration of other congenital defects might throw some light upon the causation of pes cavus, and the most common of these, talipes equino varus, appeared most suitable for this purpose. In certain cases pes cavus occurs in association with congenital club foot (Rugh\textsuperscript{17}) and Wilfred Adams\textsuperscript{22} discussing the latter says "though scant attention has been paid to it, flexion (cavus) is an element of this deformity, and needs to be reckoned with" and "the malpositions of the various types/
types of congenital club foot are no more than exaggerations of the extreme points normally attainable by the movements of the healthy foot"; pes cavus is essentially an illustration of such a malposition. He does not refer to the etiology of the condition, but the question arises, can a pure cavus deformity be produced by any mechanism which has been suggested to take part in the development of club foot?

In the absence of other etiological factors talipes equino varus has been attributed to undue pressure in utero associated with a deficiency of liquor amnii, and generalised contracture of the lower limbs is believed to be due in some cases to the same cause. In one case in the present series (No. 29) there was, in addition to the cavus deformity, congenital absence of phalanges and bilateral hallux valgus; the former is well known to be associated with oligohydramnios and the latter might conceivably result from pressure; it is not by any means an integral part of pes cavus, being in fact a very rare accompaniment of that condition. According to Fraser where hallux valgus is congenital it amounts to a subluxation of the metacarpo-phalangeal joints.

If the theory of initial foot drop, with secondary contraction of the plantar fascia can be accepted as an etiological factor in pes cavus it seems justifiable to assume that a degree of equino-varus which would/
would escape immediate recognition might develop later into cavus.

In referring to the results of treatment of club foot Wilfred Adams\textsuperscript{22} says "Intoeing and traces of equino cavus have proved the most frequent residue of the deformity"; it may be inferred that cavus persists owing to contraction of the structures of the sole associated with equinus and that such shortening does not yield to manipulation as readily as do the other elements of the deformity. If a very slight degree of equinus was left untreated, being not observed, the ultimate result would be similar to an incompletely corrected equinus initially of more severe degree.

There is also reason to believe that a pure pes cavus deformity even if present at birth would not be detected during infancy. The feet of infants and adults are not strictly comparable and it seems advisable to review the salient points in this connection before proceeding to a consideration of the mechanism involved, and the clinical features of pes cavus in young children.

COMPARISON OF THE FEET OF INFANTS AND ADULTS.

MORPHOLOGY.

Feldman states\textsuperscript{15} that in an infant the longitudinal arch appears to be undeveloped, and an impression of the foot is similar to that of pes planus/
planus in an adult. This flattening is however more apparent than real, and is due to a well developed pad of fat on the sole which obliterates the arch. Frozen sections of the feet of infants, and measurements of the height of the tuberosity of the scaphoid above the level of the sole in living children provide confirmation of this statement.

Feldman also quotes the findings of John Dane who determined the proportion of height of arch to length of foot in infants during the first two years of life.

The figures are as follows:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Proportion Height to Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children under one year old</td>
<td>0.301</td>
</tr>
<tr>
<td>Children between 1 - 2 years</td>
<td>0.218</td>
</tr>
<tr>
<td>Adults</td>
<td>0.270</td>
</tr>
</tbody>
</table>

It is therefore evident that despite its apparent flatness the arch is fully as high in the infant as in the adult foot in proportion to its length.

**FUNCTION.**

Coordination of movement also presents distinctive features. In adult life extension of the leg is associated with plantar flexion, and flexion of the leg with dorsiflexion of the foot; in infants the foot normally remains dorsiflexed when the leg is extended.

The/
The transition to the adult type of coordination is believed to be regulated by cortical centres which develop after birth, and would seem to be associated with the gradual decrease in the attitude of universal flexion of intrauterine life. If this is so it follows that whatever position is adopted in utero will tend to persist until counteracted by habit formation under the control and guidance of higher centres. A consideration of the mechanics of development shows that errors of posture may be expected to have far reaching effects.

WOLFF'S LAW.

"Every change in the form and the function of bones, or of their functions alone is followed by a certain definite change in their internal architecture and equally definite secondary alterations in their external conformation in accordance with mathematical laws."

It is thus evident that faulty posture or weak musculature occurring in the growth period will result in a bony deformity. The nature of this will depend upon numerous modifying factors and vary according to whether the child walks, or merely "delights in the agitation of its own body."

It may be assumed that loss of muscle balance and faulty posture are mutually interdependent.
CAVUS IN INFANCY.

The application of these facts would seem to be as follows:

(1) An abnormally high arch would not be noticed even if present in an infant.

(2) The second element of pes cavus, dorsal retraction of the toes, might be noticed by an observant parent, though its significance would not be appreciated.

(3) If plantar flexion occurred in utero it would persist for a time and allow shortening of the plantar fascia with perpetuation of the deformity.

(4) Loss of muscle balance, due to faulty posture, would be manifested by delay in learning to walk.

The observed facts which support these deductions are:

(1) An increase in the height of the arch is not noticed even where there was evidence that the condition was present at birth.

(2) Dorsal retraction of the toes may be noticed as in Case 36. "The toes were drawn up" (Mother's statement).

Case 48. "The toes seemed very fat" (Mother's statement).

(3) The deformity is progressive up to a certain point whereas if due to environmental conditions in utero it should regress or disappear when these were removed.
In many cases the child did not attempt to walk until the age of 19-20 months. This might obviously be due to other causes such as rickets, but a history suggestive of this is not always obtained.

CAVUS IN CHILDHOOD.

It may also be inferred that a bony deformity would not develop for some years, and this is in accordance with clinical facts. Even when an increase in height of the arch became noticeable it is doubtful whether any attention would be paid to it. Cavus is merely an exaggeration of a physiological state whose normal limit is undefined. A high arch is considered an asset rather than a defect, and even when symptoms appear their origin is liable to misinterpretation. F.R. Fisher indeed records the fact that flat foot is sometimes held responsible for pain in cases where its antithesis, claw foot, is actually present.

It is therefore evident that a cavus deformity may be present many years in advance of its recognition; in many cases it is probably exhibited at birth, and may be of congenital origin with greater frequency than has appeared.

DELAY IN EXHIBITION OF SYMPTOMS.

Case 36 may be quoted as an illustration of the tendency to error in determining the origin of/
of the condition and the date at which it was exhibited. This case was originally classified as being of adolescent type (postural), and would have remained in that category if an opportunity had not occurred of interrogating the relatives. The patient, aged 24, declared that her symptoms and therefore in her estimation the deformity also, were of six years duration, and that prior to that date her feet were perfectly normal. Nothing would shake her belief but her relatives stated that in infancy her toes were retracted, that she did not walk until 19 months old, and that they had always had difficulty in providing her with well-fitting shoes. She had also worn a support for flat foot on the assumption that this was the most probably cause of her symptoms.

Case 38 is another example of a congenital case which appeared on superficial investigation to be of "adolescent" type.

ANALOGY TO "HOOK FINGER".

In case 48 the position of the 5th toes resembled the congenital contraction of fingers described by Duncan Fitzwilliams, and attributed by him to imperfect development of the anterior ligament of the first interphalangeal joint.
GROUP II.

ORGANIC NERVOUS DISEASES.

POLYOMYELITIS.

Apart from the hereditary case referred to as a possible example of Friedrich's ataxia which is not proven, the only specific nervous disease of etiological importance was polyomyelitis, and it was apparently responsible for 9 of the 24 cases in Group II.

It was characterised by the high incidence of compound deformities and by a differential sex ratio of 6:3.

Arthur T. Legge referring to the sequelae of polyomyelitis, says "a late deformity that is much more common than is supposed is cavus, occurring in feet without apparent weakness as well as in those with considerable involvement. Between 35 and 40% of feet either considered normal at the initial examination, or which appear to have become normal after slight involvement develop the cavus deformity."

This is of interest as again it points to the slow development of cavus and the consequent difficulty in determining its true cause or date of onset, and further that a very slight or transitory paresis can produce claw foot. The explanation of these facts might be either that the intrinsic muscles are alone involved.
involved and their paralysis may pass unnoticed (Mills) or that Rocyn Jones is correct in assuming that the plantar fascia plays an important part in the initial stages and can contract to a serious extent on slight provocation, and in a very short time.

**SPECIFIC FEVERS.**

These have not figured so prominently as might have been expected judging from the experience of Fisher, Rocyn Jones, and Gordon Pugh. They are productive of a mild degree of cavus and it is probable that such cases seldom require operative treatment and therefore are absent from the present series, or the occurrence of fever might not have been noted in recording the history of the case.

In view of the large number of children confined to bed over long periods it seems that if the causative factor is largely mechanical one might anticipate a still greater prevalence of the condition and the question arises, what factor determines the development of cavus in some cases and not in others? This might be due to the occurrence of nervous complications. Various fevers such as measles are known to be followed by a peripheral neuritis with subsequent contracture; mumps may also affect the peripheral nerves and diphtheria is well known to have a specific effect upon nerve tissues and may specifically/
specifically affect the distal muscle groups. In many of these the neuritis tends to be multiple and one might expect coincident involvement of the hands, yet those appear less often affected. There must then be some predisposing condition which determines involvement of the feet alone, and here the effect of pressure probably comes into operation. The anterior muscles of the leg are under a mechanical disadvantage in the position naturally adopted in bed, though the intrinsic muscles of the foot are not, and if the latter was affected it would be necessary to postulate the selective action of some toxin upon this small muscle group. The anterior tibial muscles therefore are weakened by stretching and this is well known to render them liable to paresis. It follows also that if the mechanical factor were removed paresis would be absent and thus another explanation might be found for the absence of fevers as a causative factor in the present series. In the hospital classes from which these patients were drawn children suffering from such "childish complaints" are not kept in bed for more than a day or two at most, if nursed at home, and therefore the effects of pressure and faulty position do not come into operation. It may be that this rapid convalescence prevents foot-drop, and therefore/ 

* Frequently observed in dispensary practice, there is great opposition to keeping the child in bed.
therefore eliminates the subsequent development of cavus, and that in the relatively wealthy it is a more frequent sequel owing to a longer period in bed. It would be interesting to know from what class of society the cases quoted by Gordon Pugh were drawn.

POSSIBILITY OF A LATENT CONGENITAL DEFECT.

Yet considering the large shifting population of our fever hospitals, the long periods in bed, and the absence of prophylactic measures such as those suggested by Gordon Pugh, it seems remarkable not that so many cases occur, but that so many do not. Possibly the illness, with its general debility, accentuates a very slight degree of cavus which had previously been latent. The acute specific fevers may have been held responsible on insufficient evidence; clearly their mere occurrence does not prove any etiological relationship and it may be that some of the cases attributed to them were in reality of congenital origin.

The illness may serve to draw attention to the deformity, as in the case of trauma where closer investigation shows that the injury was so trivial as to warrant exclusion from the list of possible causes.
POSTURAL CASES - ADOLESCENT TYPE.

There is reason to believe that many of these cases could be traced to a congenital origin, but in the absence of definite proof it was not considered legitimate to include them in that category, though the term "postural" is a confession of failure to discover any explanation of their occurrence, the history being entirely negative.

SHOES.

It is in this age group (14 - 25) that faulty footwear would manifest its effects and reference has already been made to the results which should theoretically follow the wearing of shoes. In practice however there is no support for the assumption that shoes can produce pes cavus though they may play a subsidiary part in accentuation of symptoms.

SEX INCIDENCE.

In Percival Mills' series of 99 cases, half were unilateral without special incidence on right or left, the average age at which symptoms appeared was 14, which gave little time for the deformity to develop and the sex ratio appeared to favor males. Present conclusive evidence against shoes being an etiological factor, 54 of the 99 cases occurring in males.

Mills refers to his entire series; in the present series reference will be made to the sex incidence for the/
the adolescent age group (average 18 yrs) alone as its significance in this connection is greater than the ratio for the series as a whole. Of the eight cases occurring after the age of 14, and without any obvious cause, six were males and excluding cases due to polyomyelitis this was the only group in which the sex ratio did not approach equality. One of the two female cases should be discounted as it was a woman of 78 (a fracture case), and therefore quite exceptional. The cavus deformity was marked, but she had no symptoms and was proud of her "high instep" which she had had since she was a girl. This case is not included in estimating age averages, as it would obviously yield a fallacious result.

**OCCUPATIONS.**

An explanation might be sought in the more arduous nature of the occupations pursued by men, but this is not valid when it is remembered that women are frequently employed as shop assistants or in domestic service both of which entail much standing, and this especially if associated with tight shoes is pre-eminently conducive to strain.

**TRAUMA.**

Similarly trauma might be supposed to affect more particularly the adolescent male but injury can be seldom proved to be of any etiological importance (Mills).
CONGENITAL ORIGIN.

As in the congenital groups the sex ratio is equality it might seem inconsistent to attribute the "postural" group with its high male incidence, to a similar cause. But Mills observed an earlier onset among females, and it would seem that in the present series also sex was a factor determining the exhibition of symptoms, perhaps through the medium of shoes.

In the congenital group the average age at which treatment was necessary was 12 years 8 months for boys, and 11 for girls. In the adolescent group the average age of the 8 male patients was 19 and (excluding the woman of 78) there was only one female and her symptoms appeared soon after she began work at the age of 14. The average age at which symptoms necessitated treatment was 15 for both sexes if the series is considered as a whole.

It has already been noted that the deformity and its symptoms are not coincident in their development (Case 36), and it may be inferred that the former appears at a similar age in boys and girls, but that sex is a determining factor where onset of symptoms is concerned. Thus a congenital origin is rather favoured than disproved.

LATERALITY.

One or both feet suffered with equal frequency in the present series if considered as a whole, but/
but the group incidence shows significant variation. Of the three hereditary cases two were bilateral, and this one might expect.

It is of interest to compare the congenital and adolescent group with the distribution in club foot. In a series of 125 cases both feet were affected in 62 and one in 63, and in unilateral cases the left was involved twice as often as the right. In the adolescent group the distribution was similar to this in all respects; in the congenital group the incidence as regards unilateral and bilateral involvement was the same, but (where the side was known) the incidence on right and left feet was equal.

The fever and polyomyelitis groups may also be compared. In the former one or both feet were equally often involved; in the latter one foot was affected twice as often as were both. Since in polyomyelitis there is an aggregation of causative factors a bilateral deformity might be expected, and this restricted involvement may be a significant indication of the effects produced by pressure. Polyomyelitis is the one condition where prophylaxis by splints and cradles is a routine method of treatment, and this may possibly explain the limitation to one foot.

Mills considered his series of 99 cases as a whole; 42 were unilateral involving equally right or left.
left feet, while 57 were bilateral. (not stated in a) so that the distribution was approximately similar in both series, but the failure to record group incidence restricts the significance of distribution.

**COMPOUND DEFORMITIES.**

No attempt has been made to limit this discussion to cases of pure pes cavus because it seems to be generally recognised that the more severe degrees exhibit some additional element.

F.R. Fisher\(^3\) described advanced cases as talipes plantaris, a condition intermediate between pure and equino-cavus, and Sir Robert Jones distinguishes between the 4th and 5th stages of the deformity according to whether varus or equinus respectively are also present.

**EQUINUS MORE APPARENT THAN REAL.**

According to many authorities among whom may be mentioned W.A. Cochrane, Percival Mills and Rocyn Jones, there is seldom real shortening of the teno Achillis and the dropping of the ball of the foot at the mid tarsal joint only simulates equinus; it is in fact the plantaris type described by Fisher. In many cases correction of the cavus deformity by Steindler's operation removes the equinus element without any interference with the teno Achillis whose integrity is necessary as it serves as a fixed point for manipulation.\(^7\)

This illustrates the fact that shortening is often/
often more apparent than real and that the term equinus should be used with caution.

INCIDENCE OF TRUE EQUINUS.

In these records there is no reason to doubt that true equinus was present where stated, and the incidence (15 out of 48 cases) is somewhat similar to that in a series referred to by Percival Mills where 17 cases showed definite shortening of the tendo-Achillis out of a total of 64.

AGE OF CASES EXHIBITING EQUINUS.

In Mills' series the cases exhibiting equinus were invariably old standing pes cavus of severe degree, and the average age of such patients was also greater, being 22\(\frac{1}{2}\) as compared with 14 for the series as a whole. In the present series the average age of patients with equinus was 13 as compared with 15 yrs 8 months for cases of pure cavus, therefore in these equinus does not seem to have been associated with chronicity.

GROUP INCIDENCE.

In the polyomyelitis group more than half the cases showed equinus, and it was present in slightly less than half of the spastic congenital group, i.e. it was characteristic of cavus of paralytic origin. One third of the non-spastic congenital and fever cases were complicated by equinus, and it was/
was absent from what may be termed the "delayed congenital" or adolescent group.

OTHER DEFORMITIES.

Varus and calcaneus occurred so infrequently that no special reference is necessary, and the exact incidence of all deformities will be seen in the tabulated results.

RELATION OF EQUINUS TO CAVUS.

Equinus might be primary, secondary, or coincident with the development of cavus and its relation might be significant in connection with etiology and in view of the hypothesis of Rocyn Jones.

SECONDARY EQUINUS.

It is therefore necessary to consider what static alterations might result from pes cavus and lead to the production of secondary deformity as in any chronic case effects of abnormal strain and loss of balance would be seen. For example there is no doubt that patients affected with painful callosities on the ball of the foot seek to ease their discomfort by transposition of weight on to sound areas and if the head of the first metatarsal is the point of maximum tenderness the foot will tend to assume a varus position in order to relieve pain in this situation. Similarly/
Similarly in a unilateral case, if weight is taken off the foot as a whole it will be liable to be held dependant which might in time lead to adaptive shortening of the tendo Achillis.

**PRIMARY EQUINUS.**

If on the other hand foot drop is indeed a preliminary step towards pes cavus slight equinus might persist, and it must then be present in the early stage of the deformity.

This is known to be the case in a certain type of claw foot which is associated with a short tendo Achillis in its initial stages. The shortening of the tendon may be the primary defect or might itself be secondary and adaptive following a postural equinus. In either case its relation to cavus is clearly that of cause rather than effect.

Mills' observation that equinus occurred in chronic cases and in older patients is in favour of it being a secondary deformity. Observations on the present series are opposed to this view and suggest that it is a primary or coincident defect.

The average age for cases of pure cavus here is high because they include the whole of the adolescent age group, while poliomyelitis occurred in the youngest patients, presented the largest number complicated by equinus, and thus reduced the average age exhibiting the deformity. Equinus must therefore be regarded as
a criterion of severity, not chronicity; it is most common in cases of paralytic origin, and in these must be considered to represent the persistence of a primary defect, which may or may not have preceded the development of cavus.

If not primary to cavus, it was probably coincident in its time relation, and it would in that case determine a progressive increase in the cavus element, which may explain the severe degree of deformity which cases of paralytic origin assume. Therefore whether equinus is primary to cavus or of simultaneous origin it appears to be a factor of importance in the production of advanced claw foot; it must be assumed to exert its influence through contraction of the plantar fascia, and to this extent there is support for the theory of Rocyn Jones. Corroborative evidence is also found in the fact that early stages of the deformity, of whatever origin, exhibit some degree of shortening of the plantar structures. 212

Mere speculation is unprofitable, and these theories should be put to the test of experiment. Observations upon the feet of infants and young children might also throw light upon the etiology of pes cavus, determine its true age of onset and its relation to other defects. This would incidentally provide the possibility of correction while the deformity was still amenable to manipulative treatment alone.
It is admitted that 48 is too small a number from which to draw final conclusions, and that any critical inference must be deferred until further data is available. It is notoriously dangerous to argue from insufficient evidence.

The results recorded here may however represent a true average such as analysis of a larger number of cases would yield, for the figures as regards sex and age incidence, laterality and compound deformities are in close agreement with the findings of Percival Mills in a series of 99.

The facts recorded may therefore be of value; interpretation must be tentative until its validity is further established or disproved.

ACKNOWLEDGMENTS.

I am indebted to Prof. Fraser, Prof. Wilkie, Mr Cochrane, Mr Mercer, Mr Struthers and to Miss Herzfeld for permission to use their cases, and also wish to express my thanks to Mr Stewart Middleton and others who have kindly helped me to obtain necessary data.
SUMMARY.

(1) Pes cavus is probably of congenital origin in cases of obscure causation and a late onset of symptoms does not disprove the theory that it is a congenital defect.

(2) The age at which symptoms are exhibited is largely determined by sex; females require treatment earlier than males, and this may be due to shoes.

(3) There is no evidence that shoes can produce pes cavus in a previously normal foot.

(4) Hereditary cases appear to be limited to one sex in a particular family line and transmission is direct.

(5) Fevers and other acute illnesses do not produce a deformity which requires operative interference and this probably accounts for the small number of cases in the present series.

(6) Polyomyelitis is responsible for the majority of acquired cases, and for a very severe deformity with a high incidence of associated defects.

(7) The sex ratio approaches equality in all but 2 groups. In the polyomyelitis group males were affected/
affected most frequently in the ratio of 6:3, and the adolescent age group also shows a high male incidence but the reason is found under (2).

(8) The distribution of the deformity in congenital cases is comparable to that of club foot and the adolescent age group is similar in all respects. Polymyelitis accounted for more unilateral than bilateral cases in the ratio of 6:3. In the fever group one or both feet were affected equally often. Of 3 hereditary cases two were bilateral.

(9) Equinus is the most common additional deformity; it is a criterion of severity not chronicity and is characteristic of a paralytic origin. It either precedes cavus or is coincident in its time relation.

(10) Trauma is an uncommon cause of the deformity.
REFERENCES.


<table>
<thead>
<tr>
<th>No. in Series</th>
<th>Age</th>
<th>Sex</th>
<th>Age of onset</th>
<th>Etiology</th>
<th>Coincident Deformities</th>
<th>Laterality</th>
<th>Extracts from History</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>M</td>
<td>10</td>
<td>Polyomyelitis</td>
<td>Equino-varus</td>
<td>Bilateral</td>
<td>Worse recently. Some deformity for years.</td>
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<tr>
<td>2</td>
<td>18</td>
<td>M</td>
<td>Youth</td>
<td>Adolescent</td>
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<td>No Spina Bifida. Worse recently.</td>
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<td>3</td>
<td>12</td>
<td>M</td>
<td>Birth</td>
<td>Congenital</td>
<td></td>
<td>Bilateral</td>
<td>Operation for equinus at 5 yrs. Arm of same side affected.</td>
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<tr>
<td>4</td>
<td>27</td>
<td>F</td>
<td>2 6/12</td>
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<td>Equinus</td>
<td>Unilateral</td>
<td>Unilateral(R) No Spina Bifida. Worse for 3 yrs.</td>
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<td>M</td>
<td>Birth</td>
<td>Congenital</td>
<td>Equinus</td>
<td>Unilateral</td>
<td>Bilateral? Pneumonia at 6 months In bed 2 mths. 1st noticed. Scarletina &amp; Diphtheria later. Did not walk until 2 yrs 6 mths.</td>
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<tr>
<td>6</td>
<td>13</td>
<td>M</td>
<td>1 6/12</td>
<td>Fevers</td>
<td></td>
<td>Bilateral</td>
<td>Worse recently.</td>
</tr>
<tr>
<td>7</td>
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<td>Childhood</td>
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<td>Bilateral</td>
<td>Worse 2 years ago.</td>
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<td>M</td>
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<td></td>
<td>Bilateral</td>
<td>Duration of symptoms 2 weeks New shoes 4 wks. previously.</td>
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<td>F</td>
<td>12</td>
<td>Cong. Spastic</td>
<td>Equinus</td>
<td>Unilateral</td>
<td>Unilateral(R) Unusual epiphyses, especially base of 5th metatarsal. Mother's brother and cousin similar deformity.</td>
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<td>Bilateral</td>
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<td>Sex</td>
<td>Age of onset</td>
<td>Etiology</td>
<td>Coincident Deformities</td>
<td>Laterality</td>
<td>Extracts from History</td>
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<td>F</td>
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<td>Cong.Spastic</td>
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<td>Bilateral</td>
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<td>14</td>
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<td>Childhood</td>
<td>Cong.Spastic</td>
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<td>Bilateral</td>
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<td>Equinus</td>
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<td>Adolescent</td>
<td></td>
<td>Unilateral(L)</td>
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<td>Equinus</td>
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<td></td>
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<td>Fevers.</td>
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<td>Unilateral(R)</td>
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<td>Childhood</td>
<td>Polyomyelitis</td>
<td></td>
<td>Unilateral(R)</td>
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<td>Calcaneus</td>
<td>Unilateral(R)</td>
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<td>Childhood</td>
<td>Congenital</td>
<td>Bilateral Hallux Valgus</td>
<td>Bilateral</td>
<td>History of encephalitis lethargica but R. leg had always been short and right arm also.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>History of &quot;shock&quot; with paralysis at 3 affecting one side only. Congenital absence of phalanges.</td>
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<tr>
<td>No. in Series</td>
<td>Age</td>
<td>Sex</td>
<td>Age of onset</td>
<td>Etiology</td>
<td>Coincident Deformities</td>
<td>Laterality</td>
<td>Extracts from History</td>
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<tr>
<td>30</td>
<td>8</td>
<td>F</td>
<td>6</td>
<td>Diphtheria</td>
<td></td>
<td>Unilateral</td>
<td></td>
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<tr>
<td>31</td>
<td>10</td>
<td>F</td>
<td>Recent</td>
<td>Cong. Spastic</td>
<td>Sl. equinus</td>
<td>Unilateral(L)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>5(\frac{5}{12})</td>
<td>M</td>
<td>Recent</td>
<td>Cong. Spastic</td>
<td></td>
<td>Bilateral</td>
<td>History of fall. Swelling (bursa) noticed 3 weeks.</td>
</tr>
<tr>
<td>33</td>
<td>5</td>
<td>M</td>
<td>Recent</td>
<td>Congenital</td>
<td>Varus</td>
<td>Bilateral</td>
<td>Cong. varus deformity at metatarsal joint.</td>
</tr>
<tr>
<td>34</td>
<td>7</td>
<td>F</td>
<td>5</td>
<td>Congenital</td>
<td>Sl. equino-varus</td>
<td>Unilateral(L)</td>
<td>Noted that child drags left foot.</td>
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<tr>
<td>36</td>
<td>24</td>
<td>F</td>
<td>18</td>
<td>Congenital</td>
<td></td>
<td>Bilateral</td>
<td>Worn flat foot support 8 yrs with no effect. Toes dorsiflexed in infancy. Did not walk until 1 yr. 7 mths.</td>
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<tr>
<td>37</td>
<td>7</td>
<td>M</td>
<td>Childhood Compensatory</td>
<td></td>
<td></td>
<td>Unilateral(L)</td>
<td>R, equino-varus result of polyomyelitis in infancy.</td>
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<tr>
<td>38</td>
<td>26</td>
<td>M</td>
<td>14</td>
<td>Congenital</td>
<td></td>
<td>Unilateral(L)</td>
<td>Tendency to blisters on interphalangeal joint of great toe since age of 5.</td>
</tr>
<tr>
<td>39</td>
<td>38</td>
<td>M</td>
<td>28</td>
<td>Adolescent?</td>
<td>Slight varus</td>
<td>Unilateral(L)</td>
<td>Speech defect.</td>
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<tr>
<td>40</td>
<td>17</td>
<td>F</td>
<td>15</td>
<td>Polyomyelitis</td>
<td>Equinus</td>
<td>Bilateral</td>
<td>Mental Deficiency. (Weakening of peronei.</td>
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<tr>
<td>41</td>
<td>23</td>
<td>F</td>
<td>Youth</td>
<td>Adolescence</td>
<td>Varus</td>
<td>Bilateral</td>
<td>Below average intelligence. (Pain recently in ant. arch.</td>
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<tr>
<td>42</td>
<td>26</td>
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<td>12</td>
<td>Diphtheria</td>
<td></td>
<td>Bilateral</td>
<td></td>
</tr>
<tr>
<td>No. in Series</td>
<td>Age</td>
<td>Sex</td>
<td>Age of onset</td>
<td>Etiology</td>
<td>Coincident Deformities</td>
<td>Laterality</td>
<td>Extracts from History</td>
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</tr>
<tr>
<td>43</td>
<td>78</td>
<td>F</td>
<td>?</td>
<td>Adolesc. ?</td>
<td>-</td>
<td>Unilateral</td>
<td>Marked cavus deformity but no symptoms. Deformity had been present ever since patient could remember.</td>
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<tr>
<td>45</td>
<td>27</td>
<td>M</td>
<td>Childhood</td>
<td>Fevers</td>
<td>-</td>
<td>Bilateral</td>
<td>Both great toes shorter than 1st toes.</td>
</tr>
<tr>
<td>46</td>
<td>7</td>
<td>F</td>
<td>2 6/12</td>
<td>Cong. Spastic</td>
<td>Equino-varus</td>
<td>Unilateral(R)</td>
<td>History of foot being twisted at 2 yrs 6 mths. R. leg under-developed. No response to electrical stimulation of intrinsic muscles of foot.</td>
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<tr>
<td>48</td>
<td>8</td>
<td>F</td>
<td>7</td>
<td>Congenital</td>
<td>-</td>
<td>Bilateral</td>
<td>Extreme dorsal retraction of little toe especially on left side. Remaining toes practically normal.</td>
</tr>
</tbody>
</table>