# A PROSPECTIVE STUDY ON CRUSH FOOT INJURIES AT KENYATTA NATIONAL HOSPITAL.

A DESERTATION IN PART FULFILMENT FOR THE DEGREE OF MASTER OF MEDICINE (SURGERY) IN UNIVERSITY OF NAIROBI 1989.

BY

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I certify that this desertation is my own work and had not been presented for a degree in any other University.

Signed: .....

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ACKNOWLEDGEMENTS.

I would like to express my sincere gratitude to my supervisor Mr. John Ating'a for his encouragement, guidance and constructive criticism offered to me all along the period of this study.

I am also grateful to all records staff in the Orthopaedic Clinic especially Jemima Ogutu who made sure that all records were available.

Special thanks to the Ethics Committee who allowed me to carry out the study.

Lastly I wish to express my sincere gratitude to my wife Eileen Kireti for her excellent secretarial services and her encouragement and perserverance during the period of study.

CONTENTS.

INTRODUCTION.

Crush Foot Injury is a common injury seen at Kenyatta National Hospital. Most of these injuries result from objects falling on patients feet. The majority of these injuries result in extensive soft tissue injury with fractures of the bones of the foot.

Where there is extensive soft tissue injuries the patients spend long periods of time in hospital undergoing treatment. Scepsis is one of the complications resulting from these injuries despite surgical toilet and debridement. These usually prolong the period of stay in hospital and also prolongs the time for skin graft to be done.

Despite all these complications, the patients eventually are discharged from hospital but the end result of many of these patients is not satisfactory. Many of them end up with a myriad of complications ranging from pain on walking to severe deformities of the foot. These affect the patients quality of life. Infact Professor A. Bencivenga was once

quoted as saying that "It is not the European who spends most of his time in the office and travels by car that needs normal legs but the Masai who spends half his life time on his two feet[II]." These words inspired me to do a study on Crush Foot Injuries as seen at Kenyatta Hospital.

SUMMARY:

Crush Foot Injury is a common injury seen at Kenyatta National Hospital. Most of these injuries result from road traffic accidents and objects falling on the persons feet. Most of them result in extensive soft tissue damage with fractures of the bones of the foot.

A total of thirty two patients with crush foot injuries were studied at Kenyatta National Hospital. Of these the commonest cause was road traffic accidents fifteen cases followed by object falling on the patients foot twelve cases.

The commonest type of fracture was fracture metartasals nineteen, followed by fracture phalarges six, and the other type of fractures seven cases.

Sixteen of the patients were admitted. The rest were treated as outpatients. Seven patients were not followed in the clinic for foot print and gait analysis this was because two of the patients had Symes amputation and five were lost to the study.

The foot prints and gait of these patients were analysed and the result presented in this study. There were some abnormalities and deformities found. These are discussed in this study.

REVIEW OF LITERATURE.

Fracture and fracture dislocation of the foot can result from direct or indirect trauma. Hardcastle et al (7) were of the opinion that injuries to the tarsometartasal joints are not common but the results of treatment are often unsatisfactory.

Arntz et al (2) concluded that dislocation and fracture dislocations of the tarsometartasals are major injuries that are associated with a high potential of chronic disability.

Gissane (5) called tarsometartasal fracture dislocations a dangerous type of fracture.

Wilpula (12) in a series of twenty six patients found that eleven sustained their injuries from a fall from a height, eight cases was the result of direct crush injuries of the foot and seven cases due to road traffic accidents. He also carried his study further and analysed the results of these injuries. Nine had good anatomical and functional results, three good anatomical but four functional results, three fair anatomical and functional results, eight poor anatomical and functional results. He concluded that good alignment is worth striving for and operative treatment gave best results.

Other authors concluded that a good alignment is worth striving for and operative treatment gave best results.

Others concluded that a good anatomical results does not guarantee a good result but that it increased the likelyhood of a more comfortable and durable foot with better share (2,3).

Classification of these injuries should be according to the type rather than the nature of deforming force and treatment should be based on this and that whatever the severity of injury the prognosis depended on accurate reduction and maintenance of this reduction (3,7).

The mechanism of these injuries can be:-

(a) Direct or crushing injuries. These usually result in any degree of dislocation and any combination of fractures.

(b) Indirect forces. These are either abduction forces and usually cause fracture of second metartasals and fracture of the cuboid bone. Infact Aitken (1) concluded that fracture of the cuboid and second metartasal are pathognomonic of abduction injuries.

On management of these injuries most authors agree that accurate reduction gives both functional and anatomical good results.

Malcolm et al (10) concluded that closed reduction alone left much to be desired and that closed reduction can only be done when the initial reduction can be maintained.

Collete et al (4) advocated that early reduction should be done. They recommended open reduction if the initial reduction could not be maintained or the injury involved dislocation of fracture of all metartasals or at least the lateral four as a unit. They maintained reduction with Kirshner wires.

Other authors advocated open reduction but found better results with A.O. Plates and Screws (2). They found that Kirshner wires tended to migrate and easy to bend resulting in high rates of redislocation.

The results of these injuries are mainly the result of improper initial management or failure to recognise the injury. Malcolm et al (10) observed that if the initial reduction could be achieved and maintained, good results could be achieved but, if this

was not maintained recurrent subluxation resulted in vulgas or cavus deformity. They also noted that abnormal bony protrusions caused problems. They finally concluded that the final result of these injuries depended directly on the damage incurred originally, multiple injuries of the foot, loss of skin and soft tissues and crushing injuries produced poor results.

Wilson D. (13) in his series found that only two out of fifteen cases he treated conservatively were pain free and three out of four he treated by surgery were pain free. He also found that six patients had vulgas deformity, followed by cavus deformity and thirteen had bony boses around the fracture sites. These boses were due to residual bony displacement. Twelve of his patients had a limp. From his results he concluded that the least active conservative gave poor results. His results tended to agree with what other authors found.

Arterial

Arteral damage may also complicate these injuries. Gissane (5) drew the attention of vascular impairement resulting from these injuries. He observed that the wide separation of the first and second metartasals produced a tear of the communicating branch of the dorsalis pedis artery.

He discribed four cases which developed gangrene following these injuries. He concluded that this injury was an emergency and should be treated with immediate open reduction.

Throughout the literature none could be located to show how these injuries affected the heel width, arch width, arch index and fore-foot width. The only scanty literature that could be found was by Lyn et al (9) who measured the heel width and arch width in eight hundred and eighty two feet of normal children and adults. From these measurements he calculated arch index and came to a mean figure of 0.71 for males and 0.66 for females. He did not measure these on injured feet.

## AIMS OF STUDY.

This is a prospective study whose aims are:-

(1) To find out the common causes of crush foot injuries.

(2) To find the pattern of these injuries.

(3) To study the mode of management of these injuries.

(4) To study some of the complications of these injuries.

Materials and Methods.

A total of thirty two patients who sustained crush foot injuries of the foot were followed from the time of injury up to the time of discharge. The minimum follow up time was six months. The name, age and sex of the patient were noted down. There were sixteen males and sixteen females. The cause of injury in these patients was also obtained from the history. The causes were divided into the following groups:-

(a) Road traffic accidents:
  (i) Pedestrians
  (ii) Passengers
    - Alighting or boarding the vehicle.
    - Head on collision.
  (iii) Objects falling on the patients.
  (iv) Fall from a height.
  (v) Hand cart injuries.

X-rays of the patients were taken and the type of fracture noted.

Those who were admitted were then followed in the ward and those treated as out patients followed up in the clinic.

In the ward culture and sensitivity was done on the wounds. Some of them had surgical toilet and debridement. This information was also recorded down. When they were discharged the following information was recorded.

(1) Type of gait.

(2) Condition of the foot.

- Whether there was gross deformity.
- Presence of bony boses.
- Discharging sinuses.
- Circatrization of the skin.

(3) Presence of pain:

- No pain
- Mild pain
- Moderate pain
- Severe pain.

(4) Foot print pattern.

This was taken for both feet using ink. Patients sole of feet were painted with ink and told to stand on two pieces of paper. The prints resulting were then analysed.

Analysis of gait.

Gait was analysed and grouped into the following:-

(a) Presence of limp.
(b) Painful gait.
(c) Abscence of toe off.
(d) Abscence of heel strike.

In this case the patients were asked to walk without shoes and observations made on the pattern of gait.

Analysis of Footprint.

Twenty five foot prints of the patients were taken. These were analysed as follows:-

(a) Number of toes absent from the print.

In normal cases all toes should touch the ground. Absence of any toe print was assumed to be due to cock up deformity.

(b) Heel width:

The heel width of the injured foot and non-injured foot was measured. This was taken at the maximum regardless of the distance from the end. The difference was then found.

(c) Arch Width:

This was taken as the thinnest part of the arch. The difference between the normal and injured foot was found.

(d) Arch Index.

This was taken for the normal and in injured foot. Arch index difference between the normal and injured foot was found and multiplied by a factor of 100 to make computation easier.

(e) Maximum fore foot width (width of foot print at matatarsal heads). This was taken as the widest part of the print at fore foot. The difference between the normal and injured foot was found.

## RESULTS AND OBSERVATIONS.

## CAUSES OF CRUSH FOOT INJURIES.

TABLE 1.

| | NO |
|---|---|
| PEDESTRIANS | 8 |
| PASSANGERS ALIGHTING/BOARDING | 6 |
| HEAD ON COLISION | 1 |
| OBJECTS FALLING | 12 |
| FALL FROM HEIGHT | 3 |
| HAND CART INJURIES | 2 |
| T O T A L | 32 |

Road traffic accidents was the main cause of crush foot injuries fifteen cases, objects falling on the feet twelve cases followed next. Fall from height three patients and hand cart injuries two patients.

Of the road traffic accidents eight were pedestrians and seven were passengers. Six of the passengers sustained their injuries while alighting or boarding the vehicles. In this case the vehicle moved before the patient had boarded or completely alighted from it. Only one patient sustained the injury when she was involved in a head on collision and the injury she sustained was dislocation of the cuboid bone.

Twelve patients sustained their injuries from, objects falling. In this group there were eight females and four males. Most of the females, seven sustained the injuries at home and only one sustained the injuries while walking in the street and a stone fell on her from a construction site. The men, four in number, sustained the injuries from their place of work.

A total of three patients sustained the injuries when they fell from a height. The only female in this group fell from 3rd floor of a building in a suicide attempt. She also had other injuries. The two males fell from trees.

Hand cart injuries caused two crush foot injuries. In this case the hand cart went out of control crushing the patients feet.

TYPE OF FRACTURES SUSTAINED.

TABLE NO. 2.

| TYPE OF FRACTURE | NO |
|---|---|
| Fracture Metartasals | 19 |
| Fracture Phalanges | 6 |
| Fracture Calcaneum | 3 |
| Multiple Communuted Fractures | 3 |
| Dislocated Cuboid | 1 |
| T O T A L | 32 |

The most common fracture sustained was fracture metartasal, nineteen cases. This was followed by fracture phalanges, six cases, fracture calcaneum, three cases, multiple communuted fractures of tarsal bones, three cases and one case of dislocated cuboid bone.

One patient has severe communuted compound fracture of the halux with extensive loss of skin of the foot and dislocation of metartasal heads. She ended with amputation of the halux.

Seven patients had fractures of the tarsal bones. Three had fractures of the calcaleus and two of these were the results of a fall from a height. Two of these had fractures of calcaneum and talus as well. One patient had bilateral fracture of the calcaneum.

Three patients had severe communuted fracture of all tarsal bones. Of these two developed gangrene and had symes amputation. One patient had dislocated cuboid.

FOLLOW UP OF PATIENTS.

Sixteen of the thirty two patients involved in this study were admitted to hospital. The rest were treated as out patients.

SEVERITY OF SKIN/SOFT TISSUE LOSS:

SEVERITY OF SKIN LOSS.

TABLE NO. 3.

| | ADMITTED | NOT ADMITTED | TOTAL |
|---|---|---|---|
| NO. SKIN LOSS | 0 | 10 | 10 |
| MINIMAL SKIN LOSS | 1 | 6 | 7 |
| MODERATE SKIN LOSS | 3 | 0 | 3 |
| SEVERE SKIN LOSS | 12 | 0 | 12 |
| T O T A L | 16 | 16 | 32 |

Twelve of the patients admitted had severe skin loss and soft tissue damage. Three had moderate skin loss and one minimal skin loss. Those not admitted ten had no skin loss and the rest seven had minimal skin loss.

TABLE 4.

COMPARISON OF POSITIVE CULTURE RESULTS OF PATIENTS WHO HAD SURGICAL TOILET WITH THOSE WHO DID NOT HAVE SURGICAL TOILET.

| | SURGICAL TOILET | NO SURGICAL TOILET | TOTAL |
|---|---|---|---|
| POSITIVE SWAB CULTURE | 9 | 3 | 12 |
| NEGATIVE SWAB CULTURE | 2 | 2 | 4 |
| TOTAL | 11 | 5 | 16 |

Eleven of the patients admitted had surgical toilet. Nine of those who had surgical toilet had positive swab culture. Two had negative culture results.

Those who had no surgical toilet, three had positive swab culture and two negative culture results.

TABLE 5.

ORGANISMS ISOLATED.

| ORGANISMS ISOLATED | NO. OF PTS. |
|---|---|
| E. COLI | 7 |
| PROTEUS | 6 |
| KLEIBSIELLA | 5 |
| PSEUDOMONAS | 3 |
| CITROBACTER | 0 |
| TOTAL | 21 |

All of those with positive culture swab results had more than one organism isolated. The organisms isolated were E. Coli seven, proteus six, kleibsiella five and pseudomonas three. No staphylococci or streptococci were isolated.

Ten patients with severe skin loss were grafted. The two who had severe skin loss and were not grafted were those who had symes amputation. Also all the three who had moderate skin loss were grafted. None with minimal skin loss were grafted.

FOLLOW UP OF PATIENTS IN THE CLINIC.

Of the thirty two patients involved in the study twenty five were followed up in the clinic. Two of the patients who had symes amputation were not followed. Five of the thirty two patients were lost to the study.

TABLE 6.

DEGREE OF PAIN.

| | NO. OF PTS. |
|---|---|
| NO PAIN | 2 |
| MILD PAIN | 15 |
| MODERATE PAIN | 4 |
| SEVERE PAIN | 4 |
| TOTAL | 25 |

Two of the patients followed in the clinic had no pain or discomfort on walking, fifteen had mild pain, four had moderate pain and four had severe pain or discomfort on walking.

All those who had moderate and severe pain could not wear their normal shoes and had to wear open shoes or sandals.

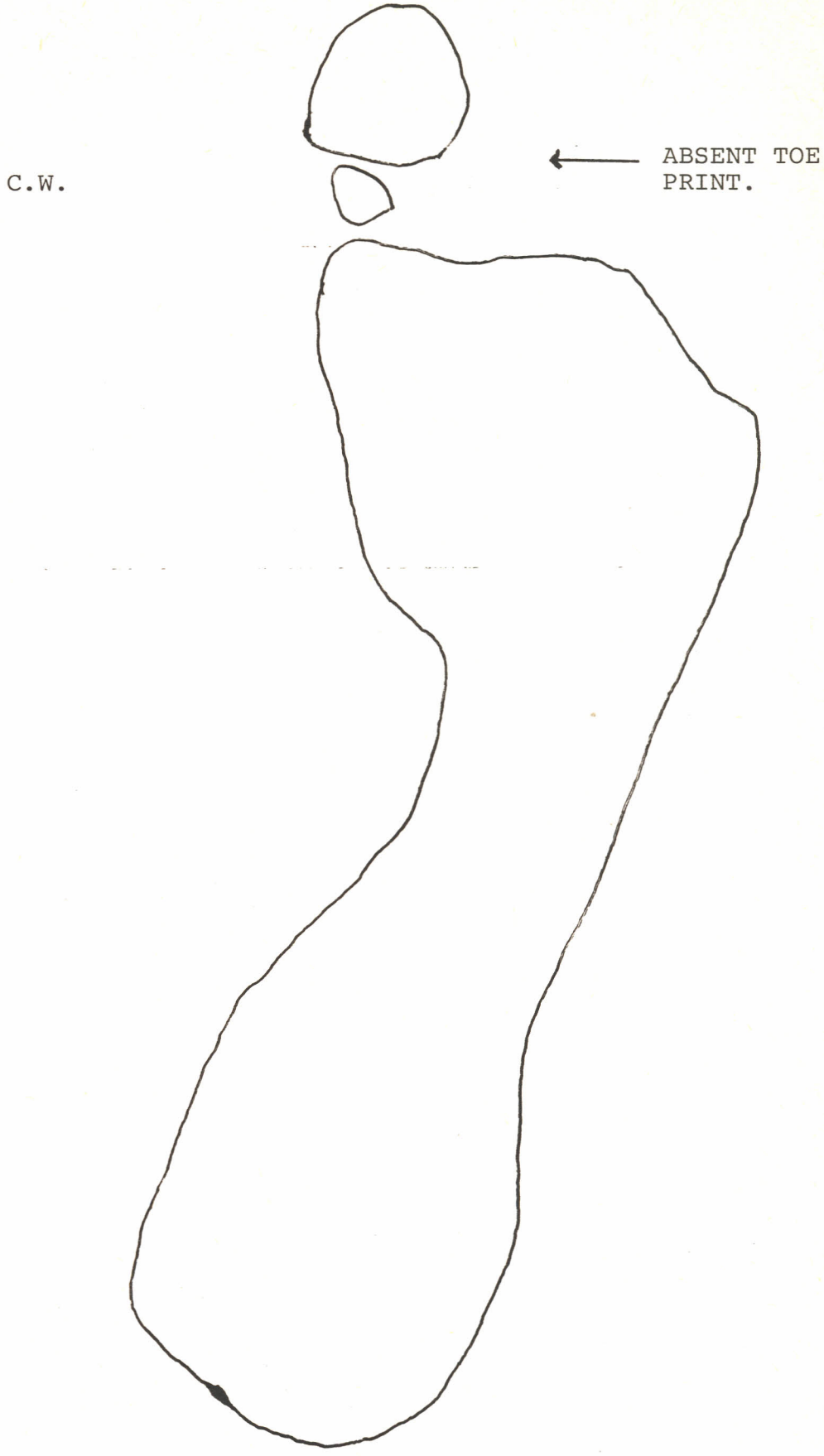
TABLE 7.

CONDITION OF SKIN.

| | | NO. OF PATIENTS |
|---|---|---|
| PAIN AT FRACTURE SITE | | 8 |
| PAINFUL SCAR | CIRCATRIZATION | 4 |
| | SENSITIVE SCAR | 2 |
| DISCHARGING SINUS OR WOUND | | 0 |
| T O T A L | | 14 |

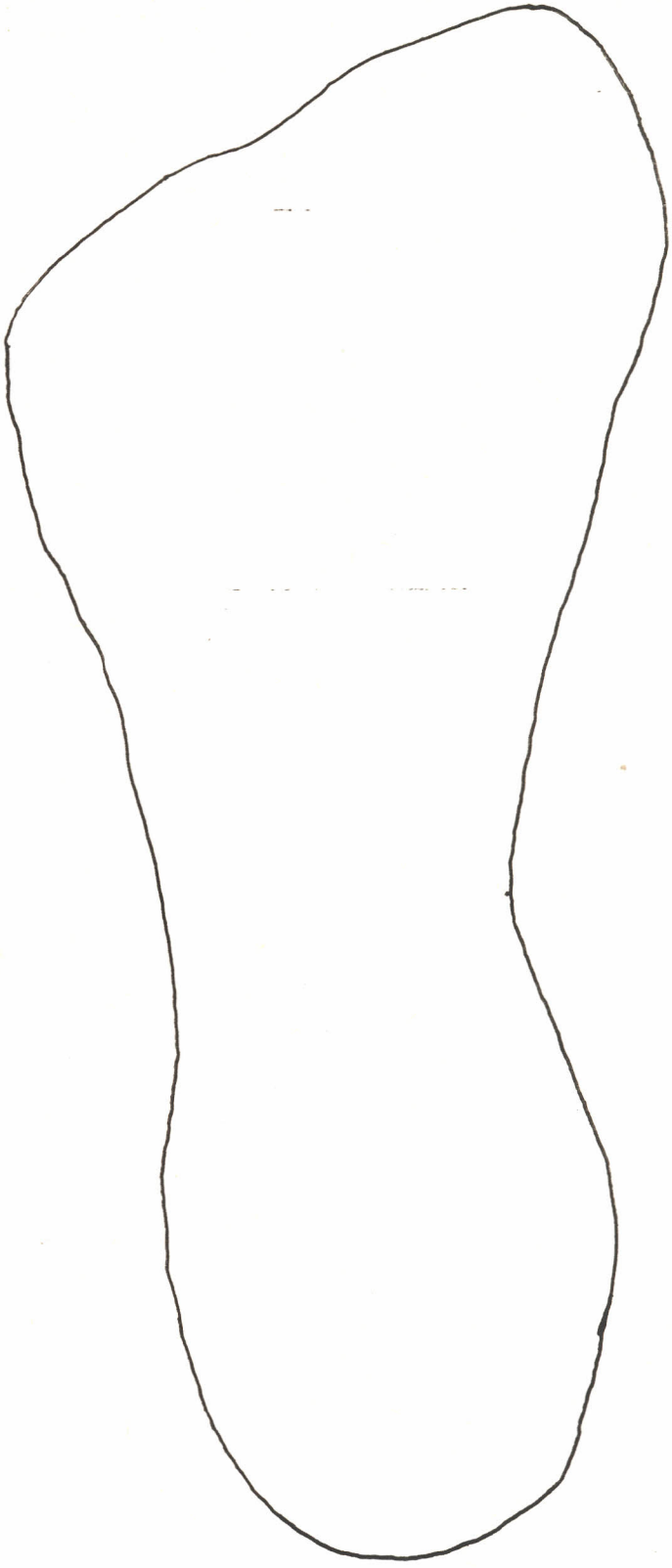
Eight of the patients had tenderness and pain at the fracture site, six had painful scar of which two had a sensitive scar.

Eighteen of the patients complained of oedema of the foot. Twelve of these had oedema which subsided at night. Six of those the oedema was constant and subsided very little at night or when the patient was lying down.

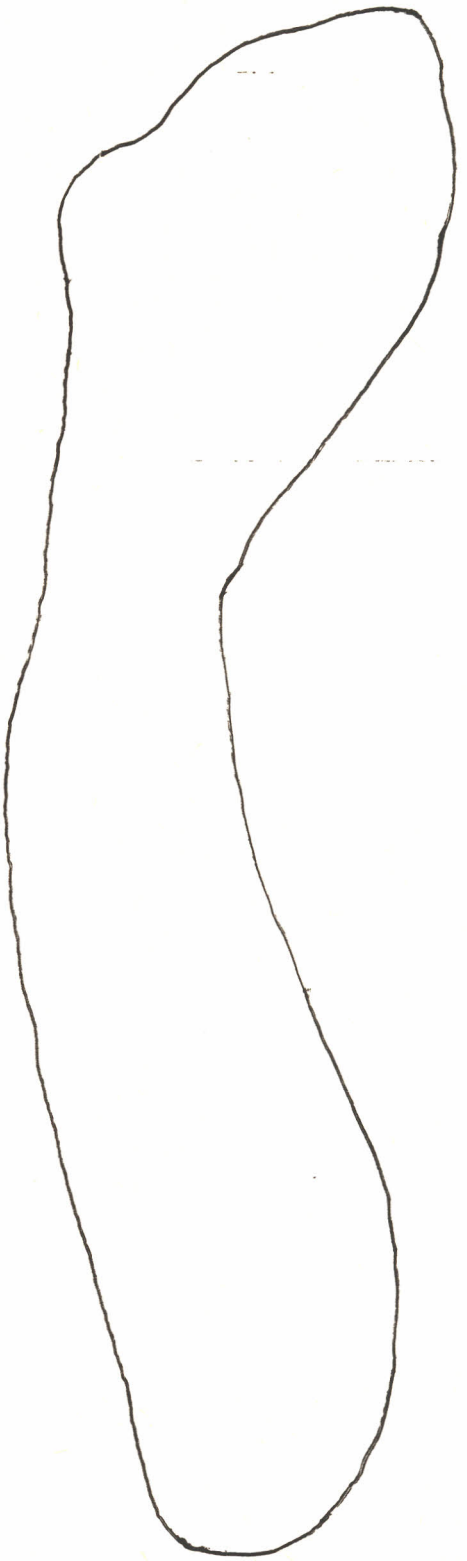



FOOT PRINT OF A PATIENT SHOWING ONLY THE HALUX APPEARING ON THE PRINT. THIS IS DUE TO SEVERE COCK UP DEFORMITY OF THE TOES.

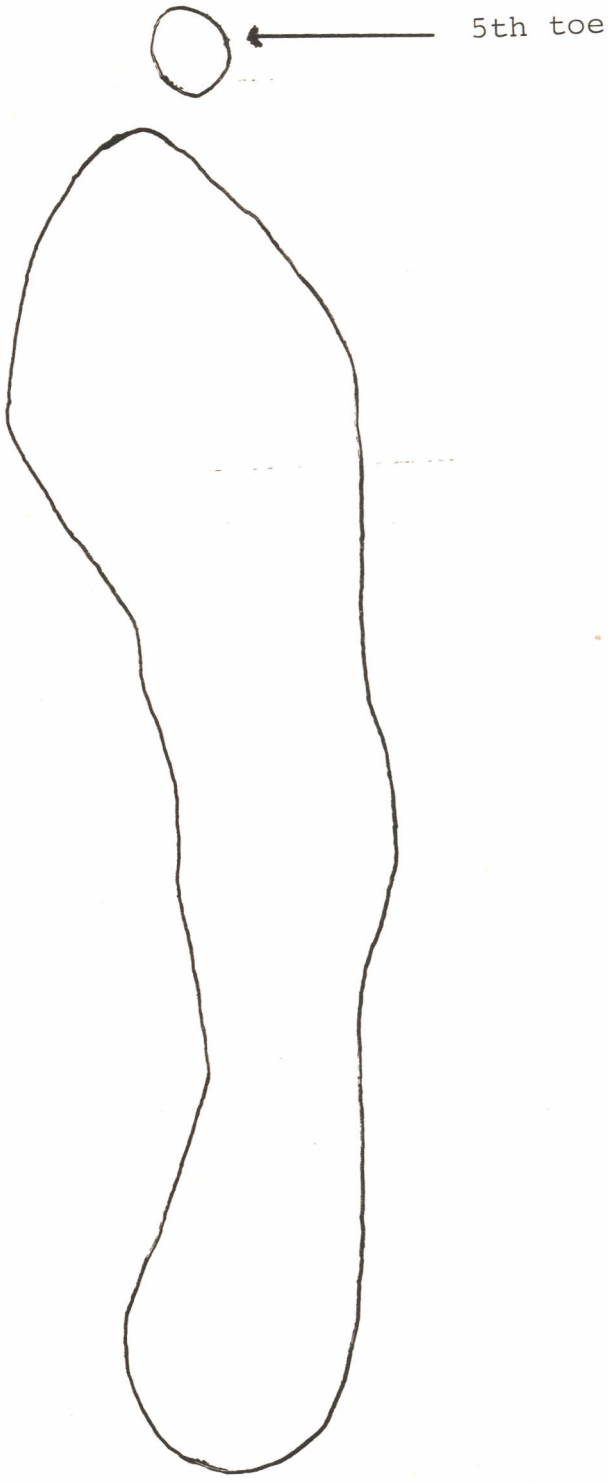
H.M.



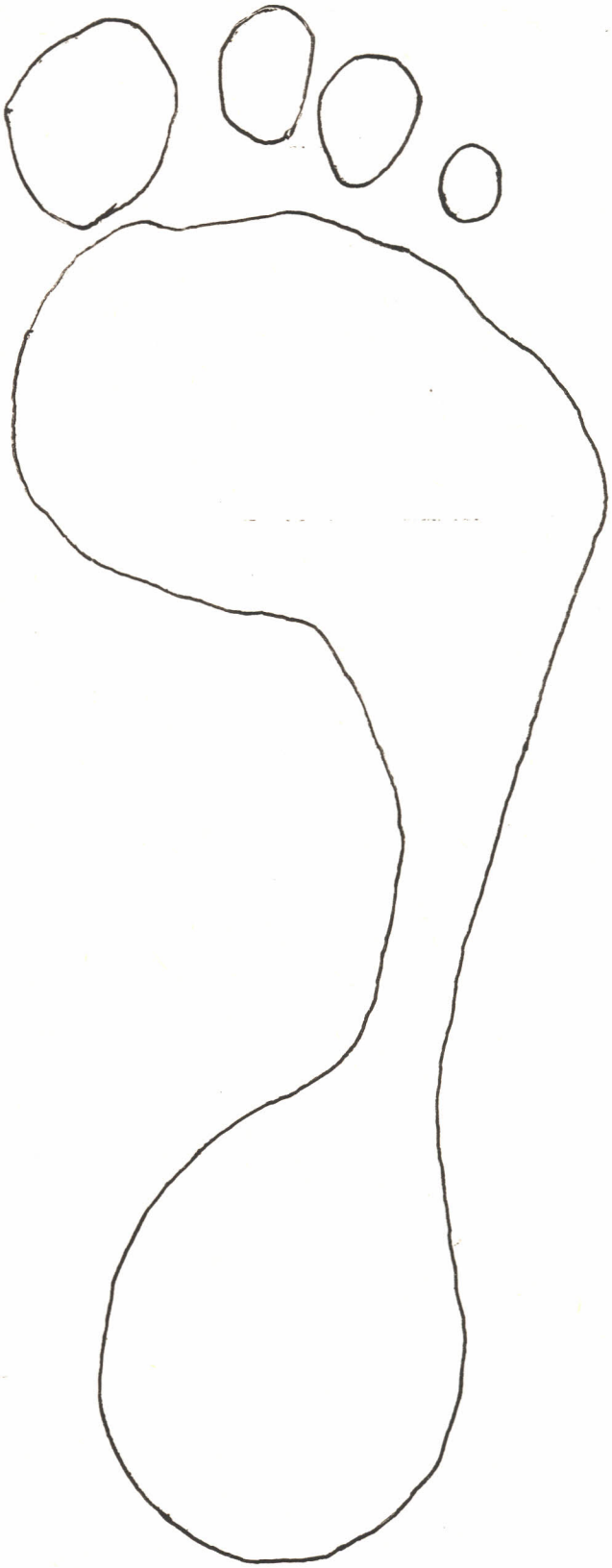
FOOT PRINT OF A PATIENT SHOWING ABSENCE OF ALL FIVE TOE PRINTS. THIS WAS DUE TO SEVERE COCK UP DEFORMITY OF THE TOES.




FOOT PRINT OF A PATIENT SHOWING SEVERE DEFORMITY OF THE FOOT PRINT. ONLY THE LATERAL SOLE OF THE FOOT WAS IN CONTACT WITH THE GROUND.



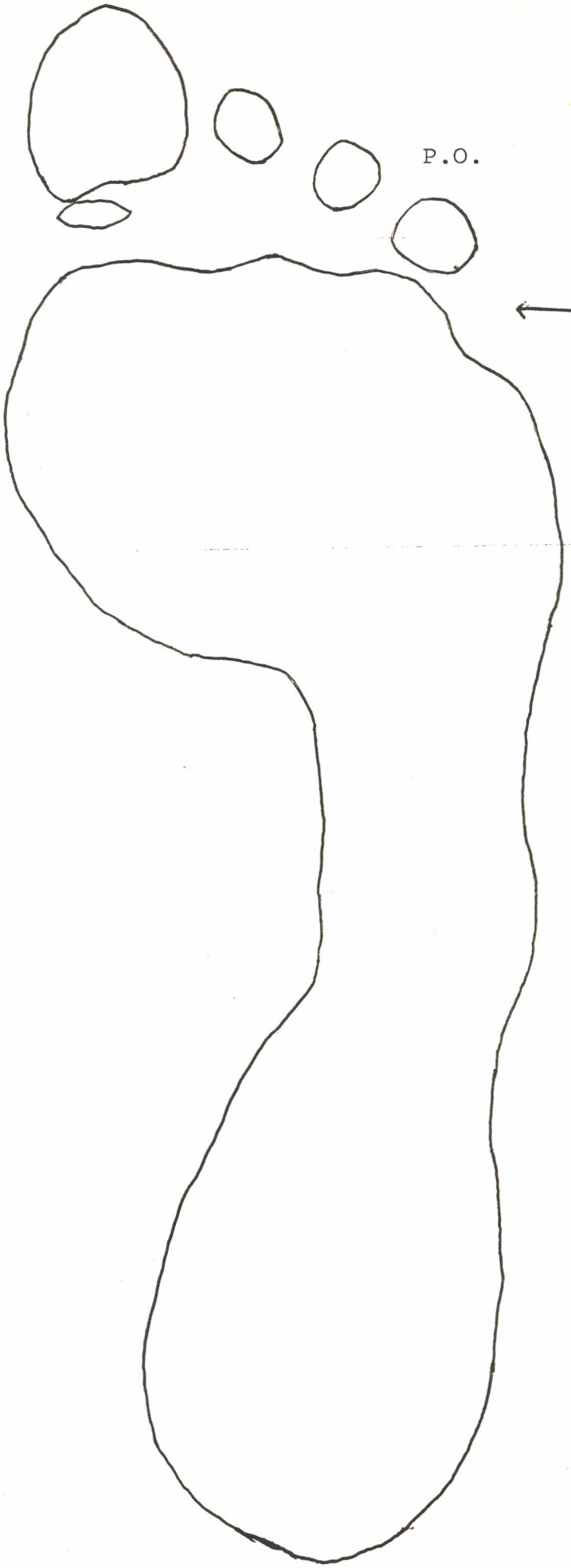

E.K.

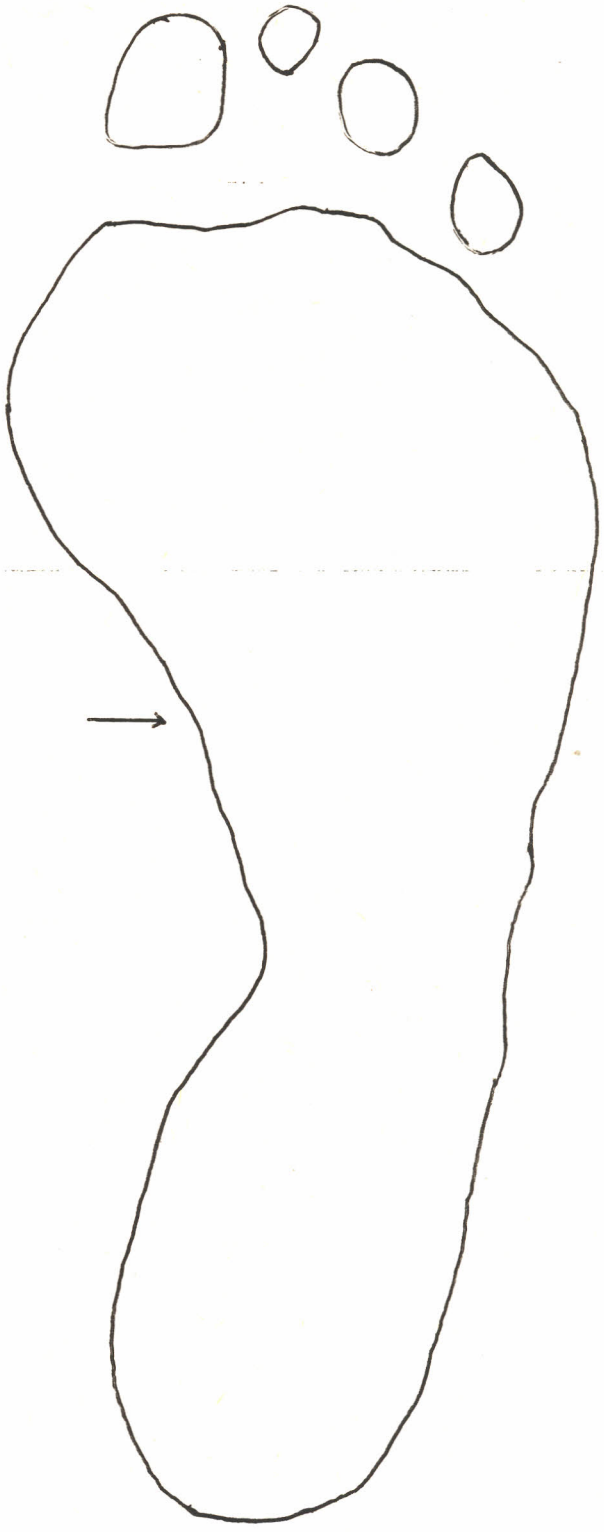


S.N.

FOOT PRINT OF A PATIENT SHOWING CAVUS DEFORMITY.

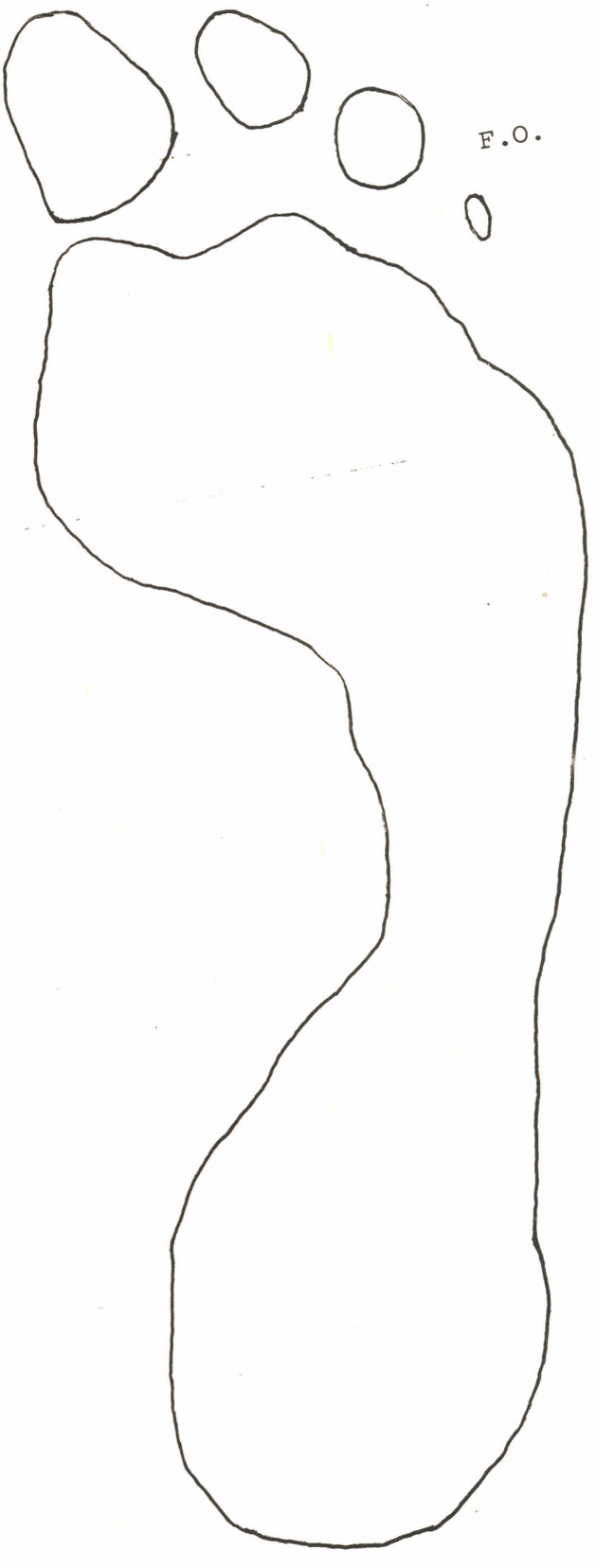

ABSENT TOE PRINT WAS
DUE TO AMPUTATION OF
TOE.

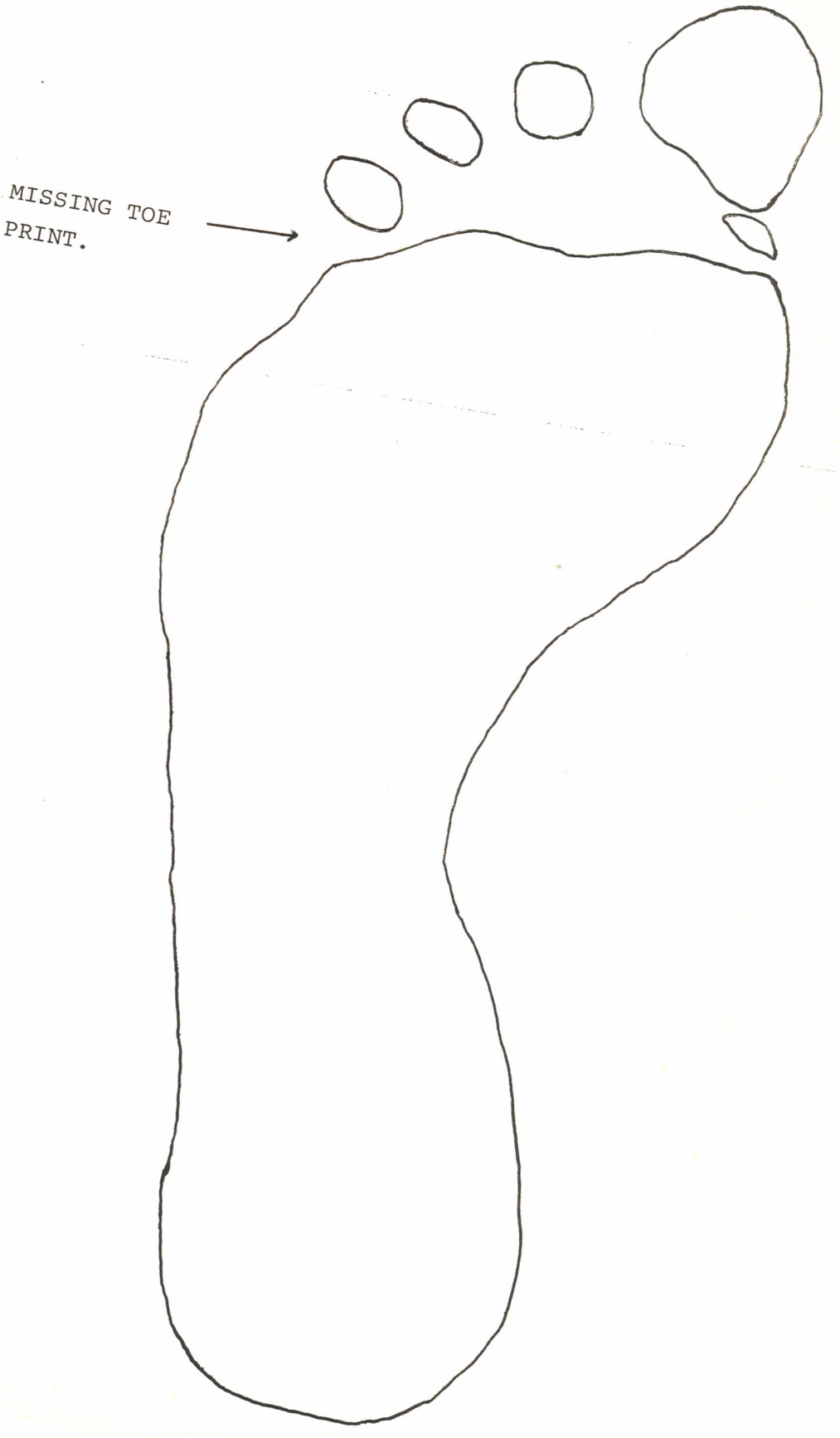

P.O.
MISSING TOE PRINT.

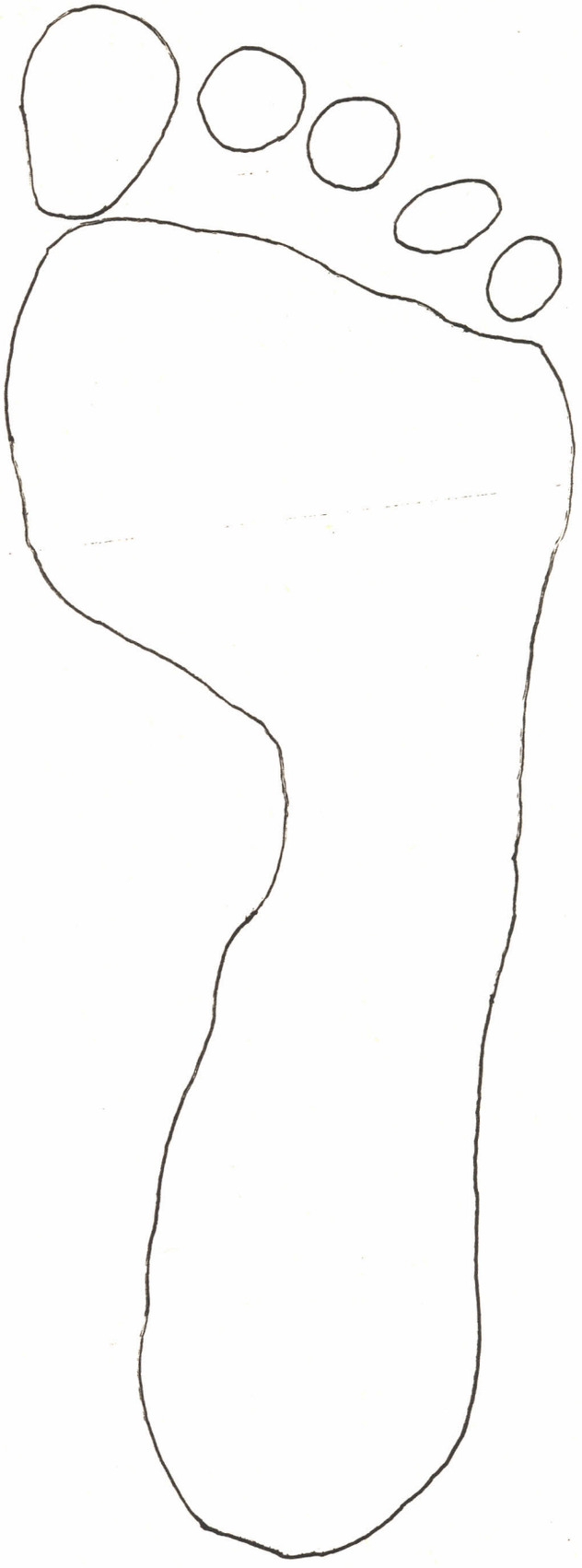


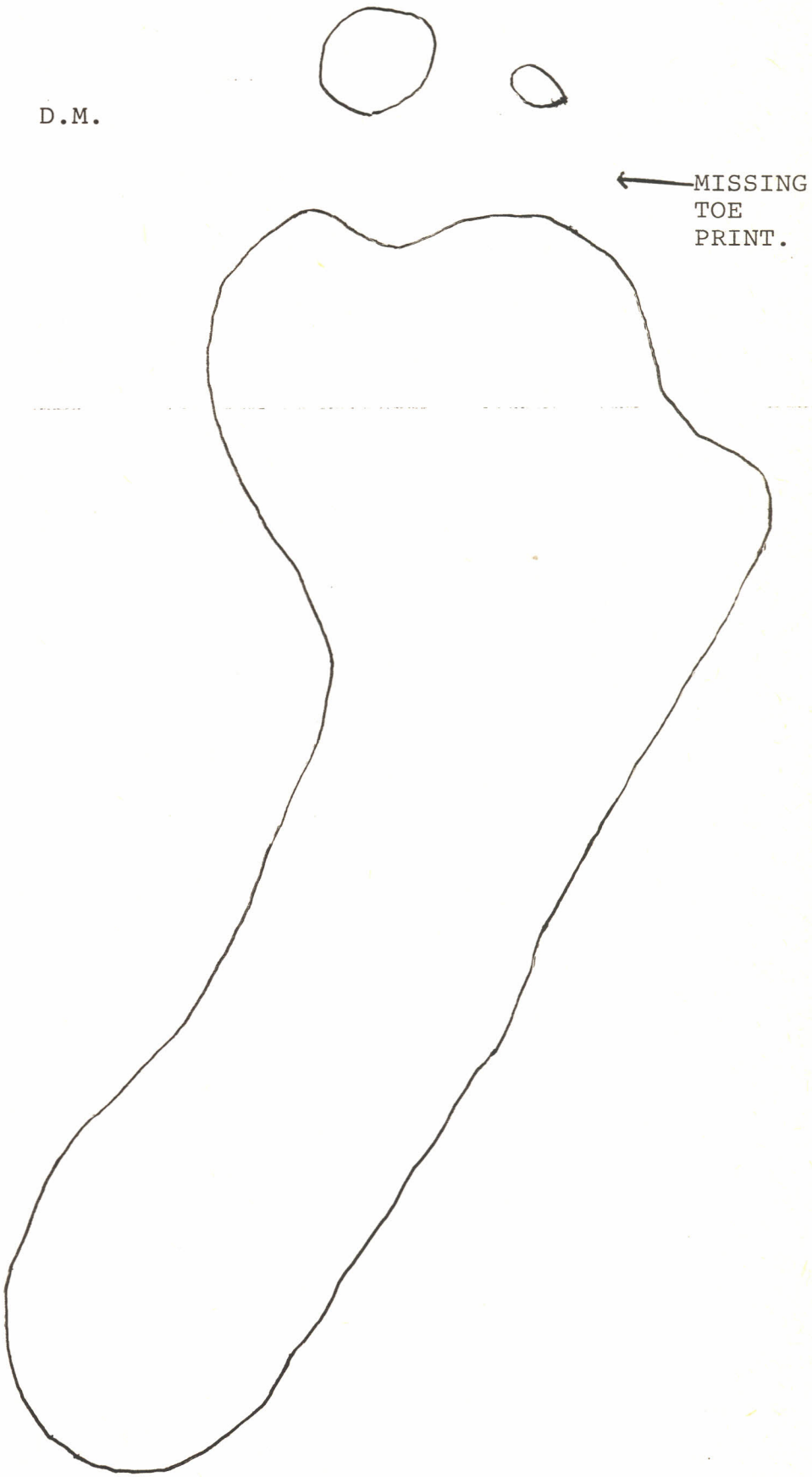
M.N.

FOOT PRINT OF A PATIENT SHOWING FLAT FOOT DEFORMITY. THERE IS FILLING OF THE ARCH AREA (ARROW).

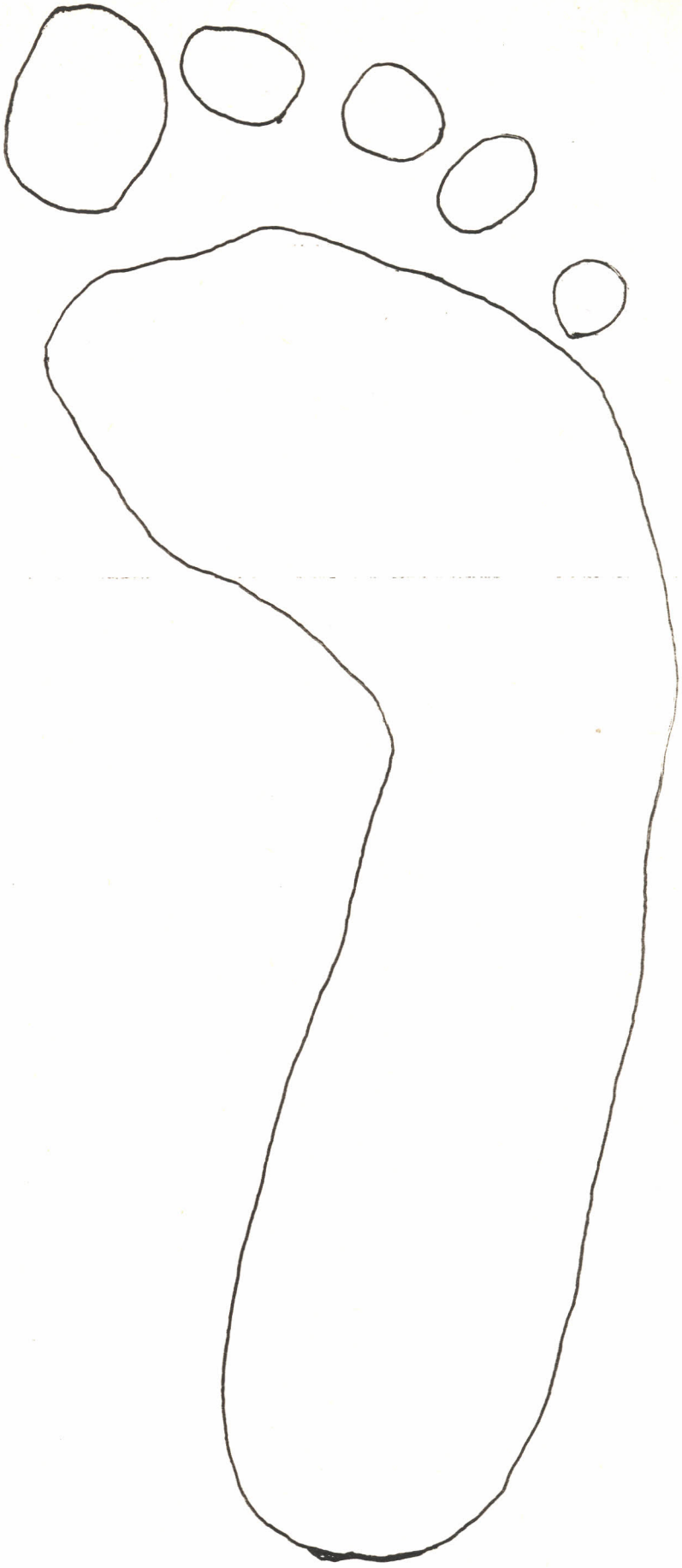

F.O.


MISSING TOE
PRINT.





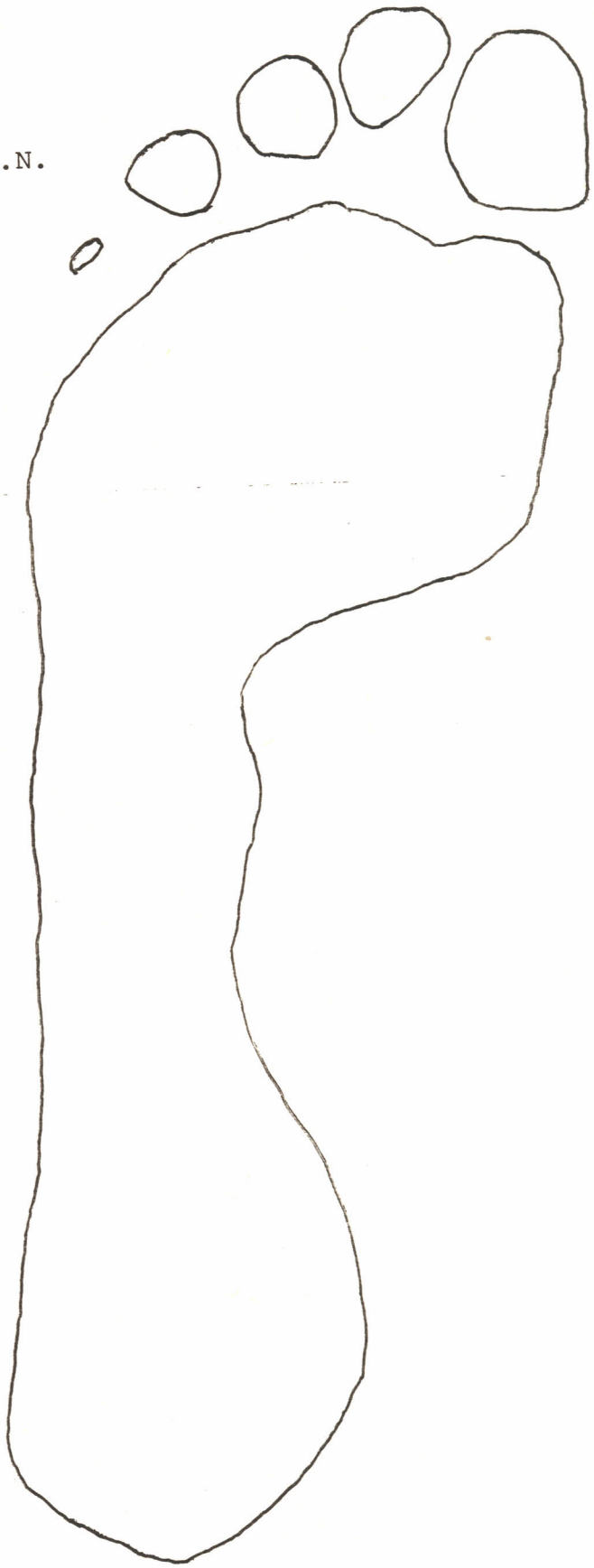

FOOT PRINT OF A PATIENT SHOWING ONLY TWO TOES ON THE PRINT.

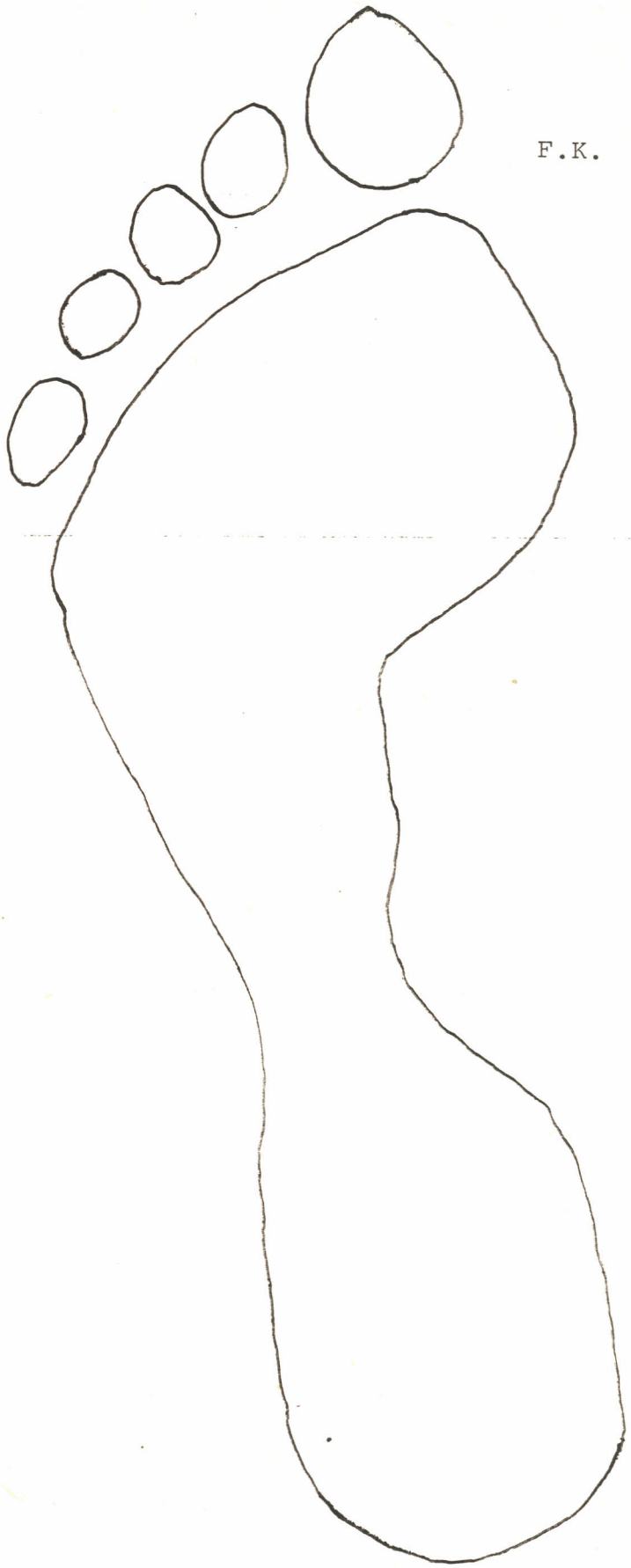


FOOT PRINT SHOWING VULGAS DEFORMITY OF FORE FOOT.

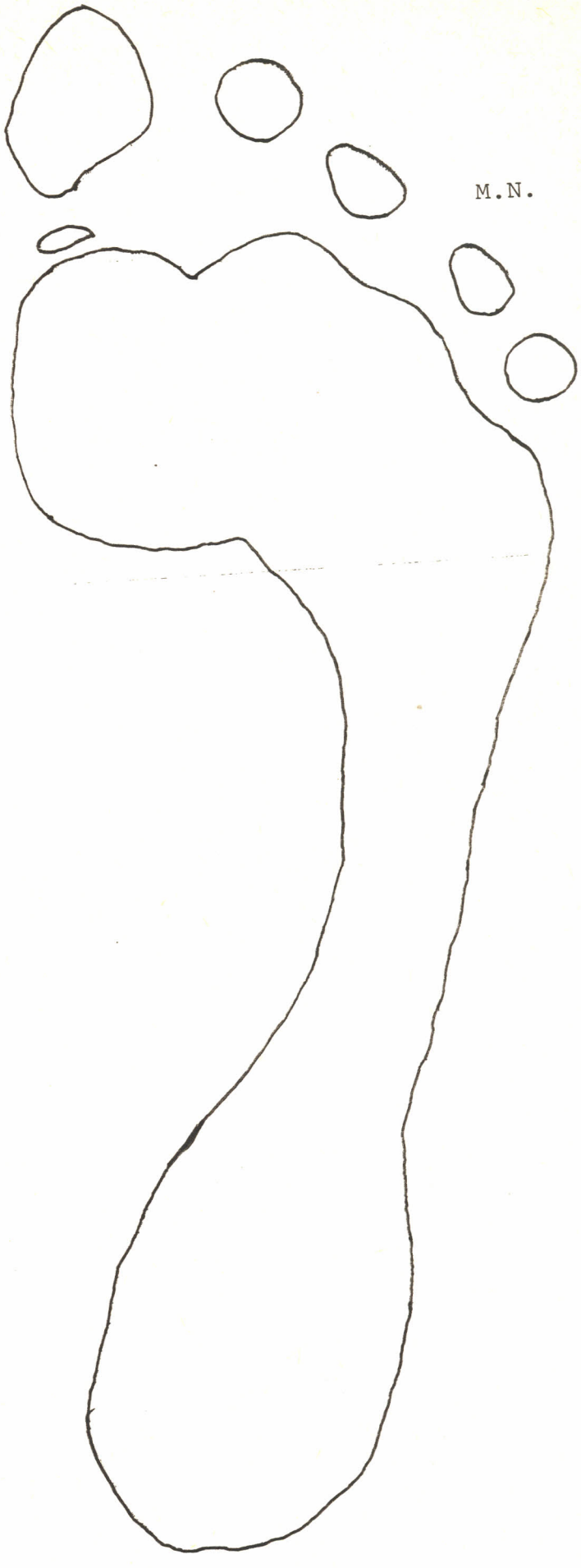

J.W.

A.N.

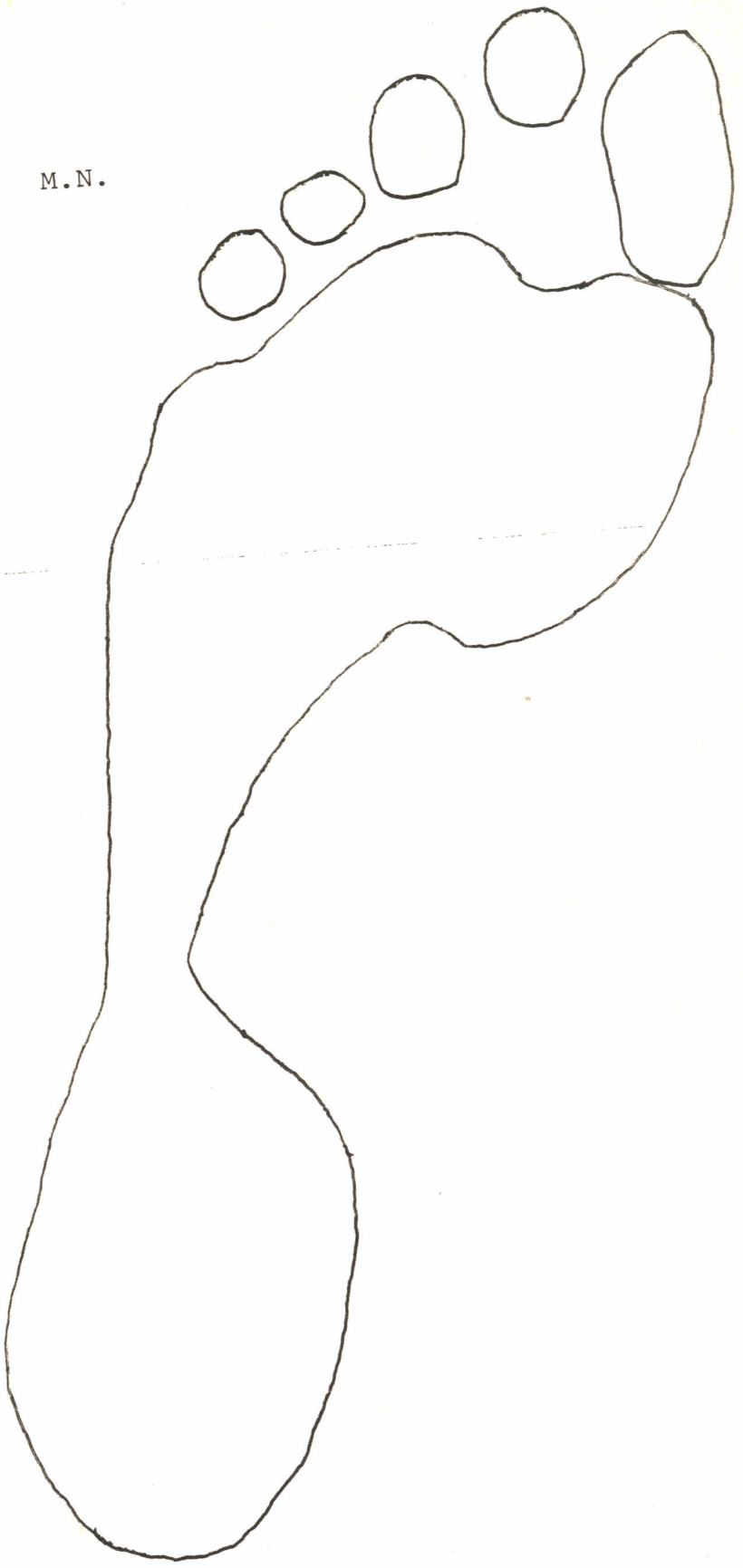


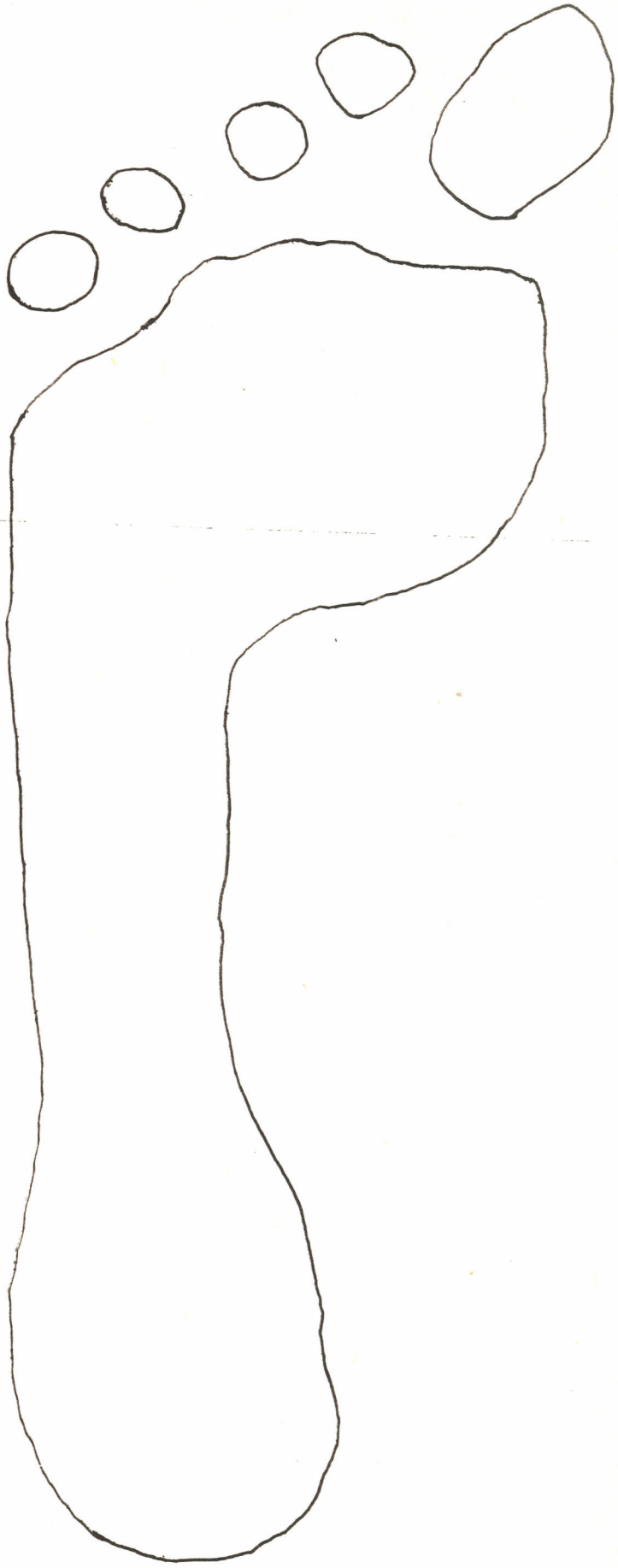


F.K.


M.N.

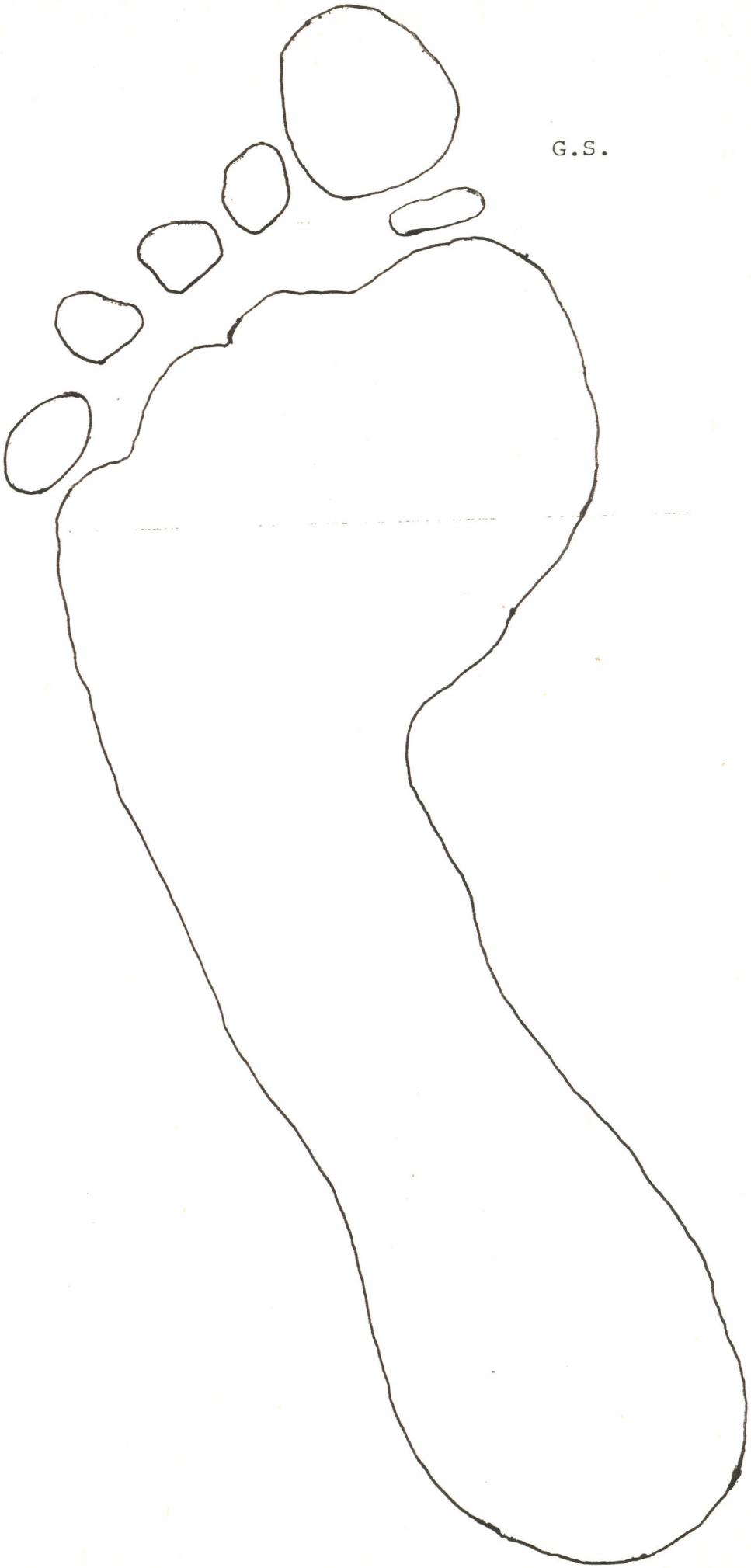
M.N.

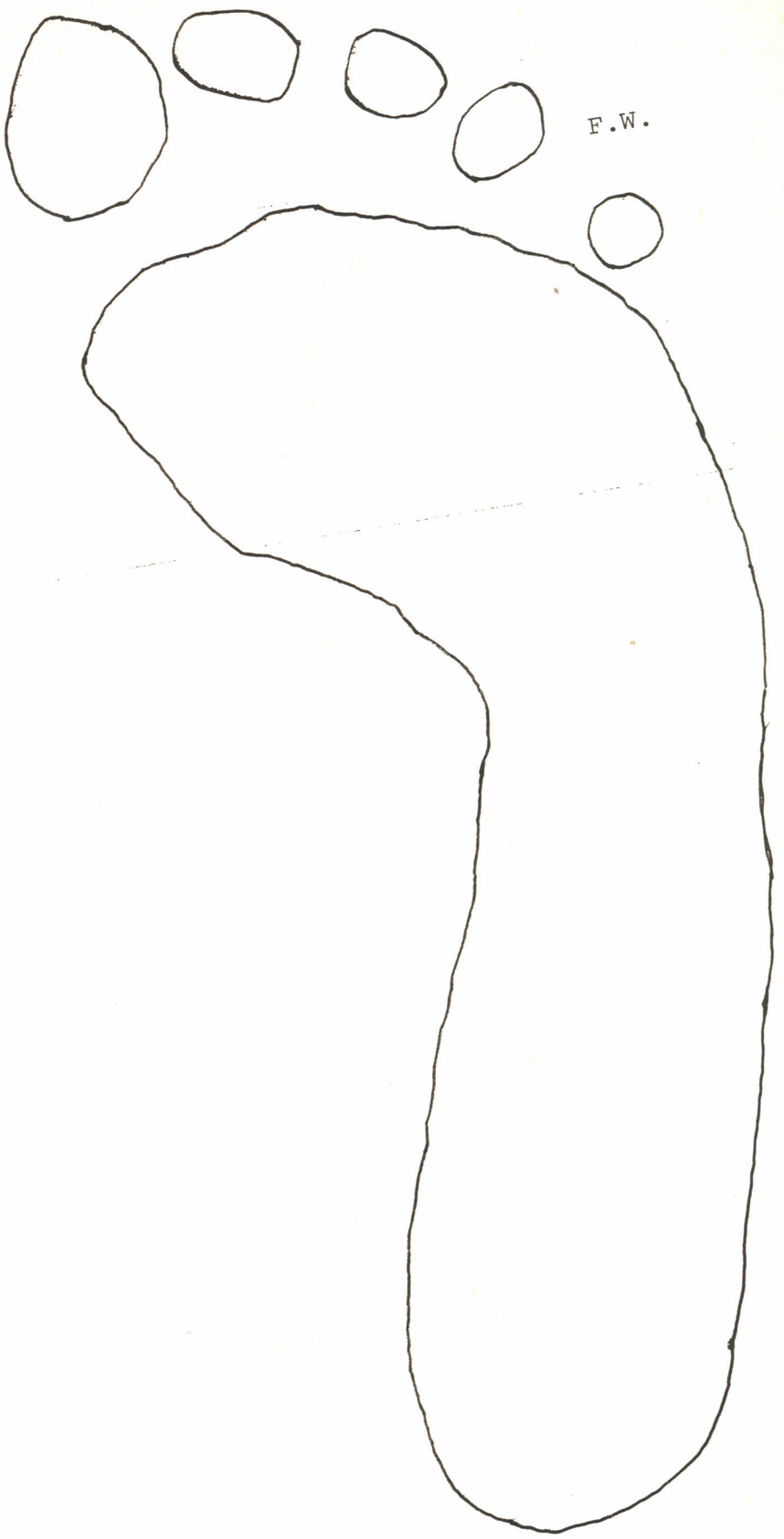




M.O.

G.S.

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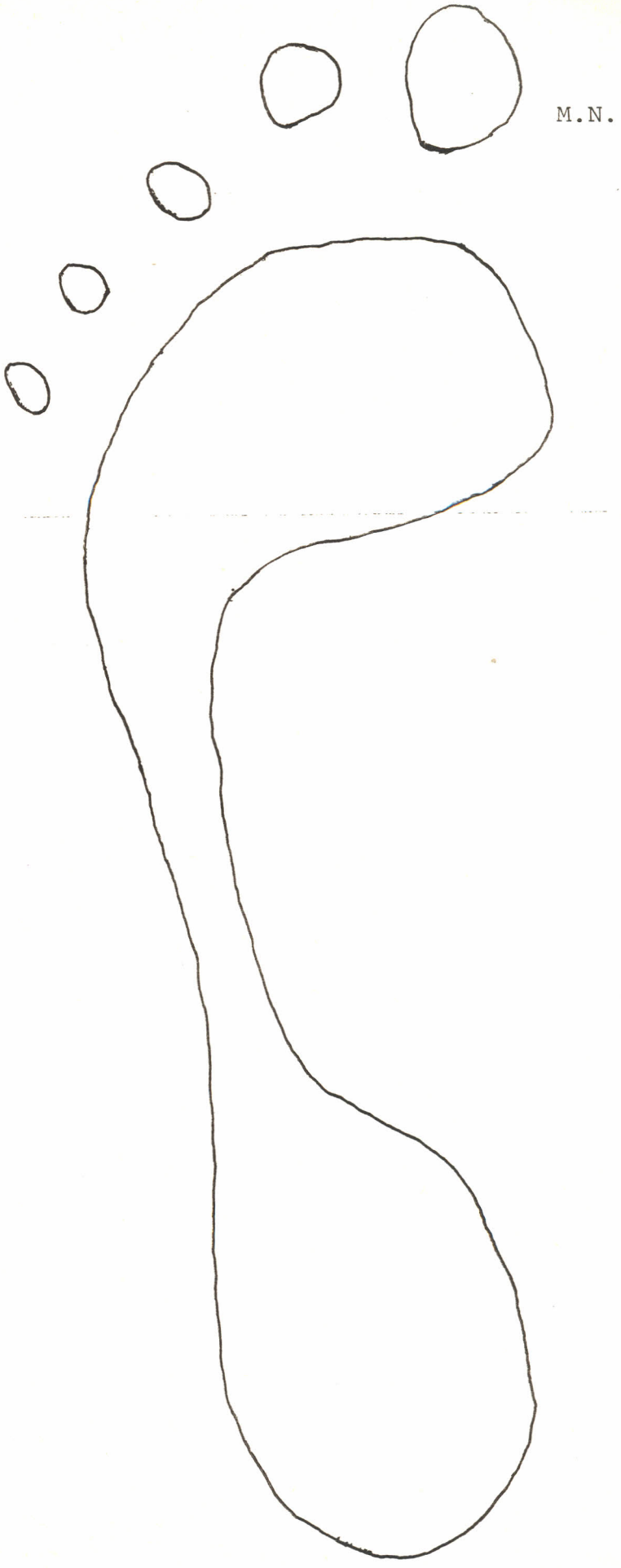
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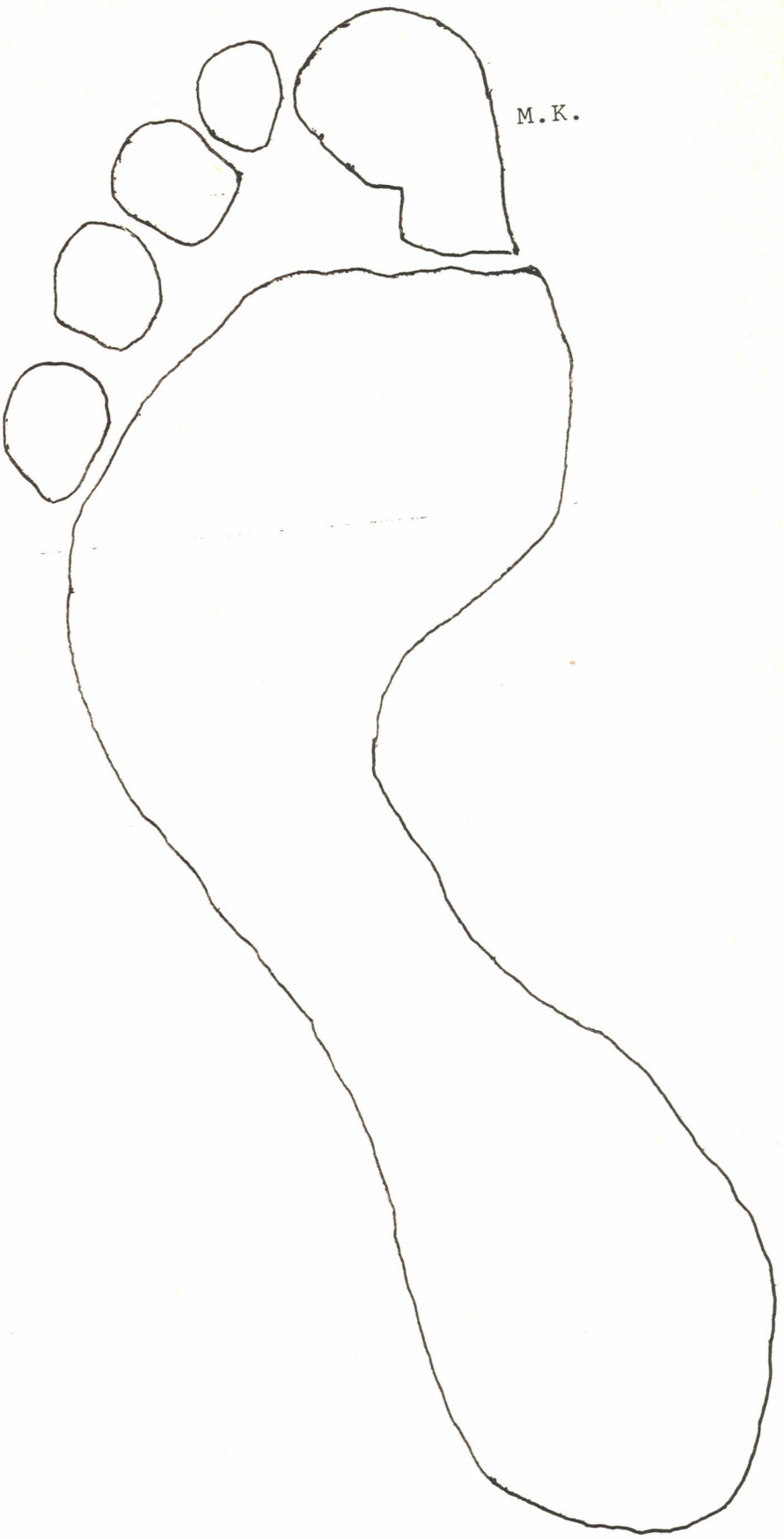
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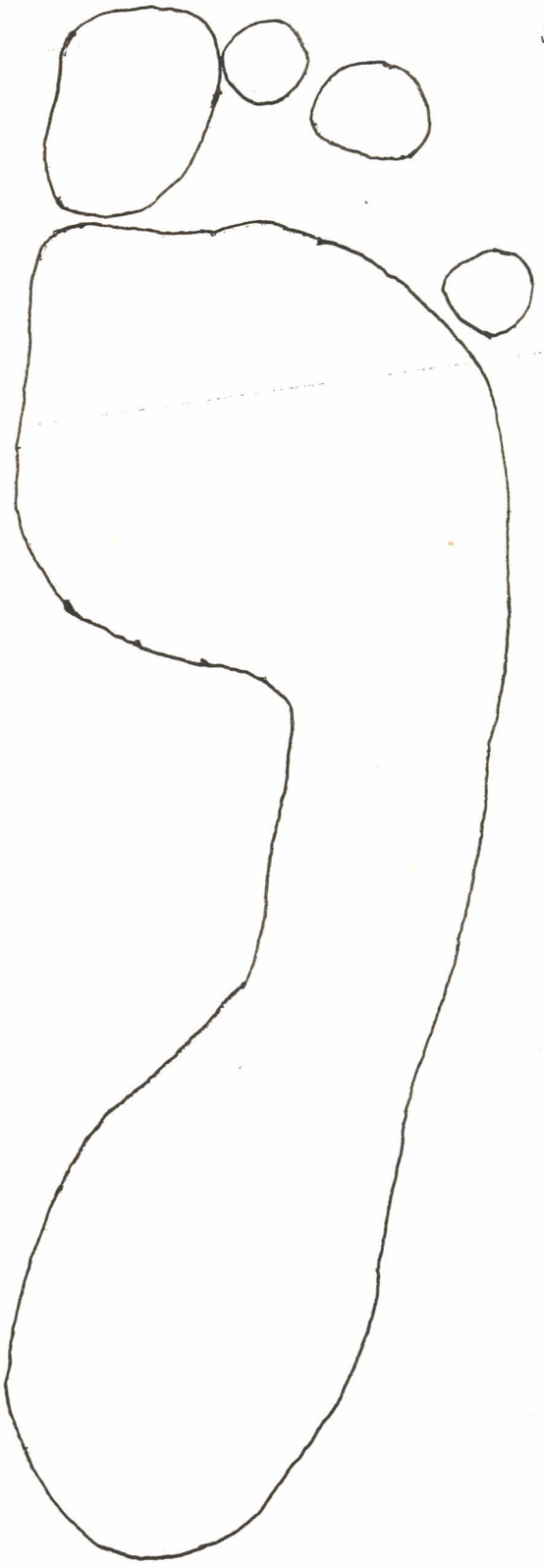
J.W.



T.W.

TABLE 8.

DEFORMITIES RESULTING.

| DEFORMITY | NUMBER |
|---|---|
| CAVUS | 5 |
| FLAT FOOT | 8 |
| VULGAS | 6 |
| NO DEFORMITY | 6 |
| T O T A L | 25 |

The feet of the patients were examined for the results of treatment. Five had cavus deformity, eight had evidence of flat foot, six had vulgas deformity of the forefoot. Only six had no obvious deformity. The presence of bony boses was found in seven patients. Four of these had isolated fracture of base of 5th metartasals, two had fracture metartasals and one had dislocation of the cuboid bone. All these boses were at the fracture site.

ANALYSIS OF FOOT PRINT.

Foot prints taken from the patients were analysed as follows: The normal (uninjured foot) was always compaired to the injured foot.

TABLE 9.

NUMBER OF TOE PRINTS ABSENT.

| NUMBER OF TOES ABSENT FROM FOOT PRINT | 0 | 1 | 2 | 3 | 4 | 5 | TOT |
|---|---|---|---|---|---|---|---|
| NUMBER OF PATIENTS | 10 | 9 | 2 | 0 | 2 | 2 | 25 |

Two patients had five toe prints absent on the foot print, two had four toe prints absent, none had three toe prints absent, two had two toe prints absent, nine had one toe print absent and ten had none of the toe prints absent.

All those who had four and five toe prints absent had fracture metartasals. Two of those who had one toe print absent had amputation of the toes due to the injury.

The four who had more than four toe prints absent had severe cock up deformity of the toes. The others who had 1-2 toe print absent had mild cock up deformity.

TABLE 10.

HEEL WIDTH DIFFERENCE.

| HEEL WIDTH DIFFERENCE | 0-5mm | 6-10mm | >10mm | TOTAL |
|---|---|---|---|---|
| NO. OF PATIENTS | 17 | 3 | 3 | 25 |

Seventeen patients had a heel width difference of 0-5mm. This was regarded as within normal limits in this study. Three a difference of 6-10mm and five a difference of >10mm.

Of these, sixteen had a heel width on the injured foot of less than that of the normal foot.

In five patients it was greater on the injured side than on the normal side and four cases there was no difference. The maximum heel width difference in the series was 18mm.

The arch width of the foot prints were then measured on both the normal and the injured foot. The difference was then found.

TABLE 11.

DIFFERENCE IN ARCH WIDTH.

| ARCH WIDTH DIFFERENCE | 0-5mm | 6-10mm | 10mm | TOTA |
|---|---|---|---|---|
| NUMBER OF PATIENTS | 7 | 9 | 9 | 25 |

Seven patients had arch width difference between the normal and injured foot of 0-05mm. For the purpose of this study this is regarded as normal.

Nine had a difference of 6-10mm and nine had an area difference of >10mm.

Eighteen of the patients, the arch was less on the injured foot than in the normal foot, five patients the arch on the injured foot was greater than on the normal foot. The highest difference was 38mm.

Arch index was then calculated. The formula used was:-

$$\text{Arch index} = \frac{\text{Arch width}}{\text{Heel width}}$$

The arch index difference between the normal and injured foot was then calculated. This was multiplied by a factors of 100.

TABLE 12.

ARCH INDEX DIFFERENCE.

| ARCH INDEX DIFFERENCE X 100 | 0-100 | 100-200 | >200 | TOTAL |
|---|---|---|---|---|
| NO. OF PATIENTS | 9 | 9 | 7 | 25 |

Nine patients had arch index difference of less than 100, nine had a difference of 100-200, seven had a difference of greater than 200. Of these, ten cases, the arch index was greater on the injured foot than in the normal. Fifteen had arch index less on the injured foot as compared to the normal foot. The maximum arch index difference observed in this series was 573. Those with difference of 0-100 were regarded as normal in this study.

TABLE 13.

DIFFERENCE FOREFOOT WIDTH.

| DIFFERENCE IN WIDTH | 0-5mm | 6-10mm | 10mm | TOTAL |
|---|---|---|---|---|
| NO. OF PATIENTS | 12 | 8 | 5 | 25 |

Twelve patients had a difference of 0.5mm, eight had a difference of 6-10mm and five cases a difference of >10mm. The highest difference 33mm for a patient who sustained fracture of metartasal heads.

In twenty three cases the injured foot had a reduced maximum forefoot width. Only two cases had the injured foot width greater than the normal foot.

TABLE 14.

GAIT ANALYSIS.

TYPE OF GAIT.

| TYPE OF GAIT | NO. OF PATIENTS |
|---|---|
| NORMAL GAIT | 13 |
| CALCANEAL GAIT | 4 |
| NO TOE OFF | 6 |
| NO HEEL STRIKE | 2 |
| T O T A L | 25 |

Thirteen patients had normal gait. Four had calcaneal gait, six patients had absent toe off phase, two had no heel strike phase of walking.

Although some had a ntalgic gait this was hoped to disappear with time. Most of the patients who had fracture metartasals did not have toe off phase.

## DISCUSSION.

### 1. Causes of Crush Foot Injuries.

From the results obtained most of the crush foot injuries were the result of road traffic accidents. Majority of the patients were pedestrians where a vehicle lost control and crushed into them. This was followed by passengers and most of them were either alighting or boarding the vehicle. In this case the vehicle moved before the passenger had completely alighted or boarded the vehicle. This is contrary to what other authors found [1,2,4,6,7]. They found that most of their patients were passengers involved in head on collision. In this case only one patient sustained the injuries from a head on collision.

Objects falling on the patients foot was the next commonest cause of these injuries. This accounted for twelve cases and the severity of the injury depended on the type of object and how heavy it was.

Fall from a height accounted for three of the patients involved in the study. These patients sustained serious fractures involving the talus and calcaneum as well.

From these results the causes of crush foot injuries is very varied and one cannot conclude accurately on the main causes but road traffic accidents account for the majority of these injuries.

2. Pattern of Fractures seen.

The commonest type of fractures seen in the study was fracture and fracture dislocation of the metatarsals. There were nineteen cases. Most of these were not isolated fractures but a combination. The commonest combination was fractures of second, third, fourth and fifth metatarsals fracturing or getting dislocated as a unit. The other combination was fracture dislocation of first metatarsal which accounted for three cases. These results agree with other studies done in which the authors found out either there is fracture dislocation of first metatarsal alone or the second, third, fourth and fifth metatarsal dislocate as a block.

The reason for this is that the second, third, fourth and fifth metatarsal bases are bound to each other by transverse ligaments located at both plantar and dorsal aspect. The planter ligaments support the arch and are stronger than the dorsal ligaments. There is no ligament between the metatarsal of the great toe and second toe. Instead the four lesser metatarsals are fastened primarily to the first cuneiform by obliguely placed plantar and dossal ligaments. The oblique ligaments are so placed that an abduction force applied to the metatarsals result in rupture or avulsion of their metatarsal insertions and permits lateral dislocation of the forefoot. The great toe metatarsal is secured to the first cuneiform by axillary placed ligaments which permit marked abduction before yielding. Great force is therefore necessary to violet these ligaments attachments[4].

The commonest isolated fracture of the metatarsal was fracture base of fifth metatarsal. This accounted for eight cases. This was the result of objects falling directly on the foot. Possible explanation to this is that the base

of fifth metatarsal is not cushioned and when objects fall on it there is no springing effect with the result that the base of fifth metatarsal fractures.

Fractures of the tarsal bones were the most serious ones. They all resulted from a fall from height. In the study there were three cases and these patients had fracture of the calcaneus and talus also. They also had fractures of the long bones.

Three patients sustained multiple communuted fractures of the bones of the foot. These were very serious injuries and two of these patients had to have a symes amputation. This was after the feet became gangrenous. These patients were initially managed conservatively with elevation of the foot and dressing.

Gissane in 1951 had a similar experience where he managed three cases conservatively All his three cases ended up with a below knee amputation. His explanation

to the disaster was that the dorsalis pedis artery was torn at the junction with the plantar arterial arch and the swelling which resulted and dislocation occluded the posterior fibial artery. His explanation could be true in these cases. He concluded that these were dangerous type of fractures which needed prompt surgical intervention in order to save the foot.

Fracture of the phalanges were the results of direct crushing forces mainly object falling on the phalanges. All of them involved the halux and these were not serious injuries except in the patient who had crush fracture of the distal phalarx and second toe. She ended up with amputation of the second toe at the second Interphalangeal Joint.

3. Degree of Soft Tissue Injury.

In any fracture or fracture dislocation there is some soft tissue injury. In this study the amount of loss was used to asses this. Most of those admitted had moderate to severe skin and other soft tissue loss. They were admitted because they needed to have surgical debridement.

This was done in eleven cases and the aim of this was to remove any foreign material and necrotic tissue in an attempt to reduce sepsis. Despite this sepsis as indicated by positive swab culture was found in nine patients who had surgical debridement and three cases out of five who did not have surgical debridement. The organisms isolated were a mixture of E.Coli, Proteus, Kleibsiella and Pseudomonas. This high incidence of sepsis leaves one wondering whether the surgical toilet and debridement was effective or whether it was done properly.

Despite all this sepsis the wounds were eventually clean enough for skin grafting and this was done in all the patients who had moderate to severe skin and soft tissue loss.

4. Condition of Skin.

It is strange that no patients had discharging sinuses or wound six months after the injury. This could be because of the surgical debridement done earlier and skin grafting which prevented the development of chronic infections.

However, four of the patients had circatrization and scar tissue formation. Arntz T. et al in a series of forty patients found circatrization in only one case. In his series the patient developed marked contracture of split-thickness skin grafts and a dorsolateral contracture development resulting in cock up deformity of fourth and fifth toes. Four out of thirty two cases developing circatrization in this study is rather high rate.

A sensitive scar was found in two cases. The sensitive scars interfered with the patients wearing normal shoes. No record in the literature reviewed recorded the presence of sensitive scar. May be they were not looked for.

5. Presence of Pain.

Pain was a constant feature of most of the patients six months from the time of injury. Infact only two patients did not have pain at all.

The amount of pain ranged from mild to severe pain. Most of the pain was at and around the fracture site. All those who had moderate and severe pain could not wear normal shoes and had to wear open shoes.

A definite limp was found in seventeen patients.

These results compare favourably with those obtained by Wilson D. (13). In his series of twenty two patients he found that only two cases were painless. The rest had pain and discomfort of some sort. He also noticed that twelve of his patients walked with a definite limp but there was no corelation of this with pain or stiffness. However it is my belief that in this study the limp was related to the presence of pain and stiffness after all a person will walk with a limp only when he/she cannot avoid it.

6. Final Deformity Resulting from Injury.

Throughout the literature review almost all authors agree that good anatomic reduction and its maintenance is the direc goal in the management of these injuries. At the same time they tend to agree that good anatomical result does not necessarily guarantee good functional results but increases the likelyhood of a more comfortable and durable foot with better shape[2].

In this study cavus deformity was found in five patients. This could have been due to scar tissue and fibrous tissue resulting from these injuries. Flat foot deformity was found in eight patients and a possible explanation to this is the collapse of the arches of the foot as a result of these injuries. Vulgas deformity was found in six patients and this could be because there was no proper reduction initially or redislocation occurred after reduction. This is in agreement with Malcolm et al [10]. The presence of bony boses was found in seven patients. These bony boses were due to residual bony displacements from the initial injuries. These results compare favourably with Wilson D. in his series of twenty two patients where he found that six patients had vulgas deformity, four had cavus deformity and thirteen cases had bony boses representing bony displacements. All his patients except four were managed conservatively. He concluded that the least conservative treatment gave poor results. The overall results of the study tend to agree with him.

Foot Print Analysis:

Abstract.

The walking cycle is normally divided into four phases.

Phase One.

This is known as the heel strike phase. The heel normally makes contact with the ground first. The posterior support of the plantar vault is flattened on the ground.

Phase Two.

This is known as maximum contact phase. The sole of the foot rests on the ground over the whole surface and this constitutes the foot print. The surface area of the foot print is maximum when the leg is vertical above the foot. The foot print is widened by 12.5mm[8]. This is contributed by the widening of the distances between the metatarsals. Thus the first and second intermetatarsal distances widens by 5mm, second and third by 2mm, third and fourth by 4mm and fourth and fifth by 1.5mm.

The anterior arch is splayed and flattened on either side of the second metatarsal. From this it can be infered that the forefoot width is at its maximum, the arch width and heel width are also at their maximum. These measurements were done during the study.

Phase Three.

This is also known as active propulsion phase. In this phase the weight of the body is shifted anterior on the supporting foot. Most of the weight is borne by the metatarsal heads and phalanges.

Phase Four.

Also known as the swing phase. The foot is off the ground. The weight of the body is borne by the other leg which is at phase two.

1. Missing Toe Prints.

Overall analysis of the foot prints for absent toe prints fifteen patients had missing toe prints on the injured foot. These were due to varying degrees of cock up deformities. Infact two patients did not have any toe prints on the foot print. The absent toe prints meant that these toes were not in contact with the ground during phase two of the walking cycle. It also means that during toe off phase the weight is taken off mostly by the metatarsal heads. In the long term this may result in calosities on the metatarsal heads from the abnormal weight. ARNTZ et al observedcock up deformity in one patient in his series. However if he had analysed the foot prints of his patients he might have detected more patients with the deformity in his series.

This cock up deformity may be due to improper reduction of the fractures or due to tight scar tissues resulting from the injuries.

2. Heel Width, Arch Width, Forefoot Width and Arch Index Analysis.

These measurements were analysed together and two patterns emerged.

(i) Those patients who had all parameters reduced:- In this group sixteen had reduced heel width, Eighteen patients the arch width was reduced, fifteen patients the arch index was reduced as compared to the normal foot. In twenty three patients the forefoot width was reduced.

Possible explanations to these observations are:

(a) Patients did not put full weight on the injured foot. The result of this is that there is no normal widening and splaying of the foot. In some cases this could have been due to pain. Infact only two of the patients involved in the study were pain free.

(b) Some patients could have put full weight on the injured foot but there was no normal splaying of the sole of the foot. This could be because there was no increase in the intermetatarsal distance, when the foot

is taking full weight and this could be because there was fibrosis and scar tissue around the fracture sites. These prevented the sole of the foot widening normally when the foot was taking full weight.

(c) The presence of cavus deformity. In cavus deformity there is reduced heel width, arch width and arch index. Cavus deformity was found in five of the patients.

(ii) Those patients who had all parameter increased. In this group of patients the heel width was increased in five cases, arch width in five cases, arch index in ten cases and forefoot width in two cases. Possible explanation to these observations is that there was colapse of the arches of the foot as a result of the injuries. Infact flat foot deformity was found in eight of the patients.

Throughout the literature review none could be located where these measurements were measured either in disease or health. The only attempt at these was by LYNN et al who measured the heel width and arch width in eight hundred and eighty two feet of normal children and adult. From this he calculated the arch index and found the mean to be 0.71 for males and 0.66 for females.

3. Gait Analysis.

Thirteen of the patients had a fairly normal gait. Four patients had calcaneal gait. These patients had fracture and fracture dislocation of the metatarsals. They had calcaneal gait because the forefoot could not take weight during phase III of the walking cycle. Most of them had residual pain.

Six of the patients did not have a toe off phase. In this case the patient simply lifted the whole foot off the ground i.e. there was no shifting of the weight of the body to the anterior part of the foot. The most common cause was pain.

Two of the patients did not have a heel strike phase. These had sustained fractures of the talus and calcaneum and again this was because of the pain.

More gait abnormalities could have been detected and analysed but the method that was used was simply observing the patient walking and this is not a very accurate way as it detects only the gross abnormalities in gait.

CONCLUSIONS.

1. Majority of the crush foot injuries were as a result of road traffic accidents. The victims were either alighting or boarding the vehicles. The vehicle moved before the victim had completely alighted or boarded the vehicle. The other causes of these injuries were objects falling on the patients foot and a fall from a height were other causes of these injuries.

2. The Pattern of these injuries are varied and depended on the cause. However, the fracture and fracture pattern of individual bones tended to agree with what other authors have found.

3. Treatment of these injuries at Kenyatta National Hospital was more conservative than surgical treatment with internal fixation. Almost all patients had application of plaster where there was no compound fractures. Those who had compound fractures the plaster was applied when sepsis had subsided. This is not in agreement with what other authors recommend. They recommend active surgical intervention as early as possible.

4. The high incidence of sepsis following surgical debridement leaves one wondering whether the

surgical debridement was done effectively. However, in the long run sepsis tended to settle down as no patient had chronic discharging sinuses.

5. Pain was one of the major complaints of the patients six months after injury. This could be a reflection of management of these injuries.

6. Deformities such as presence of residual bony boses, cavus, vulgas, flat foot and cock up deformities were a common end result of these injuries. These also perhaps reflect the initial conservative management where accurate reduction was not achieved or was not maintained.

7. The foot print analysis showed that these injuries affect the arch width, arch index and forefoot width in two main ways.

   (a) There was the group in which all these parameters were reduced.

   (b) There was the group in which all these parameters were increased.

However, these were baseline results in literature as no work had been done previously. But one thing is clear where there is gross differences in these measurements they will affect the type of shoes the patient wears and perhaps the patients gait.

RECOMMENDATIONS.

1. Drivers of motor vehicles should be educated not to move the vehicles before the patients have completely alighted or boarded the vehicles. Passengers should also be educated not to board or alight from a vehicle which is still moving.

2. To improve the results of these injuries aggressive management of these injuries is recommended. Proper reduction should be done under general anaesthesia and where this reduction cannot be maintained open reduction and fixation of the fractures with plates or kirshtner wires should be done immediately.

3. A long term study or follow up of these patients is necessary so as to establish the long term effects of these injuries and to treat the complications which may arise.

4. A local study should be done to establish the heel width, arch width and forefoot width on normal feet with the aim of establishing a mean value. This may help in designing appropriate foot wear.

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DEFINITIONS:

1. Heel Width:

   This was taken as the measurement in milimeters at the widest part of the heel on the foot print.

2. Arch Width:

   The most narrow part of the arch of the foot on the foot print.

3. Arch Index (9).

   This was calculated from formula

   $$\text{Arch Index} = \frac{\text{Arch Width}}{\text{Heel Width}}$$

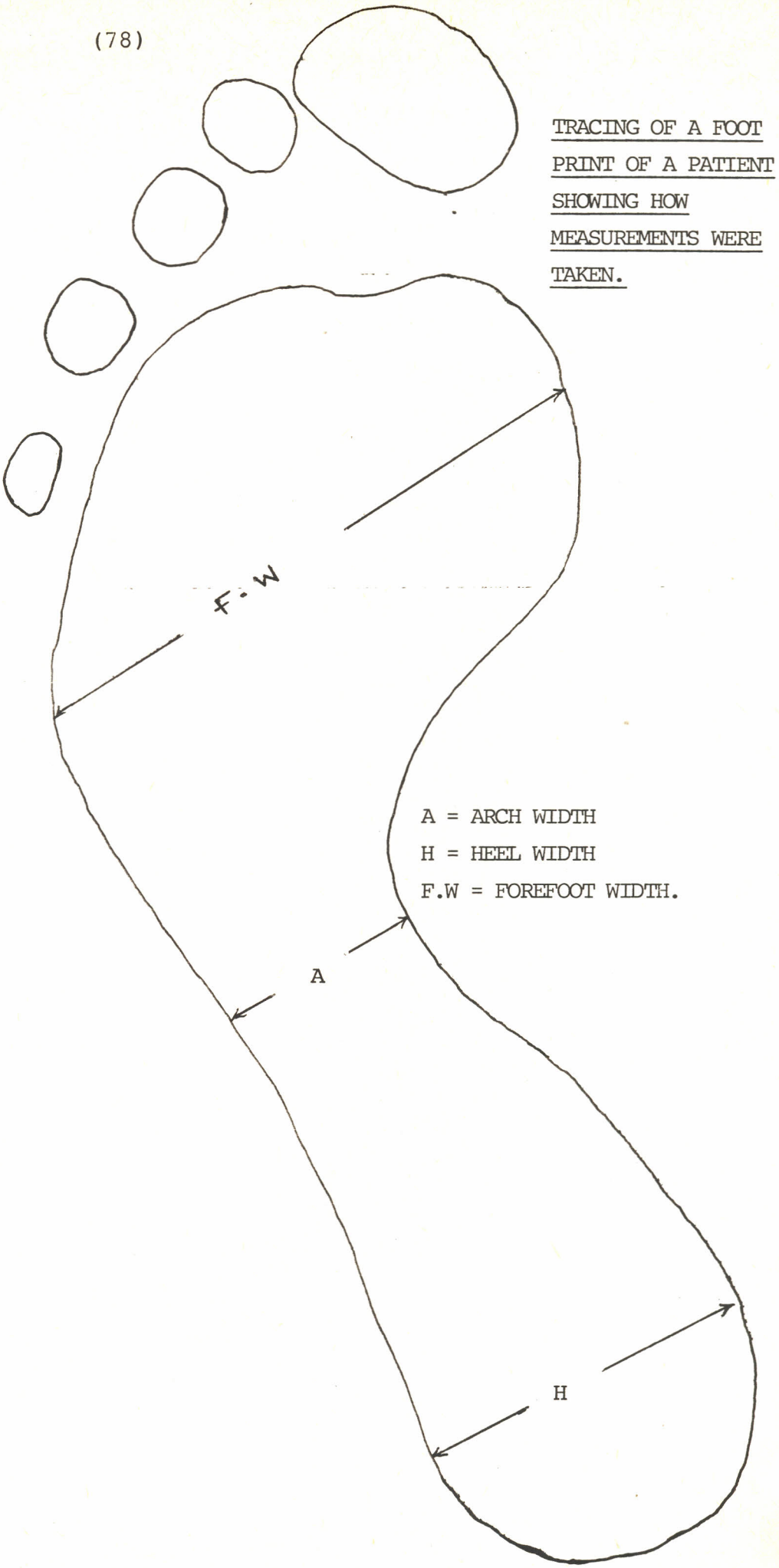
   Mean Arch Index.

   Males 0.71

   Females 0.66

4. Forefoot Width:

   The widest part of the foot print at the metatarsal heads.




TRACING OF A FOOT PRINT OF A PATIENT SHOWING HOW MEASUREMENTS WERE TAKEN.

A = ARCH WIDTH
H = HEEL WIDTH
F.W = FOREFOOT WIDTH.

| | INJURED FOOT HEEL WIDTH | NORMAL FOOT HEEL WIDTH | HEEL WIDTH DIFFE-RENCE | ARCH WIDTH INJURED FOOT | ARCH WIDTH NORMAL FOOT | ARCH WIDTH DIFFE-RENCE | ARCH INDEX INJURED FOOT | ARCH INDEX NORMAL FOOT | ARCH INDEX DIFFERE-NCE | FOREFOOT WIDTH INJURED FOOT | FOREFOOT WIDTH NORMAL FOOT | FOREFOOT WIDTH DIFFERENCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M.K | 52 | 54 | 2 | 30 | 32 | 2 | 0.577 | 0.593 | 016 | 82 | 83 | 1 |
| J.W | 63 | 75 | 12 | 41 | 47 | 6 | 0.651 | 0.627 | 024 | 84 | 97 | 13 |
| J.W | 49 | 54 | 5 | 27 | 27 | 0 | 0.551 | 0.500 | 051 | 67 | 73 | 6 |
| A.N | 50 | 54 | 4 | 27 | 42 | 15 | 0.540 | 0.778 | 238 | 80 | 84 | 4 |
| H.M | 60 | 57 | 3 | 50 | 34 | 16 | 0.833 | 0.596 | 237 | 85 | 90 | 5 |
| T.W | 49 | 50 | 1 | 34 | 40 | 6 | 0.694 | 0.800 | 106 | 77 | 82 | 5 |
| K.N | 53 | 62 | 9 | 15 | 43 | 19 | 0.283 | 0.694 | 411 | 74 | 90 | 6 |
| F.K | 50 | 58 | 8 | 21 | 32 | 10 | 0.400 | 0.345 | 055 | 76 | 85 | 9 |
| J.M | 38 | 56 | 18 | 25 | 43 | 18 | 0.658 | 0.768 | 110 | 51 | 84 | 33 |
| F.W | 52 | 56 | 4 | 25 | 39 | 14 | 0.481 | 0.696 | 215 | 82 | 86 | 4 |
| M.N | 42 | 42 | 0 | 32 | 25 | 7 | 0.762 | 0.595 | 147 | 74 | 72 | 2 |
| C.W | 55 | 52 | 3 | 32 | 25 | 7 | 0.582 | 0.481 | 101 | 65 | 70 | 5 |
| A.N | 47 | 50 | 3 | 25 | 30 | 5 | 0.445 | 0.600 | 155 | 71 | 82 | 11 |
| D.N | 35 | 46 | 11 | 30 | 26 | 4 | 0.857 | 0.565 | 285 | 73 | 70 | 3 |
| P.K | 50 | 62 | 12 | 7 | 45 | 38 | 0.140 | 0.723 | 573 | 47 | 83 | 36 |
| M.N | 50 | 50 | 0 | 10 | 15 | 5 | 0.200 | 0.300 | 100 | 75 | 83 | 8 |
| M.N | 55 | 55 | 0 | 13 | 15 | 2 | 0.236 | 0.273 | 037 | 64 | 77 | 11 |
| F.O | 55 | 60 | 5 | 25 | 32 | 7 | 0.455 | 0.533 | 078 | 75 | 82 | 7 |
| C.O | 50 | 46 | 4 | 27 | 33 | 6 | 0.540 | 0.717 | 177 | 84 | 86 | 2 |
| S.N | 48 | 45 | 3 | 11 | 20 | 9 | 0.244 | 0.444 | 200 | 78 | 68 | 10 |
| E.K | 32 | 55 | 13 | 21 | 38 | 17 | 0.719 | 0.691 | 028 | 44 | 62 | 12 |
| G.S | 60 | 60 | 0 | 40 | 45 | 5 | 0.667 | 0.750 | 083 | 82 | 74 | 8 |
| D.M | 47 | 55 | 8 | 43 | 20 | 23 | 0.915 | 0.264 | 551 | 80 | 95 | 35 |
| M.O | 47 | 52 | 5 | 30 | 30 | 0 | 0.714 | 0.577 | 137 | 78 | 80 | 2 |
| P.O | 58 | 56 | 2 | 35 | 42 | 7 | 0.603 | 0.84 | 237 | 90 | 94 | 4 |
| S.O | SYMES AMPUTATION | | | | | | | | | | | |
| J.M | SYMES AMPUTATION | | | | | | | | | | | |
| M.N | LOST TO STUDY | | | | | | | | | | | |
| K.K | LOST TO STUDY | | | | | | | | | | | |
| J.W | LOST TO STUDY | | | | | | | | | | | |
| E.N | LOST TO STUDY | | | | | | | | | | | |