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The Prevention of Flat-Foot and Similar  
Affections

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## THE PREVENTION OF FLAT-FOOT AND SIMILAR AFFECTIONS.<sup>1</sup>

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THE adult foot of the modern civilized American compares unfavorably, from an anatomical and mechanical standpoint, with the foot of the child or the savage. The child, starting in life with a foot presenting certain definite anatomical characteristics, reaches adult life among savages with a foot but little altered in these essentials; but in civilized life, in practically all cases, with a foot distorted and weakened, and these distortions are more or less uniform. These distortions are so closely allied to the disabling weaknesses of the foot, that their study becomes of interest.

A certain experience among trained nurses which has fallen to my lot, will serve as the text from which to speak.

In April, 1895, I was requested by the Superintendent of the Boston City Hospital to see if any means might be devised to diminish the loss of time caused by the breaking down of the feet of the nurses in the Training School. I undertook the investigation on condition that I might see and examine every nurse coming to the hospital and prescribe a boot for her, just as I would prescribe medicine at a drug store. The work has been conducted in that way, and I have studied with considerable care 160 nurses at that hospital. They probably present a better foot, on the whole,

<sup>1</sup> Read before the Boston Society for Medical Improvement on December 28, 1896.

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than would the same number of women taken at random in the community, for the reason that the applicants are selected more or less from the point of view of their physical condition, and women of obviously poor development are ruled out. The class of feet that I have seen among the nurses at the hospital, I consider as being fairly representative of the normal foot, as it exists in the women of a highly civilized community.

The distortions that exist among these are practically three: (1) outward displacement of the great toe; (2) crumpling of the toes; (3) excessive pronation of the foot.

#### OUTWARD DISPLACEMENT OF THE GREAT TOE.

In the foot of the infant and the unspoiled foot of the savage the line of the great toe prolonged backward, should pass through the centre of the heel. This is known as Meyer's line, and indicates the position of the great toe in which the muscles controlling it were meant to keep it. This position practically never exists in the adult civilized foot. In somewhat over 300 feet studied,<sup>2</sup> comprising those of the nurses, 100 applicants for the position of policemen, and various feet supposed to be normal, the writer has not seen a single adult case where Meyer's line passed through the centre of the heel and in a very large number, the backward prolongation of the great toe did not pass within the border of the heel at all.

The outward displacement of the great toe cripples an important muscle, the flexor longus pollicis, and, by the disabling of the great toe, removes one of the chief supports of the inner border of the foot, thus predisposing the foot to roll over inward.

<sup>2</sup> Figures 10 and 11, p. 91, Boston City Hospital Reports, Seventh Series, 1896.

## CRUMPLING OF THE TOES.

The second distortion consists in crumpling of the toes, which begins in early childhood; under ordinary circumstances and compared to the other two distor-

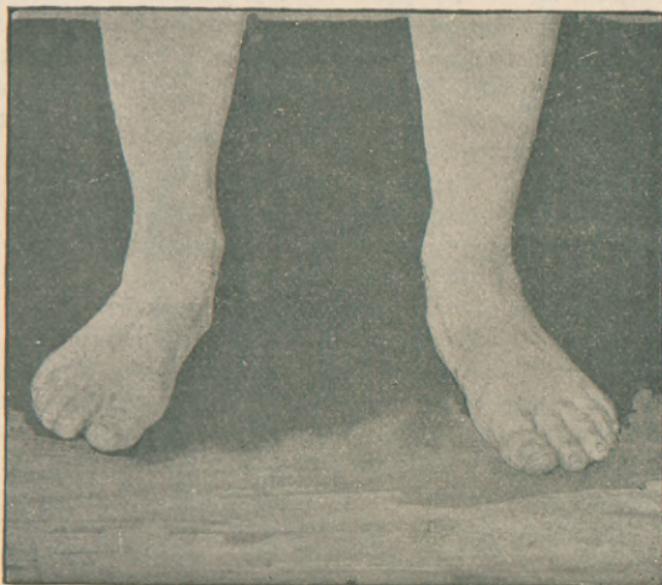


FIG. 1. The position of excessive pronation.

tions it is of comparatively little importance relatively, from a mechanical point of view.

## EXCESSIVE PRONATION OF THE FOOT.

What I speak of as excessive pronation of the foot, for want of a better name, is the most important and the most significant of the three distortions of the foot.

By pronation of the foot I mean the position of

weight bearing, the position in which the forward part of the foot is abducted and the inner malleolus becomes more prominent. In the normal foot not bearing excessive weight, the inner border of the great toe, the inner malleolus and the inner condyle of the femur should all be in the same vertical plane. A certain amount of pronation is normal; but in the weak or overweighted foot, the foot is displaced too much outward in its relation to the leg, and by this movement of pronation carried to excess. This condition is often spoken of as "weak ankles" (Fig. 1).

Finally allow me to state it in a mathematical way: Pronation is a compound anatomical movement consisting of abduction of the forward part of the foot *plus* eversion of the sole of the foot.

It is the position associated with "toeing out."

Pronation is the position taken by tired people; the position which the muscles have the least work to maintain. Excessive pronation is both a separate pathological condition in itself and it is also the early stage of flat-foot. If you will allow me to drop the use of the word excessive, I will speak of the pathological condition simply as pronation of the foot. It varies more, I believe, in proportion to the degree of pain than any other factor; and in the work of which I have spoken, I have worked upon the assumption that the prevention of pronation was, in most cases, the prevention of trouble.

If you will allow me once more to speak of my experience among the nurses. It was obvious when I began upon this work in April, 1895, that some record of the condition of the feet was necessary. I adopted the conventional one of imprint tracings. Each nurse stepped upon a smoked cardboard, which was then shellacked and preserved. It has generally been assumed that a certain type of imprint tracings repre-

seated the normal foot, and that variations from this type in a general way, represented pathological conditions. It became obvious, after a few months, that

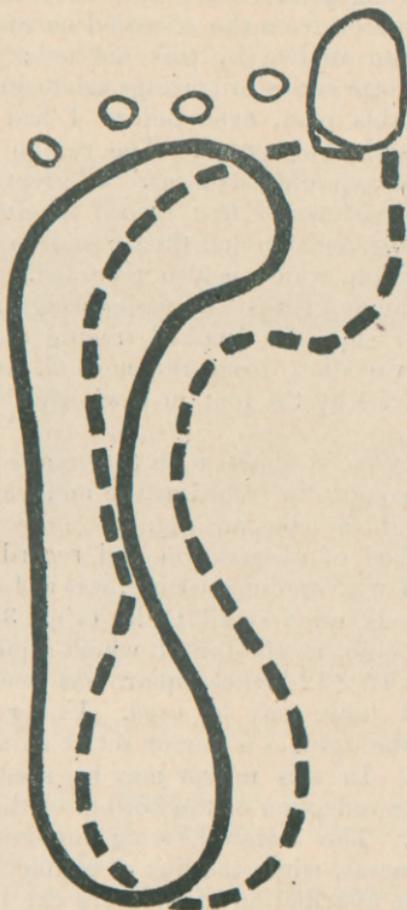


FIG. 2. A record of the non-weight-bearing (in black line) and of the weight-bearing (in dotted line) positions of the foot, drawn on the under side of a glass plate on which the patient stands. The two added together give the ordinary imprint tracing, which is a composite.

the smoked tracings afforded little trustworthy evidence of the real condition of the foot. In one or two cases where the nurses were suffering severe and almost disabling pain, when they first came to the hospital no variation from the so-called normal arch was detected when studied by this method; and after a study of a large series of tracings taken in this way, I abandoned this plan, even before I had formulated any other method of record. The reason for this unreliability became obvious later. The feet in touching the smoked pasteboard first record indelibly the non-weight-bearing position and then pass into the weight-bearing position, which is also recorded. If the foot is a weak one and gives way under weight, lying over on its inner side, the smoked tracing may show no noticeable variation from the normal, although the weight is borne by the foot in a wholly abnormal way (Fig. 2).

The difficulty, in short, with the smoked tracing is, that it is a composite record of the non-weight-bearing and the weight-bearing position.

The method of observation and record I adopted, and which I wish to demonstrate, was as follows: The patient stands on a small table (Fig. 3) about fifteen inches high, in the top of which a piece of plate glass, about  $12 \times 12$  inches square has been set; or a glass-topped table may be used. Under this table, and facing the light, is a mirror set at an angle of  $45^\circ$  to the floor. In this mirror may be seen with great clearness the reflection of the bottom of the feet, bearing weight. The weight-bearing surfaces appear as dead-white areas, while the line of contact can be seen easily. The distribution of pressure can be estimated by the intensity of the pressure anemia of the skin (Fig. 4).

For record a photograph may be taken of the image

in the mirror, or with a soft pencil held perpendicularly to the under side of the glass, an outline of the pressure areas may be traced on the under side of the glass. Then, after the patient steps down, a thin sheet of paper may be placed over the upper surface of the glass and the lines on the under surface may be readily seen through the paper and traced.<sup>3</sup>

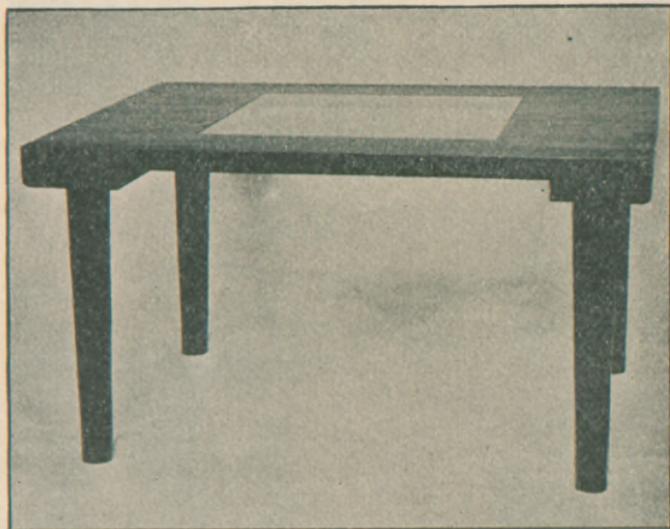


FIG. 3. Table for examination of feet.

The value of the method lies in the fact that the surgeon is able to look directly at the bottom of the foot, under pressure.

The problems opened up by this method are too new and too complex to be settled by any small number of investigations. One thing, however, may be

<sup>3</sup> Hall: Trans. American Orthopedic Association, vol. ix.

said; that in the weak foot the outer border of the foot narrows and lifts when weight is borne on the leg and the weight-bearing surface moves inward. In the



FIG. 4. Patient standing on glass table with a mirror underneath. On the mirror is seen the weight-bearing surface of the foot.

ordinary foot seen among the nurses, the outer border of the foot in most instances does not touch the ground

during weight-bearing, or, if in contact, it bears little weight. In the majority of weak and painful feet examined, it has been obvious that the weight-bearing surface was too far inside.

The problem which I met, in beginning to work upon these nurses, was this: The amount of trouble had been large; nurses had left the school with disabled and broken-down feet; regulation boots had been tried from various shoe-stores, and had not been successful. In 1892 the aggregate loss of time was 42 days. In 1893 the loss of time was 125 days, and one nurse left the school on account of foot trouble. In 1894 the loss of time was 41 days, and one nurse left the school on account of foot trouble. Previous to the adoption of the regulation boots, the superintendent thinks that there was even more trouble than that recorded. Since April, 1895, when I adopted the principle of trying to prevent pronation of the foot among the nurses, no nurse has been off duty for trouble with the feet. The time now recorded is twenty months (January 1, 1897); and it seems to me fair to assume that the method employed is of value and that the element of luck is not enough to account wholly for exemption for so long a time.

The conditions described afford a good test for the utility of any boot. These nurses are on duty from seven A. M. to eight P. M., with the usual time off. They stand or walk on hard-wood floors, and the conditions are not favorable for the welfare of the foot.

There was no boot in the market suitable for use, and one was constructed on theoretical lines to meet the practical need. It has been modified in some ways, and must be still further changed in details, but in every case the boot to be described has been used. It is of interest, inasmuch as it is the practical demon-

stration of the application of a theory to meet a practical requirement.

The endeavor has been to prevent excessive pronation by the use of a boot embodying certain principles which are neither new nor original with me.

(1) The inner line of the sole should be straight, or nearly so. In children it should diverge inside of the straight line to allow the maintenance of the great toe in Meyer's line. This requirement is necessary to prevent the displacement of the great toe.

(2) The shank should be fairly high and stiff and not cut away at its inner border, where its support is most needed to prevent the foot from rolling over on its inner side in weak feet. Cutting away of the inner side of this is almost universal in women's boots. As a rule the shanks of boots are too low, especially this is to be noticed at their inner edge and one improvement to be made is so to manufacture the boot that the shank shall be oblique, highest at its inner border and sloping from that downward.

(3) The sole of the boot should be as wide as the foot opposite the great-toe joint. It is not necessary to demonstrate that, for proper weight bearing, the ends of the metatarsal bones should be free to spread out and not to be crowded one over the other. This width of the foot is the most difficult thing to obtain, not only on the part of the wearer, but from the maker. At the hospital all boots are rejected at once, where an outline tracing of the sole of the shoe is not practically as wide as the outline tracing of the bare foot, with weight borne upon it.

What this pressure does may be seen in the radiograph taken by the kindness of Dr. E. A. Codman, of a model standing in one bare foot and one boot. The overlapping of the metatarsal bones should be especially noted (Fig. 5).



FIG. 5.

(4) The forward part of the sole should diverge inward from the long axis of the foot. That is, it should be made to hold the foot in an adducted position. This is because the prevention of abduction of the forward part of the foot is the prevention of pronation, because the position of adduction is the position of strength and of muscular activity. Holding the foot adducted tends to throw the weight onto the outer border of the foot and to preserve the arch.

When it is seen through the glass that the weight is borne too much on the inner part of the sole, some means, more than adduction of the boot is necessary, and among the nurses I have the inner side of the sole and heel made one-eighth or one-fourth of an inch thicker than the outside, whether they complain of trouble or not, using this in addition to the adducted boot to prevent pronation of the foot.

I have reserved to the end what seemed to me to be, on the whole, the most important part of the subject, namely, the use of a boot for children which shall be of the same shape as the human foot, a boot which conforms to the principles already laid down. I need not do more than comment before this audience on the manifest injustice of making children wear shoes of the ordinary symmetrical pattern, favoring those distortions of the foot which lead to weakness and to mechanical disadvantage and perpetuating the present condition of distorted feet. If persons who have reached years of discretion choose to wear boots which are unreasonable and harmful, they have a perfect right to do so; but children should at least have the chance given them of reaching years of discretion with their feet comparatively undistorted, to be spoiled later if their inclinations lead them to do so.

Finally, the prevention of disabled and disabling feet is, I believe, in general to be attained by the use

of a boot holding the foot in its position of greatest mechanical strength. The prevention of excessive pronation by adducting the forward part of the foot and preventing eversion of the sole of the foot is, I believe, the means by which this is to be done in general. And if you choose to make a wider application of this work among the nurses, the purpose of this paper will have been accomplished.



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