THE DIAGNOSIS AND TREATMENT OF THE COMMON CAUSES OF PAIN IN THE FOOT

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When a patient seeks the advice of his doctor on account of his feet, he nearly always comes with a ready-made diagnosis. When asked what the trouble is he replies "flat feet" or "hammer toes." That is not what he really means, for not one patient in a hundred minds whether his feet are flat or arched so long as they are painless. He means that his feet are hurting him, and he attributes the pain to some real or imagined deformity. Deformities, however, are not of themselves painful, though they may render the foot less able to withstand the normal strains of activity. The pain is then due primarily to the strain, and not to the deformity, since the pain will disappear when the strain ceases, though the deformity will remain.

The first step in diagnosis, therefore, is to endeavour to analyse the exact mechanism by which painful stimuli are evoked, and then, to assess the influence which any deformity may have on the production of the pain. There are only three primary causes of pain in the foot which need be considered: tension, pressure, and inflammation. It is proposed to discuss each of these primary causes in some detail and to consider the conditions under which they may be a cause of pain.

I. Tension.

In this connection the term tension is used to indicate the stress which develops in a tissue when it is subjected to a longitudinal pull. Such tension cannot produce pain in bone, for bone is too rigid and cannot be stretched, nor is it likely to do so in muscles for they are capable of relaxing, nor again in skin as it is so elastic. Pain due to tension, therefore, is nearly always developed in fibrous tissues, such as the fascial planes and the ligaments of joints. Structures such as fascial bands and ligaments are intended to prevent excessive movements, but not to withstand continuous tension. When they are subjected to any prolonged stress they invariably become tender and painful. Under normal conditions the whole of the strain of maintaining posture is taken by the muscles by virtue of their postural tone, and in this way strain on the ligamentous structures is avoided. When the tone of the muscles fails through fatigue, or some other cause, the strain falls on the ligaments; they very soon become painful and the condition known as "postural strain" develops.

It may therefore be said that the pain which is associated with "postural strain" is due to a failure of muscle tone, usually from fatigue, which results in the strain of weight-bearing being thrown on the ligamentous structures. The pain so caused has certain distinctive characteristics. It takes the form of a dull ache, coming on gradually during activity, and being always worst at the end of the day; it is relieved by rest, though a feeling of congestion may persist for a short time during rest.

In order to understand when pain of this type is likely to occur in the foot, it is necessary to consider certain features of the mechanics of the foot, and especially the mechanism of the arches.

The foot has two main functions to serve: that of a pedestal to stand on, and of a lever to propel the body forwards. When the foot is acting as a pedestal it should be flat in order to present as large a weight-bearing area as possible and thus to reduce the "pounds per square inch" to the minimum. When it rests flat on the ground it requires the minimum of muscle tone for its support, and there is no possibility of strain falling on any ligaments. It should also be supple in order that it may adapt itself to uneven surfaces. When walking or running, however, the foot is used as a lever to propel the body forwards as shown in Fig. 1. The essential feature of any lever is that it shall be rigid. There is only one way in which a lever composed of several segments can be made to bear weight without collapsing, and that is to build it into the form of an arch. In order to function efficiently as a lever, therefore, the foot should be capable of becoming arched and rigid.

The ideal foot therefore is one which is flat and supple when the individual is standing at rest, but which is brought into an arched form and held rigidly in that form by the action and tone of its muscles as soon as activity is commenced.

FIG. 1.—Showing how the foot is used as a lever of the second order when propelling the body forwards in walking or running.

The normal adult human foot is not perfect since, owing to adaptive shortening of the ligaments, it cannot flatten completely, and is therefore permanently arched. Even when standing at rest, therefore, the muscles must still maintain a state of tone sufficient to support the arch in order to prevent the strain being thrown on to the ligaments. Prolonged periods of standing will tend to cause fatigue in these muscles so that eventually their tone will fail, and the symptoms of ligamentous strain will develop. It should be noted, that in the normal permanently arched foot, periods of standing are more likely to cause foot strain than similar periods of walking, for while walking the muscles get a short rest with each pace while the foot is off the ground. On the basis of the above considerations it is possible to foretell which types of foot will be most liable to develop foot strain:—

1. *The foot which is flat when standing, but arched during activity.* This is the ideal foot, perfectly controlled. It is rarely seen in practice, except sometimes in ballet dancers and in certain native tribes. It is liable neither to pain nor fatigue.

2. *The flat supple foot,* which remains flat even during activity. Such a foot cannot develop foot strain, for, since it lies flat on the ground and is supple, there is no possibility of strain falling on the ligaments. It will, however, be an inefficient foot since it cannot be used as a satisfactory lever, and can only be picked up and put down again when walking, i.e. the flat-footed gait. It is an excellent foot for the policeman on point duty, but is no use if he has to catch burglars. Similarly, a soldier with such a foot will get no pain, but will complain that he cannot keep up with his fellows on route marches.

3. *The rigid flat foot.* This is a bad foot. It is inefficient because it is permanently flat, and painful because it is rigid. It is obvious that the stiffer the foot, the greater the liability for the contracted ligaments to be put on the stretch, and conversely the more supple the foot the less its liability to ligamentous strain.

4. *The permanently arched foot which is supple.* This is the normal or average foot. It is efficient because it is well arched, but because the arch does not completely flatten when standing at rest it demands continuous muscle tone for its support if the symptoms of strain are to be avoided. It is therefore subject to fatigue, and a period of graduated training is necessary before it can be subjected to prolonged strain without ill-effects.

5. *The rigid arched foot.* This is the worst type of all. It is very liable to develop symptoms of strain both because it is stiff and because it is permanently arched. Further, the higher the arch the smaller the area of the sole remaining to bear the weight of the body, and therefore the greater its liability to develop symptoms due to excessive pressure.

It follows that a foot cannot be assessed by looking at its shape alone. A diagnosis of flat foot is not a diagnosis at all, it is merely a description of the shape of the foot under certain conditions. One might as well say that a man holding a pint-mug of beer was suffering from a bent elbow. Any disablement that he develops will depend not on the degree of flexion of his elbow, but on the number of times that he bends it. The efficiency of a foot and its liability to pain are dependent primarily, not on its shape, but on its mobility and degree of muscular

control. In the words of Trethowan—"the first law of the foot is, thou shalt be supple, and the second law—thou shalt be controlled by good muscles."

The above analysis may be criticised on the ground that feet are seen which appear to be flat and are supple, but which are, nevertheless, painful. The explanation lies in the compensatory postural changes which are automatically adopted by most patients who have a short tendo Achilles. "Short tendo Achilles" is an inaccurate but convenient term used to denote the condition which is present when the normal tonal length of the muscles attached to the tendo Achilles is too short to permit the foot to be dorsiflexed to a right angle at the ankle joint. The patient with a "short tendo Achilles" therefore has difficulty in getting his heel to the ground when standing in the erect position. In order to overcome this difficulty the foot is everted at the subtalar joint, since the movement of eversion at this joint is accompanied by a certain degree of dorsiflexion. This, however, has the effect of rolling the foot over on to its inner border which obscures the long arch, for it is now leaning over on to its inner side. This is a most unstable attitude and causes the whole of the body weight to fall on to the medial border of the foot. The structures on the medial side of the foot are thus subjected to a considerable strain, and pain is almost certain to develop after quite short periods of activity. It must be stressed that this is not an example of a "flat foot," though the patient stands "flat footed," or more correctly—he is standing with his feet in a valgus position. The condition is usually described as being one of "valgus secondary to equinus," and the symptoms with which it is associated as "valgus foot strain." (Incidentally, it is one of the commonest causes of pain in the foot of the soldier.) It should be noted that, again, the pain is due to strain on the ligaments owing to the inability of the muscles to support the foot.

Diagnosis and Treatment.

A patient gives a history of pain in his feet which is suggestive of foot strain. When taking the history the following points should be especially noted: the type and mode of onset of the pain; its relation to activity and rest, and whether it first came on after an illness or after a change of occupation. During the examination of the foot the most important points to note are: (1) Is it supple, and is there a full range of movement in all the joints? (2) Is the muscle tone good, and is the foot well controlled when the patient is standing and walking? (3) The shape of the foot should be noted while standing, walking, and when not bearing weight; (4) Is the tendo Achilles short? To test the tendo Achilles the foot is held squarely on the leg by grasping the toes, the heel being supported by the other hand so that the leg lies horizontally, the knee being straight. The foot is now dorsiflexed as far as it will go, making sure that it

FIG. 2.—Showing method of testing for "short Tendo Achilles."

is neither everted nor inverted in the process. A perpendicular line dropped from the skin under the metatarsal heads should pass in contact with the skin of the heel, as shown in Fig. II. The Fig. shows a foot with one inch of "shortening" of the tendo Achilles, or one inch of "pitch."

If the foot is apparently normal, the symptoms are almost certainly due to muscular fatigue. This is most likely to occur after some illness or after a change of occupation to one which entails longer hours on the feet. The aims of treatment are, first, to relieve fatigue and pain, secondly, to restore tone to the muscles, and lastly to re-educate the neuromuscular mechanism so that the feet are used correctly and are properly controlled. Before any rehabilitation can be undertaken with any hope of success it is essential to relieve fatigue and pain. Much time will be saved in the long run if, in the more acute cases, the patient is put to bed for two or three days before any other treatment is commenced. Rehabilitation is then commenced. Non-weight bearing exercises to the foot and toes are followed by exercises involving carefully graduated activity until a normal life can be resumed.

If the foot is stiff the first step is to mobilise it, if possible. This is accomplished by manipulations, repeated as necessary, with daily treatments in the intervals which include heat, massage, and mobilising exercises. Unless the foot can first be made reasonably supple, which is by no means always possible, all attempts at rehabilitation will be likely to fail. In such cases little can be done beyond palliative treatment, and the patient's activities must be limited to what his feet can stand, as he is certain to have a considerable degree of permanent disablement, no matter what the shape of his foot may be. Once the foot has been rendered supple, rehabilitation can be commenced on the same lines as for foot strain.

In connection with stiff feet the condition known as *spasmodic valgus* must be mentioned. This condition is most commonly seen in messenger boys who have recently left school and have not been accustomed to long hours on their feet. It also occurs in adults after prolonged and severe strain on the feet, or during the recovery stage after some traumatic or infective condition. The foot is held rigidly in a position of full eversion by persistent spasm of the peroneal muscles, which is often associated with spasm of the extensors of the toes as well. Attempts to invert the foot merely increase the spasm so that the foot has a board-like rigidity. Unless it is relieved, the spasm persists indefinitely and, as a result of adaptive changes, the foot ultimately becomes permanently rigid and fixed in a flat and everted attitude. The rigid flat foot so produced is a painful and crippling condition, for which no treatment is of any avail. Frequently an infective element appears to be present, and the tonsils are so often found to be at fault that the condition has sometimes been called "tonsil foot."

The condition is most resistant to all forms of treatment, but the following scheme has been found to be effective in a proportion of the cases. Under deep anaesthesia any adhesions present are broken down. The foot is then held in a corrected position and immobilised in a plaster cast which is retained for six weeks. Weight bearing is not permitted. During this period a search is made for possible sources of local sepsis, which are dealt with if necessary. After removal of the plaster, a course of heat, massage and light exercises to the foot and toes is instituted. The patient remains in bed until full mobility and full muscle tone has been restored and there is no sign of any return of the spasm. He is then allowed up, wearing a foot support and also an outside iron and inside T strap, and activity very gradually resumed. If there is any sign of a return of the spasm the whole process is started over again. These measures may seem drastic, but the condition is a very serious and crippling one, and nothing less than this offers a hope of permanent cure. If it occurs in a soldier he should be boarded out of the Army.

The valgus foot with a short tendo Achilles.

The primary treatment consists either in lengthening the tendo Achilles or in compensating for its shortness by raising the heels of the shoes. The latter, being the simplest measure, should be adopted in all but the most severe cases. In either case the patient will continue to hold the foot in a valgus attitude, since this has become his habitual posture. The next step in treatment therefore consists of giving a course of re-educational exercises. The restoration of a correct posture may also be assisted by temporarily wedging up the shoes on the inner sides. It must be stressed that the deformity is a compensatory and necessary one, so long as the tendo Achilles is short. Wedges should not be given, therefore, unless the primary condition has first been corrected or allowed for by raising the heels.

To summarise: the weight of the body is normally supported by the postural tone of the muscles. If this tone is inadequate, part of the weight falls on the ligamentous structures. The prolonged tension to which they are then subjected, and which they are not designed to bear, is the direct cause of the pain. The treatment may be divided into four stages.

1. Rest to relieve fatigue and pain.
2. The search for predisposing and inciting causes and the adoption of measures for their relief.
3. The restoration of normal tone to the muscles and mobility to the joints.
4. Rehabilitation by graduated exercises and re-education in correct ways of standing and walking.

II. Pressure.

Pressure sufficient to cause pain may be imposed on the foot or some part of it from without, as for example by an ill-fitting shoe, or through faulty distribution of the body weight; in other cases localised excessive pressure may develop within the foot, usually as the result of the impaction of arthritic joint surfaces. In practice, pain due to pressure is most often encountered in the tissues which lie under the metatarsal heads. This is such a common and important cause of pain in the foot that its aetiology and treatment merit detailed consideration.

When the heel is raised from the ground the whole of the body weight is transmitted on to the heads of the metatarsals and the tissues which lie underneath them, since together the metatarsal heads form the fulcrum about which the foot moves when used as a lever. The weight-bearing area which they present to the ground is insufficient to withstand the whole weight of the body without giving rise to pain. Under normal conditions part of this weight is taken on the pads of the toes. This is achieved by active contraction of the flexor muscles of the toes whereby they are pressed firmly on the ground. As well as relieving some of the body weight from the area of the metatarsal heads, this action has the effect of steadying the fulcrum which they form, and preventing it from slipping backwards when the body is being actively propelled forwards. This flexor action of the toes is achieved by simultaneous contraction of the long flexors together with that of the interossei, lumbricals, and short flexors; for if the long flexors were to act alone they would tend to curl the toes under rather than press them flat on the ground.

If these "intrinsic" muscles fail to function, the action of both the long flexors (which by themselves act primarily on the interphalangeal joints) and the long extensors (which extend the metatarso-phalangeal joints) is unopposed, and the toes become clawed as shown in Fig. IIIA.

Their combined tone, unopposed by that of the "intrinsic" group, tends to buckle and "concertina" first the toes, which become clawed, and then the foot itself which buckles in the mid-tarsal region so that a pes cavus develops. This is illustrated in Fig. IIIB. It will be seen that the cavus deformity reduces to a minimum the area of the forefoot in contact with the ground, while at the same time none of the body weight can be transferred to the toes owing to their deformity and the failure of their muscles.

It will be seen, therefore, that proper toe action is essential for efficient and painless function of the fulcrum of the foot which is formed by the metatarsal heads.

The function of the toes may be upset by actual paralysis of the intrinsic muscles, by cramping of the toes through tight shoes or socks, which makes any function impossible, or by inhibition of proper muscle action by some painful focus, such as a corn or blister.

Diagnosis.

When excessive pressure of an intermittent character is applied to any part of the body, hypertrophy always results. In the skin, this hypertrophy results in the formation of a callosity. The thickness of the skin in any part of the body is an accurate measure of the degree of pressure to which that part is being subjected (provided that this pressure is of an intermittent character; for continuous excessive pressure causes atrophy e.g. a pressure sore). If it is suspected from the history and character of the pain that it is due to excessive pressure falling on the metatarsal heads, the diagnosis should be confirmed by noting the extent of any callosities which may be present under the metatarsal heads. If the skin in this region is normal, then some other cause for the pain must be sought.

FIG. 3.—(a) Showing effect of action of "intrinsic" muscles;
(b) Showing the clawing of toes and cavus deformity of foot resulting from unopposed action of long flexors and extensors.

Treatment.

If no contractures have occurred and there is no fixed clawing of the toes, it is unlikely that the intrinsic muscles are actually paralysed. The first steps in treatment are to deal with any sources of painful stimuli, such as corns or blisters, and to see that the shoes and socks are well fitting and of sufficient length to allow freedom of movement to the toes. A course of exercises is then instituted, designed with the object of restoring the full action and function of the intrinsic muscles. It must be remembered that their action is to flex the metatarso-phalangeal and extend the interphalangeal joints. Exercises such as trying to pick up objects with the toes are wrong, since this only exercises the long flexors (whose function is rarely impaired), instead of the intrinsics. The best exercise is as follows: the patient stands on the floor with the toes resting on the edge of a book or slab of wood about $\frac{3}{4}$ in. thick. He is now told to endeavour to force up the metatarsal heads by pressing on the book with his toes, at the same time preventing the toes from curling underneath or buckling (Fig. IV). This exercise takes considerable practice, but should be persevered with, for it is most effective in restoring proper toe action.

When actual contractures are present, these must first be corrected by tenotomy of the long extensors and fixation of the toes in a corrected position for a period, before re-educational treatment can be carried out effectively. In severe cases, and in those where actual paralysis of the intrinsic muscles is present, operative measures offer the only hope of cure. The most effective procedure consists in arthrodesis of all the interphalangeal joints of the toes. Thereafter the long flexors acting alone exert the same effect as they normally do when acting with the intrinsic muscles, namely, active flexion of the metatarso-phalangeal joints only, and thus the toes can once more take their fair share of the body weight and good function is restored.

In some cases which are too advanced for conservative treatment, and where operative correction is contraindicated for some reason, purely palliative measures must be adopted. Since excessive pressure is falling on the metatarsal heads, and it is not possible to redistribute this pressure to the toes, it must be distributed elsewhere. This is achieved by fitting a pad immediately behind the metatarsal heads, which has the effect of distributing some of the body

FIG. 4.—Illustrating exercise for intrinsic muscles of toes. The toes are pressed firmly on the book so as to exert a lifting action on the metatarsal heads.

weight on to this area of the sole of the foot. It must be stressed that the object of this palliative treatment is to distribute the weight over a wider area, and *not* to endeavour to raise the depressed metatarsal heads. The mistake is sometimes made of fitting the pads immediately under the metatarsal heads, which only has the effect of increasing still further the pressure to which they are being subjected.

Localised pressure developed at some point within the structure of the foot is also a common cause of pain and it is a frequent cause of disablement in the case of hallux rigidus. In this condition the limitation of movement is due partly to fibrous contractures in the capsule of the joint and in part to the ring of osteophytes which forms around the periphery of the articular surfaces. When the joint is forcibly dorsiflexed, as happens whenever a forward pace is taken, the osteophytes on the dorsal edges of the joint become impacted, and thus prevent further dorsiflexion. If any sensitive tissue, such as a fringe of synovial membrane, is caught between them, severe pain will be caused. In such a case a metatarsal bar should be fitted to the boot or shoe. The foot can now rock on the bar, the necessity to dorsiflex the joint is obviated, and the pain relieved.

It should be noted that pain in a hallux rigidus may also be due to pressure on the prominent and irregular edges on the under surface of the joint and the sesamoid bones. In this case a metatarsal bar would tend rather to increase the discomfort, since it localises the weight-bearing area to the immediate vicinity of the joint. The proper treatment in this case consists in fitting a pad behind the joint so as to transfer some of the weight proximally and so relieve the load on the joint itself. This explains why a metatarsal bar gives relief in some cases of hallux rigidus, but makes the discomfort worse in others, and affords a further illustration of the main thesis of this paper; that a diagnosis of, say, hallux rigidus is not adequate, since it does not define the actual cause of disablement; for a hallux rigidus may be painless, and when pain does arise it may be due to a variety of causes, the correct treatment being different in each case.

Pain, due to localised pressure within the foot, or what might be called "impaction pain," is encountered in several other situations, notably in the joints between the inner cuneiform bone and the first metatarsal. When weight is borne on the foot the tendency to flattening of the long arch is liable to cause impaction of the upper edges of this joint, and this is especially so in a highly arched foot or pes cavus. Owing to the strain to which this joint is subjected in a highly arched foot arthritic changes are very liable to develop. Pain due to the nipping of sensitive tissues between the arthritic joint surfaces may then occur in the same way as in a hallux rigidus. Relief can best be afforded by fitting an arch support which will limit the tendency to impaction of the joint surfaces.

III. Inflammation.

The pain associated with inflammatory conditions is due to the internal pressure in the tissues which results from the congestion of the part. This pressure is really another form of

tension, but whereas the tension in ligamentous strain occurs in one direction only, in inflammation it is developed in all directions equally. The pain associated with inflammatory conditions can usually be distinguished easily from that due to purely mechanical causes. It has a persistent and throbbing character; it is more diffuse; it is not entirely relieved by rest; and it is at its worst on first movements after a period of rest. The signs of inflammation will also be present as a rule, namely, heat, redness, swelling, and muscle spasm. It must, however, be remembered that some degree of inflammatory reaction always occurs in the more acute types of foot strain. This reaction, however, rapidly settles down with rest, and it can thus be readily distinguished from other types of inflammation.

When it is decided that pain of an inflammatory nature is present, immediate and complete rest is indicated. If the inflammation is due purely to the reaction to an acute foot strain, all signs and symptoms will subside within forty-eight hours. Treatment for the primary, mechanical cause can then be instituted. If inflammation is still present the next step is to endeavour to decide its cause, in order that the correct specific treatment can be instituted.

The common causes of inflammation in the foot apart from acute strain are as follows:

1. *Fibrositis*.—Fibrositis is a low-grade inflammatory condition, presumably of metabolic origin, which occurs in fibrous tissues which have been subjected to stress or trauma, and is particularly liable to occur when the local resistance has been lowered by exposure to damp or cold. The plantar fascia is frequently affected, especially near its insertion into the calcis, giving rise to severe local pain, tenderness and induration. The treatment is the same as that for fibrositis elsewhere in the body, namely, rest, heat and massage, followed by a gradual resumption of activity after the acute symptoms have subsided. Patients should be instructed with regard to the protection of their feet from subsequent exposure to cold and damp, a good precaution being to wear two pairs of woollen socks—coupons permitting.

2. *Simple synovitis*.—This condition usually appears following some infective condition such as tonsillitis or influenza, and most frequently affects the larger joints. The treatment again consists in rest and heat, until all signs of inflammation have subsided, followed by exercises to the foot and toes to restore muscle tone. Activity is then gradually resumed.

3. *Gout*.—After a period of eclipse, this condition is becoming more common again, though it is no longer the "drinking" gout which affects elderly men. In fact, it quite often attacks women between the ages of twenty and thirty. The inciting cause is uncertain, but the treatment remains the same as that for the older form of the disease.

4. *Diplococcal arthritis*.—This has become much less common since the introduction of chemo-therapy, but it is still occasionally encountered. It is characteristically of sudden onset, with severe pain and marked stiffness and periarticular inflammation. The symptoms are usually at their worst in the initial stages of the attack. When the active inflammatory process has subsided a prolonged course of physiotherapy is usually needed to restore mobility and muscle tone.

5. *Tuberculosis*.—Any of the joints or bones of the foot may be affected in children or in adults. In contrast to diplococcal infection the onset is insidious, pain is not a marked feature, but the foot becomes progressively stiffer and more swollen. An abscess usually appears at a fairly early stage in the disease.

Summary and Conclusion

The main causes of pain in the foot have been discussed and emphasis has been laid on the fact that anatomical deformities are not of themselves painful, and that a diagnosis which merely describes the visible deformity present is of little value since it does not define the actual cause of pain. Pain in the foot is nearly always due to strain, to excessive local pressure, or to inflammation. Before appropriate treatment can be prescribed it is essential to analyse the actual cause of the pain and the mechanism by which it has been produced. Only in this way can treatment be made rational and effective rather than empirical and futile.