TREATMENT OF HALLUX VALGUS AND RIGIDUS*

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Hallux valgus is met with more frequently than any other deformity of the adult foot. It is seen very occasionally in infants or children as a congenital deformity, but in the vast majority of instances it results directly from the long-continued deforming pressure of badly constructed shoes. Consequently it is found most commonly in women on account of the height of the heel and the narrowness of the toe in the so-called "smart" shoes which they usually wear, and as a rule the full development of the deformity is not seen before adult life.

The primary alteration in the alignment of the foot consists in the adduction of the great toe towards the outer border of the foot. This of itself constitutes the essential deformity of hallux valgus, and the alterations of the muscles, ligaments, and bones which are so commonly associated with this primary deviation are secondary to it and result from the abnormal position of the displaced great toe. Thus the head of the first metatarsal becomes abducted from the second, increasing considerably the width of the anterior portion of the first intermetatarsal space. This abduction of the metatarsal from its fellows often appears to be the outstanding and basic deformity, and may in some cases be associated with the presence of a small wedge-shaped bone, the intermetatarsium, which lies at the base of the first metatarsal between this bone and the internal cuneiform, and from the x-ray appearance it may seem that the abduction of the metatarsal is directly due to the presence of this abnormal bone. Such, however, is not the case, as in many instances the x-ray of an apparently normal foot has shown the presence of such a bone without any abduction of the metatarsal. The abduction, in fact, results directly from pressure applied by the base of the displaced first phalanx of the great toe on the inner side of the articular surface of the head of the first metatarsal, and correction of this abduction follows on removal of this abnormal pressure. Such an improvement in the alignment of the bone can usually be seen within a few days of the removal of this pressure, except in those old-standing cases where the articular surface of the base of the metatarsal has become altered as the result of the development of osteo-arthritic changes.

A Vicious Muscular Circle

Because of the abduction of the first metatarsal the adductor obliquus and adductor transversus, which are attached to the inner side of the base of the first phalanx, are placed under increased tension, so that by their contraction the phalanx is pulled still further round to the inner side of the head of the metatarsal. The capsule on the inner aspect of the first metatarso-phalangeal joint becomes contracted, whilst that on the outer side of the joint is stretched, together with the abductor hallucis muscle, which is also attached on this aspect of the phalanx. The articular surface of the head of the first metatarsal becomes extensively altered in shape; its inner half, which is now the only portion to articulate with the base of the phalanx, retains its normal shiny appearance, while the cartilage covering the outer side and the apex of the articular surface, having lost its contact with the base of the phalanx, is fragmented, fibrillated, and

irregularly pitted, and is not capable of acting as an articular surface, even though the phalanx were restored to its normal position. Osteophytic outgrowths also appear on the outer margin of the articular surface, and these may develop to such an extent that a definite exostosis is formed at this site. The articular surface of the base of the first phalanx also shows considerable alteration, the centre becoming depressed with a raised ring around the margin, so that the appearance of the base of the phalanx is very similar to that of the head of the radius. Over the outer aspect of the head of the first metatarsal increased pressure of the shoe, consequent on the displacement, results in the formation of a bunion, which may at times be the site of inflammation, or may even become the seat of a definite septic infection.

Owing to the displacement inwards of the great toe the direct distance between the point of origin and insertion of the extensor longus hallucis muscle is diminished; the tendon of this muscle is displaced inwards so that it lies in the first intermetatarsal space, and by its contraction acts as a strong deforming force. The flexor longus hallucis muscle cannot act in this way, as its tendon is firmly held in a rigid fibro-cartilaginous tunnel on the under surface of the head of the metatarsal and of the phalanx. The transverse metatarsal ligament, which connects the heads of the metatarsals, becomes stretched by the abduction of the first metatarsal, with the result that the support given by it to the transverse arch is lost, and the heads of the second, third, and fourth metatarsals fall and bear an increased proportion of the body weight in walking.

Further Deformities

Certain other changes occur more slowly, and are found only in cases where the deformity has been present for a long time. Thus the adducted toe, by its pressure, may lead to the development of a hammer-toe deformity of the second toe; or by its presence, either above or below the second toe, may result in flexion or contraction deformity of this digit, or may produce a displacement of the base of the first phalanx on to the dorsum of the head of the metatarsal. The third and fourth toes may also be similarly displaced or deformed, and almost invariably become the site of painful corns over the dorsum of the first interphalangeal joints or over the tips of the toes under the nails. These other deformities are usually the direct results of the adduction of the great toe, but after their full development correction of the causative deformity of the great toe does not necessarily lead to a correction of these secondary deformities, each of which may require treatment.

Treatment in Early Stages

In the early stages of the deformity, where the secondary contractions of the soft tissues and the alterations of the articular surfaces have not become permanent, correction is occasionally possible by moulding the toe and fixing it in the corrected position for a period sufficiently long to overcome the constant tendency to recurrence which is such a striking feature. In carrying out this line of treatment the toe is moulded by hand, combined if necessary with division of the contracted capsule on the inner side of the metatarso-phalangeal joint, followed by fixation in the corrected position for a period varying from two to six weeks. Such a correction of the alignment can, however, only bring about a restoration of shape and function in those cases where the displacement of the base of the phalanx to the inner side is slight, and where the articular surface of the head of the metatarsal is more or less normal. If such a procedure is

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carried out after the alterations of the articular surface the invariable result is a rapid reappearance of the deformity or the development of an arthritis which is so painful that the function of the joint is greatly impaired. Correction by moulding is of value only in the younger patient, in whom arthritic changes are uncommon, and its employment in the older type of patient is followed by failure in almost every instance. The correction may be maintained most efficiently by the application of a straight splint along the medial side of the toe, the splint being firmly bound to the arch of the foot and the toe being bound to the front part of the splint, so that its alignment with the first metatarsal is restored. After wearing such a corrective apparatus day and night for the first two months it may then be discarded during the day, being reapplied at night only. Toe stalls or wedges, placed between the great toe and the second, are frequently employed in the treatment of the deformity of hallux valgus. They may with advantage be used after some method of corrective treatment, but without such preliminary correction their usefulness is negligible. The pressure of the deformed great toe is always sufficiently great to lead to an increased pressure on the second, third, and fourth toes without producing any appreciable correction of the alignment of the great toe. As a result of their use the other toes become more crowded and deformed, and the presence of the toe-wedge leads only to an increased pressure on these other toes without having any compensating effect on the deformed great toe.

Operative Treatment

As a rule, even when first seen by the surgeon, the deformity of hallux valgus is so great that manipulative correction alone is insufficient to produce a cure. The changes in the articular surfaces of the first metatarsal have already appeared, the soft tissues have become contracted, and operative intervention remains the only possible method of correction. Many operations have been suggested, and most of them have been extensively tested. These various procedures may be placed under the following headings, according to the site of operation and the character of the tissue with which the surgeon is dealing.

1. Operation to shave off the prominences on the head of the metatarsal.
2. Operation on the neck of the metatarsal.
3. Operation on the head of the metatarsal.
4. Operation on the shaft of the metatarsal.
5. Operation on the base of the phalanx.

Shaving off Metatarsal Head Prominences

Shaving off the exostoses on the outer aspect of the head of the first metatarsal can at best result simply in an improvement in the appearance of the foot. The procedure does not in any way alter the relation of the base of the first phalanx to the head of the metatarsal; the deformity of the great toe remains as before; and if the operation be combined with manipulative correction of the alignment of the toe the result is the development of a painful inflammation, and possibly arthritis of the joint so long as the correction is maintained.

Metatarsal Neck Osteotomies

These operations, which consist in the removal of wedges from the neck of the metatarsal, have been performed through various incisions, some oblique, some curved, and some directly transverse. They result in a rotation of the articular surface of the head of the first metatarsal, but owing to the fact that they have not so definitely shortened the distance between the base

of the first metatarsal and the tip of the terminal phalanx of the great toe the short oblique muscles of the foot are not so efficiently released from tension, and a recurrence of the deformity after this form of operation is unfortunately all too common.

Operation on the Head of the Metatarsal

This type of operation is probably used more commonly than any other in the treatment of hallux valgus, and although most surgeons employ some slight modification of technique they may all be classified under the general heading of "Mayo's operation," by which is meant the removal of the head of the metatarsal. After this the gap left by its removal is filled by the intumed bursa which was present over the medial aspect of the great-toe joint.

This operation has been carried out for many years, and with care and suitable after-treatment has given many excellent results. It has, however, the great disadvantage that it results in the removal of the anterior pillar of the internal arch and the inner pillar of the transverse arch of the foot. After removal of the head of the metatarsal both these arches are necessarily weakened, and unless suitable protection is provided subsequently the unsupported heads of the second, third, and fourth metatarsals fall to a lower level, with the probable development of pain under one or all of these fallen bones in walking. The operation results in a great improvement in the appearance of the foot with a considerable diminution in its width, and if the patient's status in life is such that no prolonged standing or carrying of heavy weights is necessary the result may be considered as being satisfactory.

In carrying out the operation the incision should be a straight one along the supero-internal border of the first metatarso-phalangeal joint. After being freed from its ligamentous attachments the head of the metatarsal is removed by cutting across the neck of the bone close behind its articular surface, and the bursa, which has previously been freed anteriorly but left attached to its posterior connexions, is then sutured in position between the raw surface of the metatarsal and the base of the phalanx.

By removal of the head of the metatarsal the distance between the base of the first metatarsal and the tip of the great toe is diminished. The tension on the oblique muscles of the foot which are inserted into the base of the phalanx is lessened, and the toe can be easily placed in alignment with the remaining part of the first metatarsal. Walking should not be permitted for at least four weeks after such a removal, and exercises to develop the muscles of the sole of the foot and massage of these muscles to improve the circulation are of the very greatest benefit in the after-treatment. The use of a suitable "insole," which supports the heads of the other metatarsals and prevents their complete collapse, is of the greatest help, and should be persisted in for at least twelve months.

Metatarsal Shaft Osteotomies

These operations, which are usually associated with the names of Hohmann and Ludloff, consist in an oblique osteotomy of the shaft of the first metatarsal. The operation is carried out through a long incision on the medial border of the foot. The metatarsal is now divided obliquely from above downwards and inwards, after which the great toe is forced into the correct alignment with the rest of the foot. As a result there is a definite shortening of the metatarsal, the two portions overriding and the posterior end of the anterior fragment adducting towards the second metatarsal, allowing the articular surface of the head of the metatarsal to be rotated so

that the portion of the articular surface which originally formed the inner side of the head and articulated with the base of the displaced phalanx now points straight forward, although it still bears the same relation to the phalangeal articulation.

Although this operation corrects the alignment of the toe, it has most of the disadvantages of removal of the head of the metatarsal. Owing to the shortening of the first metatarsal the normal support given by this bone to the inner side of the foot is lost; the heads of the second and third metatarsals project considerably beyond the first, with the result that abnormal pressure is placed on the two former bones and is frequently followed by the development of a painful metatarsalgia.

An attempt has been made by Hohmann to reduce this tendency to falling of the anterior arch by flexing the terminal fragment at the time of the correction of the alignment. This procedure results in a prominence of the head of the metatarsal on the sole, but does not affect the great problem of the shortening of the bone, with increased pressure on the other metatarsal heads.

Excision of Base of First Phalanx

The operation of removal of the base of the phalanx has many advantages over any of the other procedures. After this removal the deforming pressure exerted by the displaced great toe is obliterated, and correction of the alignment of the inner side of the foot is rendered possible. The abduction of the first metatarsal from the second immediately disappears unless a secondary arthritis is present at its base. In addition to this the whole correction has been carried out without weakening the strength of either arch of the foot.

The operation is carried out through a straight incision on the supero-internal border of the metatarso-phalangeal joint. After completely freeing the base of the phalanx from its ligamentous and muscular attachments, the bone is cut transversely about its middle and the whole of the proximal fragment removed in one piece. This removal of half of the phalanx constitutes one of the most important principles in the operation; if less bone is removed the result may be the development of a painful fibrous ankylosis—a tragedy which can be avoided by a sufficiently extensive removal of bone. If the deformity is of long standing and the extensor proprius hallucis tendon has been displaced and is acting as a deforming force it should be divided subcutaneously at some distance from the site of operation. If divided near the operative field the divided tendon may become involved in scar tissue and its action may be lost. If divided subcutaneously two or three inches above the site of operation union of the tendon will occur after six or eight weeks, with a complete restoration of its function.

After-treatment in this operation is comparatively simple; the abnormally mobile toe must be maintained in a fully abducted position until voluntary control of flexion and extension is restored. This object can easily be attained by placing a small wedge of wool between the great toe and the second until this voluntary muscular control of the toe has been re-established, when recurrence of the deformity is unlikely. Walking is permitted three weeks after the operation, and exercises and massage of the toe soon produce a diminution of thickening and an improvement in the circulation round the joint. The presence of a wedge of wool between the great toe and the second does not now involve the risk of increasing the pressure on the other toes as the adducting strength of the great toe is lost owing to removal of the base of its phalanx.

In carrying out any of these operations removal of any very prominent osteophytic outgrowths of the head of

the metatarsal is of considerable advantage, raw surfaces being covered over by fascia, or fat from tissue in the operative field.

Hallux Rigidus

The deformity of hallux rigidus is met with either in adolescence or in late middle life. In adolescence the condition is usually found in association with a long foot which is narrower than normal, and examination of the great toe shows that the power of dorsiflexion is lost. Flexion is free, but movement above the horizontal line is restricted by an intense muscle spasm, both of the flexor longus hallucis of the toe and more especially of the short flexor muscles of the sole of the foot. X-ray photographs at this stage usually show no bony change, although there is often some thickening. Examination of the child's foot and the shoes usually worn indicates that the abnormally long foot has led to pressure on the end of the great toe, even though the shoe may be much too wide and does not grip the sides of the ankle. The reason is that the child is wearing a stock size in which the length of the shoe is out of proportion to its breadth in relation to the patient's foot. When these children wear shoes which are sufficiently long they are so wide that the heel and instep are completely loose. As a result a compromise between the correct length and the breadth of the shoe is given, and the child has to suffer continuous pressure between the tip of the great toe and the heel. There then follows inflammation of the great-toe joint, with irritation and secondary spasm of the muscles governing the inflamed joint.

Conservative Treatment

At this stage improvement can usually be obtained by the provision of shoes made to fit so that no pressure is exerted on the end of the great-toe joint. In addition, the wearing of a metal plate inside the normal sole of the shoe prevents dorsiflexion of the toe and diminishes the irritation, with a consequent gradual improvement in the condition. If this line of treatment is followed for at least two years the movements may be restored to normal and the development of secondary bone deformity prevented. In some cases operative intervention is unnecessary, as with relief from movements of the joint in walking and irritation from pressure on the end of the toe the inflammation lessens. Gentle massage of the toe-joint will lead to a gradual increase in the range of movement. Generally, however, treatment is not carried out sufficiently long, and eventually arthritis develops in the joint, leading to a clinical condition exactly similar to that of hallux rigidus occurring in the adult.

In adults the condition is accompanied by definite osteophytic outgrowths on the dorsum of the head of the metatarsal and on the base of the phalanx, while the capsule on the plantar aspect of the metatarso-phalangeal joint becomes contracted. Dorsiflexion of the toe is therefore prevented by a combination of protective muscle spasm, secondary soft tissue contraction, and the mechanical block of the bony outgrowth on the dorsal aspect of the joint. Under these circumstances, and if pain and discomfort are present in the joint, operative intervention is advisable.

Operative Treatment

The operations which may be carried out for the relief of hallux rigidus are almost identical with those for the relief of hallux valgus. When wedge osteotomies are used the wedge in this case is placed so that the base is directly upwards on the dorsum of the metatarsal, and the apex downwards just behind the articular surface of the head of the metatarsal. In this way, by removing

a considerable wedge of bone, the articular surface is altered so that a greater range of dorsiflexion is given without any alteration in the relation between the head of the metatarsal and the base of the phalanx.

The most satisfactory operation for the condition has been that of removal of the base of the phalanx. When this is carried out care should be taken to make certain that at least half of the phalanx is removed at the time of operation; if less than this is taken the usual result is a painful fibrous ankylosis, and the patient may even complain of more pain than previously.

After-treatment is identical with that for hallux valgus; walking is permitted after three weeks, and exercises and massage of the toe lead to an improvement in its range of movement. With a restoration of voluntary control of movement the disability is overcome.

PROBLEMS OF CHANCE IN CLINICAL WORK

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A recent article on Bell's palsy in this *Journal*¹ recorded an attempt to find "a criterion whereby we may decide in the early stage [of the palsy] that a given case is unlikely to recover." The reason for the search was that facial nerve decompression should not be undertaken unless the odds against natural recovery were sufficiently high. Even a reader not specially interested in this question will easily recognize that this type of problem is extremely common, and the purpose of the present paper is to use the work on Bell's palsy simply as an example of ideas and methods applicable to many problems. In that work comparison was made between twenty-five cures and eighteen failures (Table I), and the

TABLE I.—Data on Bell's Palsy (Tumarkin¹)

Cases	No Pain, No Loss of Taste	Pain, but No Loss of Taste	No Pain, but Loss of Taste	Pain and Loss of Taste
25 cures ...	18	4	2	1
18 failures	2	6	4	6

conclusion was that "if the patient has both pain and loss of taste the chances are 2 to 1 that he will not recover; but if he has neither of these symptoms the chances are 25 to 1 that he will recover."

Neglect of Chance and of Sampling Errors

This work is a useful illustration of a general statement made two years ago in the editorial section of the *Canadian Medical Association Journal*²—namely, that in much medical literature there is inadequate recognition and treatment of questions of chance, of the allowance to be made for small samples, and of natural variation from sample to sample of the same material, whether that material is composed of blood specimens or cases of paralysis. This statement applies equally to all kinds of unpublished clinical and non-clinical discussions. It is, for example, not uncommon to hear an admission that a certain set of cases is too small to justify conclusions, but it is very uncommon to find any attempt to show what conclusions can be reasonably accepted from the given sample; fairly often the speaker will, in spite of his admission, proceed to generalize and argue from his sample.

To avoid the hasty conclusion that these comments are those of an outsider, a statistical expert unacquainted with clinical problems, it is perhaps desirable to note the stages by which the present writer arrived at this point of view. A medical training in which no attention

was paid to problems of chance and sampling errors was followed by research in embryology and histology in which these problems at once arose. The adequate teaching of anatomy entailed wide and continued acquaintance with clinical matters, and it soon became obvious that the same kind of problem was present everywhere.

Certain other things that became obvious may be summarized thus: (1) the term "statistics" is unfortunate because it suggests either masses of data, sometimes inaccurate, or highly artificial mathematical tests; (2) the numerous books on the subject, including those on medical statistics, give too much and too complicated detail for clinical workers, and commonly fail to show that statistical ideas are of any use to a practitioner; (3) the most important part, even of elaborate statistical technique, is the critical selection of material; (4) for ordinary clinical work it is the ideas underlying the words "chance" and "sampling variation" that are of most importance, while the necessary technical tests are few and simple.

Everyone recognizes that diagnosis and prognosis are based to a very large extent on the weighing of probabilities, even if the physician or surgeon is not thinking in terms of exact numerical odds or chances. For many purposes it is unnecessary to go farther than this, but there are numerous other cases, such as the investigation of Bell's palsy, here discussed, where misleading conclusions are drawn unless the observer and reader of the article understand more clearly how to handle the tool that they are using—namely, the calculation of odds. It is not suggested that the clinical observer should apply elaborate mathematical analysis, but that he should examine more fully the ideas underlying his judgements—ideas that are fundamental in dealing with any living material.

Errors in Estimation of Chances

With regard to the conclusions drawn from Table I the first criticism concerns the numerical value of the chances. Out of twenty cases with no pain or loss of taste eighteen were cured and two were not cured. Therefore the chances of cure in such cases, so far as they can be estimated from this sample, are 18 out of 20—that is, the odds are 9 to 1 that such a patient will recover. Out of the seven cases with pain and loss of taste one was cured. Therefore the odds, so far as this sample shows, are 6 to 1 against cure.

The odds of 2 to 1, quoted above, seem to have been derived from a consideration of the eighteen failures, six of whom showed pain and loss of taste, and the only conclusion from this fact could be that, among the cases of failure, the odds were 12 to 6—that is, 2 to 1—against a patient who failed to be cured having shown both pain and loss of taste—a deduction that was not required. A similarly erroneous method seems to have been employed in assessing the odds of 25 to 1 in favour of cure when neither pain nor loss of taste is present.

Variation between Samples

It is true that the results of this investigation on facial palsy were put forward tentatively, but before even a tentative argument was based on them a second question should naturally have been asked—namely: how far is one justified in generalizing from these samples—that is, in applying the (corrected) odds, 9 to 1 and 6 to 1, to other patients?—one of the specified objects of the investigation. This question can be expressed otherwise by asking: what evidence is there from the sample of twenty patients (with paralysis but no pain or loss of taste) that, if all the thousands of patients in that class could be examined, the odds in favour of cure would not be 3 to 1 or 2 to 1, instead of 9 to 1 as suggested by the sample? The same kind of question can be asked regarding the sample of seven patients of whom only one was cured. The answer to such questions involves ideas of sampling that seem almost too elementary to mention, but which are often not properly considered before calculation is started.