DEFINITION

Hallux valgus is a forefoot deformity in which the great toe, at the metatarsophalangeal joint takes a valgus position toward the fifth toe (Fig. 37-1A).

There is no clear agreement as to how many degrees the great toe must deviate from the normal position in order to be called hallux valgus. However, treatment of the condition must be considered even with only slight deviation if the patient is suffering severe pain or if the patient's daily life and activities are affected.

As the degree of valgus position increases, the metatarsophalangeal joint of the great toe becomes dislocated, the first metatarsal bone shifts to the medial side, and the great toe becomes deformed in the shape of the Japanese "kana" character く (く), hooking toward the lateral side (Fig. 37-1B). In many cases, this process results in a bunion, with symptoms such as redness, swelling, and pain.

Hallux valgus deformity of the foot occurs both with and without pain; today many people consult their doctors simply for cosmetic reasons.

FREQUENCY OF HALLUX VALGUS CASES IN JAPAN

In comparison with Western countries, the frequency of hallux valgus cases in Japan is quite low. The reason is that the traditional Japanese geta or zori footwear is unconfining, being much like modern sandals. Even today, the custom in Japan is to remove the shoes inside the home. However, with the rapid westernization of the nation's life style following World War II, many women joined the commercial work force, and the traditional Japanese geta and zori have been almost completely abandoned and replaced by fashionable Western shoes. This has caused a rapid increase of hallux valgus cases in Japan in recent years.

Table 37-1 shows the number of hallux valgus patients and operations performed at Jonan Hospital, Tokyo. During the 6-year period from January 1, 1985 to December 31, 1990, the total number of such patients visiting our hospital was 1,077, of which 70 were men and 1,007 women. Of that number, 166 patients were treated surgically with procedures being performed on 309 feet. In 1985, only 12 feet were operated on, while in 1989 the number had reached 118. Over the 6-year period, patients suffering from hallux valgus visiting Jonan Hospital increased tenfold, just as the number of surgical cases also increased (Table 37-1).

SURGICAL PROCEDURES

All the operations I performed were on patients complaining mainly of pain, but whose daily lives were also adversely affected by difficulty in walking.

The surgical procedures can be roughly divided into two types: treatment primarily of the soft tissues, and treatment of the bones.
In Japan, bone treatment is generally practiced. There are four methods of correcting hallux valgus through bone procedures:

1. Treatment of the distal phalanx of the great toe, the middle phalanx and the proximal phalanx
2. Treatment of the metatarsal bones
3. Treatment at the same time of both the tendon, soft tissues and bones
4. Implantation of artificial joints

**Treatment Primarily of Soft Tissues**

**McBride Procedure**

The salient feature of the McBride procedure is the relocation of the adductor hallucis muscle (Fig. 37-2). First, the bunion is removed and the joint capsule is sutured, thereby shortening the capsule. Then the adductor hallucis muscle, which is attached to the bottom part of the proximal phalanx of the hallux, is resected and reattached, together with the flexor hallucis brevis muscle, to the lateral side of the metatarsal head by means of implantation in a drilled hole. At the same time, the sesamoid bone on the lateral side is removed. For patients with only slight to moderate hallux valgus and for those with relatively flexible metatarsal joints, considerable benefit from this approach can be obtained.

**Relocation of the Abductor Hallucis and Chiseling of the Medial Side of the First Metatarsal Head**

It is often the case with hallux valgus patients that the abductor hallucis muscle is located more toward the...
Table 37-1. Hallux Valgus Patients Surgeries Performed at Jonan Hospital, Tokyo, 1985–1990

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<td>286</td>
<td>9</td>
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No. of surgeries performed one side

|                  | 0      | 0      | 0      | 0      | 0      | 2      | 0      | 5      | 0      | 8      | 3      | 5      | 3     | 20    |

No. of surgeries performed both sides

|                  | 1      | 5      | 2      | 9      | 5      | 10     | 3      | 29     | 2      | 53     | 2      | 22     | 15    | 128   |

Total no. of surgeries performed

|                  | 1      | 5      | 2      | 9      | 5      | 12     | 3      | 34     | 2      | 61     | 5      | 27     | 18    | 148   |

Total no. of feet on which surgeries performed

|                  | 2      | 10     | 4      | 18     | 10     | 22     | 6      | 63     | 4      | 114    | 7      | 49     | 33    | 276   |

Abbreviations: M, male; F, female.

Fig. 37-2. The McBride procedure.
plantar aspect of the metatarsal head than normal. In this procedure, the abductor hallucis muscle tendon is detached and then transposed into the proximal phalanx (Fig. 37-3). This method is effective for relatively moderate valgus cases with flexible and mobile metatarsophalangeal joints. Transfer of the abductor muscle tendon shows better results when it is used in conjunction with osteotomy of the lower section of the metatarsal head, as described below.

**Treatment of the Bones**

**Keller Procedure**

In the Keller procedure (Fig. 37-4) the first metatarsal joint capsule is opened and one-third to one-half of the proximal phalanx of the hallux is removed, including the joint surface. If the medial side of the metatarsal head is protruding, a part of it is removed. Suturing is done in such a way that the great toe is fixed in its normal position. This method has proven highly effective in severe cases of hallux valgus. However, patients have subsequently had difficulty in weight transfer with walking. Another observed shortcoming is that stability of the joint at the point of resection is reduced.

**Hohmann Osteotomy**

The Hohmann osteotomy (Fig. 37-5) is performed in the first metatarsal head and parallel to the longitudinal axis of the metatarsal bone. The metatarsal head is

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*Fig. 37-3. Relocation of the abductor hallucis muscle, with chiseling of the medial side of the first metatarsal head.*

*Fig. 37-4. The Keller procedure.*
shifted slightly to the lateral side and secured in that position. At present, this procedure is widely practiced internationally and has the advantage of correcting abnormal rotation (rotatory position) of the great toe. Kato et al. have reported good results using this procedure together with relocation of the abductor hallucis muscle.

**Gibson Oblique Osteotomy**

As with Hohmann, the Gibson osteotomy is performed in the first metatarsal head. The difference is that the osteotomy is done obliquely, more distally on the medial side and proximal to the lateral side (Fig. 37-6). In this procedure the metatarsal head is slightly shifted to the

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**Fig. 37-5.** The Hohmann osteotomy.

**Fig. 37-6.** The Gibson oblique osteotomy.
lateral side precisely in line with the oblique cut in the bone and secured accordingly. In the original version of this procedure, a portion of the medial side of the metatarsal bone is removed and the remaining lateral spike or post is then inserted into the head of the metatarsal bone (see Fig. 37-6).

**Chevron Osteotomy**

In the Chevron osteotomy (Fig. 37-7), the metatarsal joint capsule is opened from the medial side, the protruding medial portion of the metatarsal bone is excised, and the osteotomy is performed with an inverted V-cut on the medial side of the metatarsal bone. With lateral pressure, the head of the metatarsal bone is shifted to the laterally and secured in the new position.

The disadvantages of this procedure are the difficulty in determining the angle and size of the V-cut and the complexity of the manual techniques required. Unless the operation is performed with great attention and care, it is not possible to achieve adequate reduction and correct hallux angle. If performed satisfactorily, the metatarsophalangeal joint is retained and a thoroughly acceptable degree of correction is achieved with respect to the second metatarsal bone. This procedure is excellent from the cosmetic point of view.

**Mitchell Osteotomy**

In the Mitchell osteotomy (Fig. 37-8), which is widely used internationally, the metatarsophalangeal joint capsule is opened up with a Y-shaped incision. The protruding medial part of the metatarsal head is removed, and holes are drilled at two different points. A wedge-type osteotomy is performed, after which the metatarsal head is shifted laterally. The previously removed pieces of bone are then implanted in the new position and are firmly secured with silk thread through the drilled holes.

**Z-Shaped Osteotomy (Ishizuka Osteotomy)**

The Z-shaped osteotomy (Figs. 37-9 and 37-10) is an osteotomy of the metatarsal bone and represents a variation of the combination procedure of Hawkins, Mitchell, and Hendrick. The head and shaft of the metatarsal bone are exposed, after which the deformed and protruding exostosis of the metatarsal head is removed with a chisel and the bone is filed smooth. The Z-shaped osteotomy is carried out in the head of the metatarsal with a small bone saw. The length of the cut is usually slightly less than one centimeter.

The head of the metatarsal bone is then shifted laterally to the proper position (Fig. 37-10). In other words, the proximal edge of the metatarsal bone is positioned in alignment with the medial side of the metatarsal head. It is then secured in that position with Kirschner wire (K-wire) (Fig. 37-10).

Examination of the abductor hallucis muscle is essential. If it has slipped down to the plantar side, it must be detached and transferred to a more dorsal
position and sutured to the periosteum of the proximal phalanx of the great toe. This procedure must be carried out simultaneously with the osteotomy.

With the bone cut in a Z shape, the contact surface area of the graft is greater than with other methods and the bone healing occurs more readily. Another advantage is that it results in a shortening of the great toe and can therefore be used to adjust metatarsal and great toe length for patients with Egyptian toe (in which the great toe is
longer than the second toe). Conversely, for patients with Greek toe (in which the second toe is longer than the great toe), it has the cosmetic disadvantage of further shortening the great toe. It is therefore necessary to properly counsel the patient on this point before performing the operation.

Recovery from this surgery is very satisfactory, and the degree of valgus angle correction is also quite acceptable.

**Swanson Artificial Joint**

In the application of artificial joints for hallux valgus surgery, two Swanson joints are available: the Swanson hemi single stem joint and the double stem joint (Fig. 37-11). In addition, there are the artificial joints developed by Wenger and Whalley. At the present time, osteotomy of the metatarsal head has become a generally satisfactory procedure for correcting valgus. Those cases in which use of an artificial joint is an absolute necessity are rare.

**CASE STUDIES**

To think of hallux valgus as a disorder limited to the great toe is to understand it in only a very narrow sense. Other toes can also acquire a valgus position, as typified by the following cases.

**Phalangeal Valgus**

The patient was a 51-year-old housewife in good health with no history of disease that might cause de-
formity of the feet, such as rheumatism or diabetes. However, she had been forcing herself to wear shoes about two sizes smaller than her actual size in order to make her feet appear more dainty. Furthermore, for the previous 5 to 7 years she wore fashionable, high-heeled shoes with pointed toes. (Fig. 37-12)

In both feet, all toes manifest a valgus position. In my opinion, such cases should be called phalangeal valgus instead of hallux valgus. Radiographs show deformity, especially of the metatarsal bone head, as well as atrophy of the bones themselves.

All ten toes were treated surgically. For both great toes, a Keller procedure was performed; for the second to fifth toes of both feet, Lips-comb metatarsal bone head arthroectomy (metatarsal head resection) was used. In this particular case, I operated in such a way as to avoid resection of the proximal phalanx, leaving joint cartilage and excising only the metatarsal heads. Postoperative progress was satisfactory. A large plantar tylosis with pain that existed before the operation also showed improvement. The tylosis itself resolved almost completely after 6 months.

Serious Deformity of the Forefoot Caused by Rheumatism

The following very unusual case demonstrating extreme deformity involved a 52-year-old woman (Fig. 37-13). The patient was suffering from hallux valgus, hammer toe, and a large plantar tylosis accompanied by pain of both feet, caused by rheumatism. In this case as well, the great toe was treated by a Keller procedure, while
in the other toes, the metatarsal head was removed by a Lipscomb procedure (metatarsal head resection). The operation was concluded with insertion of K-wire in all ten toes. Four weeks after the operation, the K-wire was removed and physical therapy was begun. Therapy involved both self-movement and assisted movement. The results were quite satisfactory.

After the operation, the patient was equipped with a modified Thomas heel, known in Japan as the Ishizuka heel. In addition, by placing a bar beneath the metatarsal head, some protection was provided at the site of the metatarsal head excision. At the same time, attention was given to maintaining flexibility of the metatarsal joints. Furthermore, cushioning material was put inside the patient's shoes.

Once so equipped, the patient was allowed to stand and walk. The results were quite satisfactory, with the patient experiencing greater relief from the operation than had been anticipated.

**EVALUATION OF RESULTS**

The following are considered to be the essential criteria for evaluating the results of the surgery:

1. The degree of patient satisfaction
2. Whether abnormal sensory response or feeling are observed in areas near the point of surgery
3. The degree of functionality of the great toe (muscle strength for up and down movement, as well as the ability to stand on one's tiptoes)
4. The results of treatment of additional complications (i.e., whether or not tylosis, callosus, plantar myositis, or metatarsal head pain have been eliminated)
5. How well shoes can be made to fit after the operation

Figure 37-14 shows the results of the operations performed on the patients described above from 6 months to 5 years after surgery. Results are classified as excellent, good, fair, and poor. "Excellent" means that the patient is very pleased with the results and that there have been almost no complaints. "Good" means that the patient is satisfied with the results of the operation; however, muscle strength is slightly reduced from its preoperative state. Also, slight sensory abnormality is experienced in walking and tylosis with pain still persists in the plantar. "Fair" means that there may be complaints of medium-level pain while walking in shoes and when attempting to stand on tiptoe, and inadequate strength in the great toe. "Poor" means that the patient obtained no satisfaction.

![Figure 37-14](image)

**Fig. 37-14.** Follow-up study of each of seven surgical procedures for hallux valgus. The observation period was from 6 months to 2 years postsurgery.
CONCLUSIONS

There is quite a variety of surgical procedures currently under development in addition to those described above. Regardless of the procedure of choice, it is not possible with a single approach to address all possible problems. It is therefore recommended that the surgeon select from among the already developed procedures the one that is most suitable to that particular patient. At the same time, the surgeon should consider applying two or three different procedures concurrently.

Based on my experience, I consider the most critical element to be the postoperative fitting of shoes. Even if the operation has been successful, its evaluation should not be based only on appearance. Patients may complain that they cannot find shoes that fit their feet after the operation. The physician who performs the surgery must always provide for shoe fit that satisfy the patient and enable the patient to function well in daily life. Assessment of surgical success should also include the degree to which postoperative shoes can be fitted comfortably to the feet.

Japan's post-World War II economic development has been remarkably successful and the country is becoming an affluent society. Compared with the past, peoples' material wishes are more easily satisfied and they tend to have a great deal of freedom. In recent years, there has been a tendency for them to damage their bodies through incorrect health care as they abuse such freedom.

At the same time, physicians are inclined to concentrate on treatment of the condition, and it is doubtful that they are giving proper guidance and advice to patients with problems that could easily have been prevented. Physicians must not only concern themselves with treating illnesses after they have appeared. They must also recognize their responsibility to provide their patients with guidance on how to maintain healthy feet and to improve their patients' innate human capacity for standing and walking.

SUGGESTED READINGS

Hattrup SJ, Johnson KA: Chevron osteotomy: analysis of factors in patients' dissatisfaction. Foot Ankle 5527, 1985
Hohmann G: Symptomatische oder physiologische Behandlung des Hallux valgus. Munch Med Wochen 33:1042, 1921
Mann R: Surgery of the foot. 5th Ed. CV Mosby, St. Louis, 1986
Regnauld B: The Foot. Springer-Verlag, New York, 1986
Podiatry as a health care specialty does not exist in China today, where most foot problems are cared for by orthopaedic surgeons. In this country with its vast population dependent upon their feet for walking or for pedaling bicycles, foot problems are naturally more prevalent than in the West. Following a modernization drive by the state, women in China began wearing high-heeled and pointed shoes; as a result, hallux abducto valgus has become one of the most common foot disorders in China today. Since these cases are treated by orthopaedists, hallux abducto valgus is to a certain extent underestimated or even neglected; the Chinese literature dealing with its treatment is very limited. To meet the current demand of foot care and to take advantage of visits of the American delegations of podiatrists in recent years, Sino-American conferences on foot disorders were held in 1987 and 1990 respectively in Beijing. From the Chinese participants, a total of ten papers on the treatment of hallux abducto valgus and two on clinical research from ten major hospitals were presented. Measurements were made of the hallux abductus and intermetatarsal (IM) angles and the congruity of metatarsophalangeal joint (MPJ). The deformities were grouped into mild (HA, 20° to 30°, IM, 8° to 10°, congruous MPJ); moderate (HA, 30° to 40°, IM, 10° to 15°, deviated MPJ); and severe (HA, 40°+; IM, 15°+, subluxated MPJ). Accordingly, among the 333 feet treated by these five authors, there were 257 feet of the mild, 49 of the moderate, and 27 of the severe types. Osteoarthritic changes of the first MPJ were seen in 31 cases, all above the age of 60. In 615 cases (90.9 percent) patients were treated surgically for pain relief; in 25 cases (3.7 percent) in the age of 20 to 30 years, the patients had the deformity corrected for cosmetic purposes.

**CLINICAL DATA**

Of the 676 cases (979 feet) 122 were men and 554 women, giving a male-to-female ratio of approximately 1:4.5. Sixty-nine cases (10 percent) had a family history of hallux abducto valgus and 120 cases (18 percent) were associated with hammer toe deformity. The ages ranged from 16 to 85 with an average of 42. Of all cases, 525 (77.7 percent) were between the age range of 20 to 35; among the 412 women in this age group (77.7 percent), 339 cases (82.3 percent) had a history of wearing high-heeled and pointed shoes. Classification of hallux abducto valgus was done by five authors. Measurements were made of the hallux abductus and intermetatarsal (IM) angles and the congruity of metatarsophalangeal joint (MPJ). The deformities were grouped into mild (HA, 20° to 30°, IM, 8° to 10°, congruous MPJ); moderate (HA, 30° to 40°, IM, 10° to 15°, deviated MPJ); and severe (HA, 40°+; IM, 15°+, subluxated MPJ). Accordingly, among the 333 feet treated by these five authors, there were 257 feet of the mild, 49 of the moderate, and 27 of the severe types. Osteoarthritic changes of the first MPJ were seen in 31 cases, all above the age of 60. In 615 cases (90.9 percent) patients were treated surgically for pain relief; in 25 cases (3.7 percent) in the age of 20 to 30 years, the patients had the deformity corrected for cosmetic purposes.

**ETIOLOGY AND PATHOGENESIS OF HALLUX ABDUCTO VALGUS**

Over the years, efforts have been made to establish the etiologic factors in the development of hallux abducto valgus. Currently those factors can be grouped into two categories: predisposing structural factors and mechanical factors.
Predisposing Structural Factors

Predisposing structural factors include splay foot, metatarsus primus adductus, general ligamentous laxity, and muscular imbalance of the forefoot. These are all hereditary factors. Three authors,\(^1,2,5\) have clinical data showing family histories of hallux abducto valgus in 20 to 30 percent of their cases. However, none of these authors made in-depth observations as to the genetic abnormalities. Zhao\(^11\) studied radiographs of 140 adults in two age groups with equal numbers of men and women. Observations were made on the shape of the cuneometatarsal joint, the base and distal shaft of the first metatarsal, the base and shaft of the hallucal phalanx, the MPJ, the sesamoid positions, the distal and the proximal articular set angles (PASAs), and the shape of the head of the first metatarsal. Bony structural abnormality of the first ray was always present in cases of hallux abducto valgus deformity.

Mechanical Factors

Mechanical factors mainly involve the wearing of shoes that force the hallux into a deviated position. The first metatarsal head acts as one of the three points of balance for the entire foot. It has a greater diameter and is able to bear twice the weight of any of the other metatarsals. High-heeled shoes adversely affect the first ray. Dorsiflexion and inversion of the first MPJ, deviation of the sesamoids, and rotation of the first MPJ are the compensatory processes of the first metatarsal to the wearing of the high-heeled shoes. This is the primary etiology of many cases of hallux abducto valgus. Five authors\(^1,2,5,6,8\) recorded a history of inappropriate footwear among more than 60 percent of women aged 25 to 35. According to He et al.,\(^8\) one-third of the patients aged 25 to 35 years (75 cases, 105 feet) had a history of wearing high-heeled and pointed shoes. In the outpatient department of the foot section of the Institute of Orthopaedics, 60 percent of the cases were sufferers of hallux abducto valgus. Among them more than 70 percent had a history of wearing the high-heeled shoes. Chen and Tian\(^12\) studied the modified dynamics of the feet with hallux abducto valgus. The ratio of the amplitude of the electromyographic action potential of the abductor hallucis and the adductor hallucis were reversed from 2:1 in normal persons wearing flat shoes to 1:3 in patients with hallux abducto valgus wearing the same kind of shoes. When both groups wore high-heeled shoes, the ratios were 2:1 and 1:6. The abductor hallucis undergoes a reduction of function in feet with hallux abducto valgus and the action potential of the adductors is intensified, making the deformity worse. The results indicate that muscular imbalance of the forefoot chiefly involving both the abductor hallucis and adductor hallucis may present a predisposing factor, and the wearing of high-heeled shoes makes the condition worse (Table 37-2).\(^6\)

**METHODS AND RESULTS OF TREATMENT OF HALLUX VALGUS**

The surgical procedures used in the ten hospitals consisted of simple bunionectomy (Silver procedure; 39 feet), Keller procedure (344 feet) McBride procedure (239 feet) and a variety of osteotomies of the first metatarsal (in 295 feet). The Joplin and Lapidus procedures were used by only one author, in 5 and 2 cases respectively.\(^1\) The results of the treatment were evaluated on the basis of the relief of bunion pain, the
appearance of the feet postoperatively, the free choice of the types of shoes worn by the patient, the improvement of walking ability, and the occurrence of the postoperative complications. Overall excellent to good results were obtained in 609 cases (90 percent) by the 10 authors during a follow-up period extended from 1 to 14 years (Table 37-3).

PROCEDURES

Well over 100 different surgical procedures have been described for the treatment of hallux abducto valgus. This procedural diversity leads one to believe that no procedure has been entirely satisfactory by itself, and the surgeon must study each individual case and apply a method or a combination of procedures to suit that particular case. In this review of 676 cases (979 feet) treated with surgery by ten different Chinese orthopaedic surgeons, the most commonly used procedures are the Keller procedure, osteotomies of the first metatarsal with different modifications, and the McBride procedure. The Keller procedure was used on 344 feet; osteotomy of the first metatarsal was used on 295 feet; and the McBride operation was used on 239 feet. A simple bunionectomy is indicated only in elderly patients; often it was used in combination with the other procedures.

The Keller procedure involves the amputation of the proximal half of the first phalanx and is indicated in severe cases of hallux abducto valgus with arthritic changes in the MPJ. The base of the proximal hallucal phalanx is resected. It basically decompresses the MPJ, corrects the deformity, and overcomes the bowstring effect of the tendons after excision of the base of the proximal phalanx. The toe remains comfortable for the rest of the patient's life. If however the big toe is shortened too much, the patient is left with a floppy toe and persistent weakness. Simultaneously, the second toe may be left too long and hammer toe may develop, which may need correction. Dorsal displacement or rotational deformity of the great toe may also occur and requires intrinsic tenotomy. The advantage of the Keller procedure is its simplicity and the ease with which it is carried out. Both Lu of Beijing and Zhu of Nanjing obtained satisfactory results in 95 percent and 86 percent of their cases, respectively, by carrying out the procedure in the elderly with osteoarthritic changes in the MPJ. Zhao of Beijing reported 60 cases treated with Keller's operation with an average follow-up period of 4.2 years. This procedure gave excellent to good results in 80.0 percent. Surgical correction of hallux valgus involving the distal aspect of the first metatarsal shaft had been devised by Wilson, Austin, Reverdin, Mitchell, and others. Osteotomy of the first metatarsal is done with the purpose of realign-
ing the great toe and reducing the medial bony bump without disturbing the MPJ. It is useful for adolescent cases. In a review of the surgery for hallux valgus, Helal found that metatarsal shaft osteotomy is the most successful operation, since it narrows the forefoot, relaxes the soft tissue, and maintains excellent mobility of the first MPJ. The osteotomies can be performed at the head and neck, the shaft, and the base of the first metatarsal. Jiang and Gu of Shanghai performed 86 osteotomies of the first metatarsal similar to Wilson's technique and obtained satisfactory results in 90 percent of the cases during a follow-up period of 6 years. Similarly, Zhao of Shanghai performed 34 ball and socket osteotomies at the neck of the first metatarsal, and Shi et al. of Beijing performed 85 cases of impacted osteotomies of the metatarsal shaft. They obtained satisfactory results in 90 percent and 85 percent, respectively. In 89 cases (148 feet) Fang and Ma of Beijing, obtained the best results in those cases treated with the Simmond and Michell osteotomies. These results indicated that in the treatment of hallux valgus, especially in the adolescent cases, attention must be paid to the correction of pathologic changes of the first metatarsal.

McBride's (1928) and Joplin's (1950) procedures are the so-called conservative procedures for the correction of hallux abducto valgus. In McBride's operation, the adductor hallucis tendon is transferred onto the first metatarsal after simple bunionectomy. In order to make the anchoring of the adductor tendon secure over the metatarsal head, Zhao of Shanghai modified McBride's procedure by making a drill hole transversely through the metatarsal head and a through-and-through suture was used for the fixation. Zhu of Nanjing and Lu and He et al. of Beijing had successful results using McBride's procedure in young individuals without arthritic changes in the MPJ.

Joplin's operation is a plantar sling technique valuable for hallux valgus associated with splay foot. The long extensor tendon of the fifth toe is divided and passed under the metatarsal heads. Together with the tendon of the adductor hallucis, it is then threaded through a drill hole in the first metatarsal head and sutured to the capsule on the tibial side. This is used only occasionally in China. Lu of Beijing had reported 5 cases with good results.

The Lapidus procedure (1934) is an arthrodesing operation. It was originally designed for the correction of varus deformity of the first metatarsal. The Lapidus technique for correction of hallux abducto valgus involves a closing abductory wedge resection and arthrodesis at the first cuneometatarsal joint. This procedure is most useful when the first metatarsal is in extreme varus in adult cases of hallux abducto valgus. Lu of Beijing reported two successful cases.

The minimal incision surgery for the treatment of hallux abducto valgus has been described only rarely in the orthopaedic literature, and controversies still exist as to its use. Since the introduction of minimal incision surgery for the treatment of foot disorders by podiatrists to China in 1983, the Chinese orthopaedic surgeons began using this technique in decompression osteotomies of the os calcis and for treatment of heel pains. Some also used the method for the treatment of hallux valgus. The minimal incision technique used in China is not completely the same as that practiced by the American surgeons. Li and Hu reported 14 cases (24 feet) of hallux valgus in patients ranging in age from 20 to 35 years. The patients were treated with an incision of 1 cm for bunionectomy and osteotomy of the distal end of the first metatarsal. Ten cases were followed for more than 1 year; excellent to good results were seen in all. Tian and Chen had reported 30 cases treated with the minimal incision technique for the treatment of hallux abducto valgus. They concluded that the minimal incision method must be done with utmost care and the patients must be observed carefully after surgery. For the severe cases of hallux abducto valgus with the HA angle of 40°, IM angle 15°, and a subluxated MPJ, the conventional method using the regular incisions is still preferable.

REFERENCES


Cerclage Techniques for the Treatment of Hallux Valgus

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Although more than 100 different operations have been devised to correct hallux valgus, the majority are varieties of osteotomy, arthrodesis, or arthroplasty. Soft tissue techniques are less frequently performed and with the exception of McBride's procedure are also probably less well known.

In this chapter part we describe another type of soft tissue procedure designed to approximate the first and second metatarsals. Thus the metatarsus varus is reduced and the valgus deformity of the great toe corrected. However, before describing the salient features of the operation and postoperative management we give a brief historical review of other similar types of procedure that have been described.

HISTORICAL REVIEW

Cerclage procedures appear to have originated in Europe and have one of two main conformations. The hallux valgus deformity is either corrected by approximating the first to the second metatarsal, or by fashioning a sling between the first and fifth metatarsals. Lexer (1919)\(^1\) (Fig. 37-15A) employed the first technique, while Lenggenhager (1935)\(^2\) described a similar procedure except that fixation was achieved by passing the suture through rather than around the first metatarsal (Fig. 37-15B). Goeball (1927)\(^3\) used fascia to secure the first to the fifth metatarsals (Fig. 37-16A), and Joplin (1950)\(^4\) (the first non-European, who worked in Boston, MA), achieved his correction by rerouting the detached proximal end of the fifth toe extensor tendon. This was taken across the sole of the foot and through a drill hole made in the first metatarsal neck. In addition, adductor hallucis was detached from its insertion and also passed through the drill hole. Both tendons were sutured to the capsule over the medial aspect of the first metatarsophalangeal joint (MPJ) (Fig. 37-16B). More recently, Botteri and Castellana (1961)\(^5\) and Pagella and Pierleoni (1971)\(^6\) described a distal osteodesis of the first two metatarsal bones. In this operation, the adductor hallucis was detached from its insertion and the lateral sesamoid excised. The opposing surfaces of the first and second metatarsal necks were scarified and two double threads of chromic cat gut passed through holes in the neck of the first metatarsal and around the second metatarsal. The threads were firmly tied, producing approximation of the metatarsal heads with correction of the deformity (Fig. 37-17). Although the authors obtained excellent results by this technique, osteodesis between the first and second metatarsals might theoretically be expected to interfere with normal forefoot function.

The technique we describe approximates the first and second metatarsals and incorporates some of the features from these earlier operations.

CRITERIA FOR SURGERY

Since 1980, this technique has been our preferred operation for all teenage patients presenting with bunion pain and deformity of the hallux. In addition, it has also been performed on older patients providing that on examination there is no restriction of MPJ movement and no evidence of degenerative changes radio-
logically. The severity of intermetatarsal and hallux valgus angulation has not been regarded as a contraindication to surgery, although it should be noted that in our experience this is usually not excessive in teenagers, and in adults with marked angulation there is often associated arthritic changes at the MPJ, which does preclude the procedure.

Fig. 37-15. (A) Lexer's single suture approximations of the first and second metatarsals. (B) Lengenhager passed his suture through the shaft of the first metatarsal.

Fig. 37-16. (A) Goeball used fascia to approximate the first and fifth metatarsals. (B) The detached proximal end of the fifth extensor tendon is passed across the sole of the foot and with adductor hallucis through the first metatarsal neck (Joplin [1950]).
SURGICAL TECHNIQUE

Under tourniquet control a 4 cm. to 5 cm. straight incision is made on the dorsal surface of the foot between the first and second metatarsals (Fig. 37-18). The skin edges are retracted, superficial veins ligated, and the small cutaneous nerve branches protected. This reduces the risk of subsequent sensory disturbance or painful neuromata formation. The space between the first and second metatarsals is then opened and the first dorsal interosseous muscle freed along its attachment to the first metatarsal and displaced laterally. A self-retaining retractor should then be inserted and opened out between the adjacent metatarsal bones. This improves visualization of the adductor hallucis, which can then be released from its insertion (Fig. 37-19). Unlike the McBride procedure, no attempt is made to reattach the muscle more proximally. Care must be taken during the release of adductor hallucis since the medial plantar nerve will be seen in the wound and must not be divided. It is now possible to approximate the first and second metatarsals and when this is done the valgus deviation of the great toe is automatically corrected. To hold the metatarsals in

Fig. 37-17. Distal osteotomy of the first two metatarsal bones.

Fig. 37-18. Skin incision for the cerclage technique that we have used.
the new position a double thickness # 2 nylon suture is passed carefully around the shaft of both bones and firmly tied (Fig. 37-20). The suture must pass between both the extensor tendon and bone and the flexor tendons and bone. If any tendons are trapped by the suture the patient will be unable to flex or extend the affected toe. Although we have found the steela suture passer to be the most useful instrument in aiding passage of the suture around the bones, an alternative that can also be used is an appropriately sized aneurysm needle.

Absorbable suture is used to repair the subcutaneous tissues and cover the approximation suture, while nylon is used to close the skin. A below-the-knee walking plaster is applied; it provides external splintage, holding the foot in the corrected position. The wound is inspected and sutures removed at 2 weeks, but the walking plaster must be maintained for a total of 6 weeks.

**SURGICAL RESULTS**

All the patients who have undergone this procedure have had their hallux valgus deformity improved. Review of our early cases showed the mean preoperative hallux valgus angle of 38° (range, 25° to 48°) to be reduced to 14° postoperatively (range, 2° to 30°), with a commensurate decrease in the intermetatarsal angle from a mean of 15° preoperatively (range, 13° to 18°) to 9° postoperatively (range, 7° to 12°). This gave a 93 percent excellent or good result as judged by Bonney and MacNab's classification. Symptomatic pain relief based on the same classification was also impressive with 86 percent of patients having either an excellent result (no pain) or good result (occasional pain). Figure 37-21 shows the pre- and postoperative radio-
graphs of a typical patient, while Figure 37-22 shows one of our best results.

**COMPLICATIONS**

The only complications we have experienced have been tenderness over the knot of the approximation suture and the occasional stitch abscess at the same site. Where this has occurred removal of the approximation suture has been performed. Subsequent follow-up has failed to show clinical or radiographic evidence of a loss of correction.

**CONCLUSIONS**

The merits of this operation, apart from patient satisfaction, are that the procedure is limited, requiring...
minimal soft tissue release and no bony correction or destruction. This is of particular importance in skeletally immature patients since it avoids the risk of bone growth disturbance. In addition, since the MPJ is not violated the patients are able to wear shoes of variable heel height. Further, if at any stage failure occurs, all other surgical options remain open.

REFERENCES

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3. Goebell R: Uber Arthroplastische Freie Fascien und Apo-
Hallux valgus is a predominantly transverse plane deformity occurring at the first metatarsophalangeal joint (MPJ). Important in the evaluation and treatment of this malalignment is that consideration be given to the forefoot as a whole in order to properly correct the hallux valgus and associated forefoot syndromes. Without precise reconstruction of these disorders the deformity of hallux valgus is doomed to recurrence.

Hallux valgus is a disorder that is both structural and functional in nature. The varus deformity of the first metatarsal is reflected by the increase in intermetatarsal (IM) angle which may be increased as high as 20°. Hallux valgus increases gradually from 10° and may advance to a rather large angle approaching 90° with dislocation of the MPJ. The deformity is accompanied with displacement of the sesamoids into the first metatarsal space.

Functionally, the deformity is precipitated by a dynamic imbalance of the musculotendinous structures of the first MPJ. This imbalance results in contracture of the long toe flexor and extensor. There is shortening of the adductor and short flexor of the great toe accompanied by apparent elongation of abductor tendon and medial capsule, causing essentially a contraction of the joint dorsally and laterally with elongation of the medial anatomic structures.

At the joint level the disorder is brought about by simultaneous flexion and abduction of the great toe, which may be accompanied with axial rotation. It may also be associated with contracture and malalignment of the lesser toes. Symptomatology, especially, with weight-bearing is characteristic of this disorder. Plantar callosities beneath the second metatarsal associated with the pathologic varus of the first metatarsal is also seen. A medial bursitis may be present with inflammation, and plantar callouses of the hallux may be present as a result of the axial rotation of the great toe.

Morphologically there is an loss of the aesthetic appearance of the foot because of the hallux valgus, digital deformities, contractions, and other malalignments of the forefoot.

Deformity of hallux valgus is characterized and classified in three degrees. The first degree is characterized by a metatarsus primus varus with an IM angle ranging from 5° to 20° and a hallux valgus (HV) angle of 10° to 20°, usually with isolated inflammatory symptoms (e.g., pain) limited to the first ray. Inflammation may also be associated with metatarsalgia due to friction.

The second degree of deformity is characterized by a varus of the first metatarsal from 20° to 30° associated with an HV angle of 20° to 40°. This is complicated by joint aches and painful malalignment of one or several of the lesser rays. It is often associated with clawing of the second toe and the appearance of dorsal digital corns. Contraction and prominence of the extensor tendons may be visualized and there is an increase of pressure in weight-bearing borne by the central three metatarsals.

Third-degree deformity is characterized by varus of the first metatarsal. It is reflected by an increase of the IM angle of more than 30° and an HV angle greater than 40° associated with a global deformity of the forefoot. This is associated with uniform or disorganized digital malalignments in either varus or valgus, with contraction of the tendons dorsally and laterally, and subluxation of the MPJs. There is a syndrome of hy-
perpressure on one or two of the metatarsals—either the second or the third, second and third, or else the third or fourth. There may also be association with forefoot syndromes such as the anterior round or flat triangular forefoot.

The deformity of hallux valgus can appear and be associated with any of the classic forefoot morphologies; however, the frequency of occurrence is highest with the Egyptian, then Greek, and lastly the squared forefoot configurations. As mentioned previously, treatment must not be directed only to the first ray as an isolated pathology, but a deformity of the whole forefoot must be taken into consideration. It is important to perform a complete examination of the foot to identify factors that would contribute to the foot deformity, such as inflammatory or arthritic conditions.

Surgical treatment must do the following: (1) address and correct the varus of the first metatarsal and the valgus of the great toe but respect physiologic diversion of the first metatarsal; (2) reconstitute the articular anatomy by implantation of an osteocartilaginous graft; (3) reestablish function; and (4) correct associated deformities of the other rays to avoid occurrence.

The specific operative criteria are chronic pain and discomfort, the inability to ambulate in conventional shoe gear, and recurrent inflammation regardless of the degree of the hallux valgus deformity. Surgical intervention is not necessary if there is no pain or functional disability. The operation must correct the deformity, reestablish the regularity of the weight-bearing of the forefoot, and recreate our aesthetic forefoot.

The operative technique is one of the metatarsophalangeal arthroplasty with implantation of osteocartilagenous graft to the proximal phalanx, represented graphically in Figure 37-23. The technique is the same in all cases of hallux valgus except those that are accompanied by arthritis within the joint, thereby necessitating an interpositional prosthesis for one year period. The operative technique is performed in the following manner.
Fig. 37-24. First degree hallus valgus. (A) Preoperative view. (B) Postoperative result.
TECHNIQUE

A medial skin incision is performed with deepening of the dissection through the subcutaneous tissues. A capsular incision is also produced medially. The capsular tissue is dissected around the base of the proximal phalanx. Care is taken to preserve the dorsal attachments of the metatarsal capsular plane in order to permit a good point for reattachment to reduce the sesamoid subluxation. Care must be taken to respect the posterior medial attachments of the metatarsal capsule in order to avoid sesamoid retraction. The base of proximal phalanx is resected at an appropriate level so that when inserting the osteocartilagenous graft the length of toe will be restored, giving the Greek forefoot configuration. The canal is then reamed carefully into the base of the proximal phalanx. The medial exostosis of the metatarsal head is resected without damaging the medial cortical bone or extending too far onto the medial cortical bone. Next, by means of an osteotome or elevator at the lateral and plantar surface of the metatarsal head, the sesamoids are freed to help reduce their external subluxation. This allows reduction of the varus of the first metatarsal and repositioning of the sesamoids and first metatarsal head.

The osteocartilagenous graft from the resected proximal phalanx is most frequently fashioned in a hat shape because this confers excellent stability (see Fig. 37-24). The hat-shaped graft is implanted into the pre-made canal of the phalanx. During the impaction of the graft great care must be taken to avoid damage to cartilagenous surface. One must avoid tapping the graft and manipulating to check the impaction of the graft.

The capsule of the joint is then repaired initially by three relaxed sutures. One plantar sesamoid-phalangeal suture passes backwards in the substance of the capsule between the two sesamoid and the remaining capsule-periosteal tissue of the phalanx. This point approximates the plantar capsular plane of the sesamoid apparatus to resist retraction.

A second metatarsophalangeal suture reduces the hallux valgus, and lastly a simple capsular suture is attached into the dorsal plane of the metatarsal head and into the medial capsule including the medial sesamoid. This suture replaces the sesamoid under the metatarsal head and also corrects the varus of the first metatarsal. While correcting the varus it is important to preserve the vertical and lateral amplitude of movement of the first metatarsal by allowing sufficient freedom between the first and second metatarsal heads. Additional sutures close the joint and the skin is closed.

The key points of the procedure of this operation are the size of the osteocartilagenous graft and graft stability when implanted into the phalanx.

RESULTS

The desired results are incorporation of the osteocartilagenous graft, physiologic mobility, and suppleness of the first MPJ, normal amplitude of dorsiflexion and plantar flexion of the great toe, absence of pain, and the aesthetic appearance of the forefoot.

COMPLICATIONS

Although they are rare, complications due occur. They include rigidity of the joint, which follows an osteophytic reaction around the graft. Pseudoarthrosis, lysis, fracture, necrosis, luxation, and dislocation of the graft may occur when the osteocartilagenous graft is poorly implanted into the phalanx or when the grafted bone was of poor quality.

Osteomyelitis is unusual but usually results in complete failure of the procedure. Recurrence of the deformity is unusual, but is felt to occur due to high-heel shoes or wearing of shoes with a triangular sole postsoperatively. Recurrence is associated with the correction of the first ray problem without total evaluation of the forefoot as a whole. This procedure provides a reconstruction to a functional foot, repair with uniformity of metatarsal weight-bearing, mobility, and suppleness with painless motion of the first MPJ.

Postoperatively management is accomplished with a dressing change 48 hours after the operation on the eighth and twelfth day postoperatively for the removal of sutures. Protection from loading for 30 days is followed by walking with special shoes. Active rehabilitation by the patient obviates the need for passive mobilization through physical therapy. Restitution of nor-
Fig. 37-25. Second degree hallux valgus. (A) Preoperative view. (B) Postoperative result after osteocartilagenous graft and forefoot reconstruction.
Figure 37-26. Third degree hallux valgus with flat triangular forefoot. (A) Preoperative view. (B) Postoperative result after hallux valgus correction and forefoot reconstruction.

Fig. 37-27. First degree hallux valgus of the left foot treated by metatarsophalangeal arthroplasty with hat-shaped graft. (A) Preoperative view. (B) Four days postoperative. (C) Eleven months postoperative.
Fig. 37-28. Second degree hallux valgus of the left foot treated by metatarsophalangeal arthroplasty with hat-shaped graft. (A) Preoperative view. (B) Four days postoperative. (C) One year postoperative.
Fig. 37-29. Third degree hallux valgus associated with a convex triangular forefoot, frontal protrusion, equinus of the central metatarsal and dorsal subluxation of the second toe. Treatment included metatarsophalangeal joint arthroplasty with hat-shaped graft, metatarsal head-shaft enclavement of central metatarsals, arthroplasty of the fifth digits, and extensor tendon lengthening. (A) Preoperative view. (B) Four days postoperative. (C) Eleven months postoperative.
mal walking is encouraged as soon as possible postoperatively for the resolution of the postoperative edema. Radiographs are usually taken to allow postoperative assessment at 8 days, 3 months, and 6 months postoperatively with personal follow-ups at the first, second, and fifth year postoperatively.

This procedure of metatarsophalangeal arthroplasty with osteocartilagenous grafts has proven to be successful in the management of the hallux valgus deformity. Clinical and radiographic examples are demonstrated in Figures 37-24 to 37-29.

SUGGESTED READING

Regnauld B: The Foot. Springer-Verlag, New York, 1986
PROCEDURES

In searching for optimal methods for the treatment of hallux valgus, we aimed for sound, joint-preserving procedures, and tried to improve techniques for resection arthroplasties.\(^1\)

The Hohmann procedure\(^2\) was abandoned because of postoperative complications involving plaster casts as well as the necessity of internal fixation.

With Regnauld’s replantation of the base of the phalanx\(^3\) we experienced technical difficulty, dislocation and fracture of the replant, and stiffening of the joint.

The Mitchell procedure\(^4\) was technically difficult. There was marked shortening of the first metatarsal and occasional tilting upward of the metatarsal head, creating transfer metatarsalgia.

The Kramer osteotomy,\(^5\) a Hohmann-type distal osteotomy that is stabilized by a Kirschner wire (K-wire) that is inserted transcutaneously into the medullary space, was associated with pin-track infections and was therefore abandoned. As joint-saving procedures there remained a modification of Silver’s operation, which we named after Petersen,\(^6\) who was the first to recommend a lateral release; the chevron osteotomy of Austin,\(^7\) which was introduced to us by Dr. Hetherington in 1983; and a minimal incisional technique of the Akin\(^8\) type that was taught to us by Dr O.T. New in 1983.

If proximal osteotomies of the metatarsal appeared to be necessary, an opening-wedge type procedure after Trethowan\(^9\) was used.

To the Keller procedure a fibrous cerclage of the capsule was added, in the manner of Lelievre.\(^9\) With larger intermetatarsal angles we combined the Keller procedure with a proximal opening wedge osteotomy according to Trethowan, which was popularized by Gore.\(^10\)

MATERIAL AND METHODS

While following patients whose halluces had been treated with different methods, we developed guidelines for establishing appropriate indications in respect of the size of the valgus and metatarsal angles by evaluating the best results that were possible with the largest angles in the respective group.

OPERATIVE PROCEDURES

Petersen Procedure

At the medial side of the joint a distally based capsular flap is developed, the width of which being directly proportional to the malalignment of the metatarsal head and the sesamoid apparatus (Fig. 37-30A). After removal of the exostosis, the lateral capsule is dissected and a transverse capsular incision is carried down to sever the insertion of the adductor hallucis tendon at the base of the phalanx (Fig. 37-30B). Medial capsulorraphy is performed by suturing the capsule from proximal to distal while the metatarsal head is held laterally (Fig. 37-30C). The remaining flap is sewn over the suture (Fig. 37-30D).

New’s Procedure

New’s procedure\(^11\) represents a minimal incision technique based on the principles of Akin.\(^8\) It consists of the removal of the pseudoexostosis with a burr and a
corrective osteotomy near the base of the first phalanx, using a side cutting burr.

**Austin Procedure**

Austin's operation\(^7\)\(^{12}\) is a V-shaped transpositional osteotomy of the metatarsal head. The exostosis is removed. After completion of the osteotomy and a lateral capsular release, the metatarsal head is shifted laterally and the capsule is reefed medially.

**Trethowan Procedure**

Trethowan's opening wedge osteotomy\(^13\) near the base of the first metatarsal with insertion of a wedge-shaped part of the removed base of the phalanx was...
used in combination with a lateral release and a medial reconstruction of the ligaments at the metatarsophalangeal joint (MPJ).

**Keller’s Procedure**

Keller’s procedure was always combined with a fibrous cerclage after Lelievre. This consists of a lateral capsuloligamentous release, mobilization of the sesamoid apparatus, and a medial reefing after resecting a longitudinally oriented strip out of the medial capsule.

**Gore Procedure**

The Gore procedure, used to control large intermetatarsal angles, was performed in the same way as the Keller, adding a proximal Trethowan osteotomy.

The follow-up period ranged from 1 to 8 years. Pain at the first MPJ, metatarsalgia, shoe conflict, mobility of the joint, and size of hallux valgus and intermetatarsal angles served as criteria for evaluation of the results. A joint without pain and shoe problems and the reduction of the valgus angle below 20° and an intermetatarsal angle below 10° was considered an excellent result. A dorsiflexion of 50° after the Petersen, New, and Trethowan procedures, 40° after the Austin procedure, and 30° after resection arthroplasties were considered sufficient for an excellent outcome of the operation. Concessions were necessary after New’s operation because this method does not aim at reducing the intermetatarsal angle.

**RESULTS**

Of 55 Petersen procedures, 13 were graded as excellent. In these, the average valgus angle was reduced from 26° (20° to 40°) to 11° (0° to 20°), the intermetatarsal angles from 10° (5° to 16°) to 8° (5° to 10°).

Although in this group excellent results were achievable, with preoperative valgus angles up to 40°, we do not recommend the method with valgus angles larger than 30° preoperatively because the results were very inconsistent.

With New’s operation 11 excellent results were found among 72 operated feet. The mean reduction of the valgus angle in these cases was from 27° preoperatively to 14° postoperative. The intermetatarsal angle remained unchanged. Therefore, a reduction of the valgus angle of approximately 13° is possible. According to our experience it is not recommended to use this technique on a valgus angle exceeding 30° because in these cases subluxation of the phalanx is usually already induced and is prone to proceed after the operation.

Assuming the intermetatarsal angle is not addressed, 12° is the maximum intermetatarsal angle tolerable for this procedure.

The V-shaped transpositional osteotomy of the metatarsal head after Austin gave 21 excellent results out of 31 feet. In these, the mean valgus angle of 31° (15° to 37°) was diminished to 14° (0° to 20°), the intermetatarsal angle averaging 14.5° (11° to 19°) to 6.6° (4° to 10°).

When the extreme 37° valgus angle is not considered, it seems realistic to limit the indications to a valgus angle up to 35° and an intermetatarsal angle of 15°.

Two Trethowan’s osteotomies combined with removal of the exostosis and a capsular reconstruction at the joint gave 1 good and 1 excellent result. In the latter an intermetatarsal angle of 25° was reduced to 8° and the valgus angle of 40° to 12°, Extension exceeded 50°. Although few data are available, this method might be the solution in cases of an intermetatarsal angle significantly greater than 15° provided there is good mobility and healthy cartilage of the joint.

With the Keller resection arthroplasty plus the fibrous cerclage of Lelievre, 20 of 74 operated feet were graded as excellent. A preoperative valgus angle averaging 37° (25° to 50°) was opposed by a postoperative angle of 14° (0° to 20°). By reduction of the mean intermetatarsal angle from 16° (12° to 20°) to 8° (7° to 10°) it was normalized. Perhaps until now the efficiency of the fibrous cerclage was underestimated since in some cases we indicated the proximal opening wedge osteotomy with an intermetatarsal angle of 14°. It seems justifiable to aim for a good result with intermetatarsal angles up to 18° if there is no concomitant metatarsalgia found preoperatively.

With larger intermetatarsal angles the Keller procedure was combined with an opening wedge adduction osteotomy near the base of the first metatarsal according to recommendations of Gore. Even here the cerclage fibreux was added, although surprisingly enough the first metatarsal head was reposed on the sesamoids without it in individual cases.
In 12 excellent results out of a series of 30 Gore operations the mean preoperative valgus was reduced from 41° (32° to 55°) to 8.7° (0° to 16°), the intermetatarsal angle from 17.3° (14° to 22°) to 6.2° (0° to 10°).

CONCLUSIONS

Thirteen excellent results out of 55 feet (24 percent) in the Petersen group were contrasted with 21 excellent outcomings out of 31 feet (64 percent) in the Austin group. There was no excellent result in the Petersen group when the preoperative valgus angle exceeded 30°. Results of surgical treatment of the capsuloligamentous apparatus were the same. The reason for the discrepancy of the results seems to be the beneficial effect of shortening of the first metatarsal by 3 to 4 mm on the tension of the tendons. The shortening is compensated by directing the V-osteotomy obliquely plantar-ward at an angle of approximately 20°.

We therefore abandoned the Petersen technique and indicated the Austin procedure at valgus angles up to 35° and intermetatarsal angles up to 15°. With a skillful technique and internal fixation with a K-wire we were able to be successful with this technique in valgus angles up to 40° and intermetatarsal angles up to 20°. If the latter is exceeded, the proximal metatarsal osteotomy combined with a distal reconstruction of the capsuloligamentous apparatus is appropriate.

New's procedure was recently used rather infrequently and cannot be considered as a routine method. With New's procedure, a valgus angle over 30° and an intermetatarsal angle over 12° are limiting factors.

In joints damaged by osteoarthritis the Keller operation can be tried with intermetatarsal angles up to 18° when the cerclage fibres is added. Above 18° the procedure should be combined with a proximal metatarsal osteotomy as recommended by Gore, especially if metatarsalgia of the lesser metatarsals is present.

According to the overall results the most successful type of operation in the joint-preserving group was the chevron osteotomy designed by Austin.12 With larger intermetatarsal angles we used a proximal horizontal V-osteotomy after Kotzenberg, as described by Schotte,15 combined with a lateral release and a medial capsular reconstruction. This method avoids lengthening of the first metatarsal as in opening wedge procedures, which can lead to undesired tension of tendons.

If the MPJ cannot be preserved the Keller operation is combined with a fibrous cerclage9,16,17 This provides for correction of intermetatarsal angles up to 18° and improves the results compared with a simple Keller procedure.16,17

When there is a rigid first ray or an intermetatarsal angle larger than 18° an opening wedge osteotomy is recommended. Especially in index minus cases of hallux valgus the lengthening of the first metatarsal will be of biomechanical benefit. A summary of indications and procedure choice is demonstrated graphically in Figure 37-31.

METATARSALGIA

Metatarsalgia is a consequence of disturbed function of the foot. Insufficiency of the first ray is followed by overload of the lesser rays. The connections of the second to fourth metatarsals with the tarsus are more stable than those of the first and fifth rays. This along with muscular imbalance leads to overload of the lesser metatarsals accompanied by transmittal of shear forces to the tissues between the ground and the metatarsal heads, resulting in painful callosities.

In the pronated foot an orthotic device aiming at controlling movement of the subtalar joint about its neutral position and preventing excessive pronation during the stance phase of gait is an efficient treatment. Sometimes this requires much patience of the patient, the technician, and the physician.

Gross deformity of the foot such as cavus deformity may have to be addressed surgically. The function of an insufficient first ray in severe hallux valgus or sequelae of inadequate hallux valgus surgery must be improved before osteotomies at the metatarsals are planned.

Lesser metatarsals that are too long and that cause "dynamic" callosities distal to the metatarsal heads must be shortened. It must be kept in mind that all shortening along the longitudinal axis of the metatarsal always leads to elevation of the metatarsal heads.

Static callosities situated directly under the metatarsal heads are treated by elevation of the metatarsal heads. This can be accomplished by distal or proximal
dorsiflexion osteotomies. Metatarsalgia in the elderly caused by atrophy of the adipose cushion over the metatarsal heads must be treated by soft orthotics. We indicate an operation if conservative measurements fail or are rejected by the patient and if dislocated hammertoes are present. Many methods have been developed to treat metatarsalgia surgically; for none of them are the results clearly predictable.

**METHODS**

**Helal's Telescoping Osteotomy**

Helal's telescoping osteotomy has been used at the Orthopedic Hospital of Vienna since 1978. Of 87 patients operated on between 1979 and 1983, 62 were seen at follow-up presenting 75 operated feet. Using Helal's score, of the 75 feet 56 (75 percent) were graded as good, 11 (14 percent) as fair, and 8 (11 percent) as poor. Patients were very satisfied with 44 feet (59 percent), satisfied with minor complaints with 20 (27 percent), and unhappy with 11 (14 percent).

The technique of the operation was as described by Helal (Fig. 37-32). In all but 2 feet all three central metatarsals were osteotomized. At radiologic and clinical evaluation the following reasons for the unfavorable results were identified.

In 9 feet there was insufficient elevation of the metatarsal heads, which resulted in persistent keratomas and pain. In 4 feet painful keratomas developed under the first and fifth metatarsal heads. In 6 osteotomized metatarsals pseudarthrosis developed, but were painful in only one. The nonunions were caused without exception by an osteotomy.

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**Fig. 37-31.** Selection chart for method of operation depending on intermetatarsal and hallux valgus angles.
placed too far proximally. Only one of them caused pain.

Floating toes occurred in 57 feet. If at the time of the operation a dorsiflexion contracture of the MPJ, subluxation, or dislocation is not corrected, the whole complex of the clawing toe and metatarsal head will be elevated and no contact of the toe with the ground will be possible (Fig. 37-33).

With 89 percent good and fair results in the Helal score and 86 percent of the patients satisfied, this method may be recommended as a comparatively simple and sound way to treat metatarsalgia if conservative measurements are not successful. Factors for success include a metaphyseal position of the osteotomy, an angle of the osteotomy of 45°, plantar mobilization of the metatarsal heads to allow their gliding up and proximally, and correction of contractures and dislo-

Fig. 37-32. Helal's oblique osteotomy. (A) The inclination is 45° to the longitudinal axis of the metatarsal. (B) The metatarsal head moves dorally and proximally.

Fig. 37-33. If metatarsal head is not mobilized sufficiently the metatarsal tilts upward rather than slides. If there are contractures at the metatarsophalangeal and interphalangeal joints the whole complex moves up, inducing the toes to float.

Fig. 37-34. Correction of contractures, subluxations, and dislocations, including resection of the head of the first phalanx; dissection of the extensor hood; lengthening of the extensor tendons; dorsal, medial, and lateral capsulotomy; oblique osteotomy; and transfixation by K-wire.
lations of the MPJ (Fig. 37-34). Early weight-bearing seems to be of good influence on results.

**Shortening Osteotomy by Reverse Helal**

The direction of the "reverse Helal" osteotomy is from distal dorsal to proximal plantar (Fig. 37-35). The procedure is indicated if metatarsalgia is caused by overly long lesser metatarsals. The advantage is that upward movement of the metatarsal heads is controlled, especially if internal fixation with a K-wire is provided. Sometimes a tilting upward of the metatarsal heads can be detected radiographically, but this-tilting aligns the metatarsal heads in a frontal plane. Although follow-up of the thirty operated feet has not yet been initiated, early results appear favorable.

**Regnauld's Reenclavement of the Metatarsal Heads**

In Regnauld's reenclavement, the metatarsal heads are removed, shelled out, and replaced onto the remaining shaft of the metatarsals (Fig. 37-36). The operation requires much skill, but if properly performed the results are good. Occasionally partial osteonecrosis of the metatarsal heads is evident radiographically, but this does not influence the results. We rarely use the technique because it is difficult. Because of the transverse incision and mobilization of soft tissues, swelling of the forefoot persists for several months.

**Forefoot Correction**

Forefoot correction refers to metatarsal head resections, usually performed in rheumatoid arthritis. The U-shaped, distally convex incision is at the plantar aspect of the foot for the metatarsals and medial for the hallux. An ellipse of skin 1.5 cm wide containing the plantar keratomas is resected. Thus a plantar dermodesis can be performed, pulling the distally dislocated adipose cushion over the metatarsal stumps after mobilization. We aim at an alignment of the metatarsals in a manner such that the length of the first equals the second, the third is shorter than the second, and so on (Lelievre).21 Hammer toes and claw toes are manipulated straight and a special foot orthosis is worn dur-
ing the first 2 weeks and after this for 3 months at night.

The results are good and long lasting in feet with a low arch. In cavus feet the cavus would have to be addressed first. Recently the first MPJ was arthrodesed after equalizing the length of the first metatarsal to the stump of the second to provide for more stability of the first ray.

REFERENCES