Metatarsalgia and Toe Deformities

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Keywords
Metatarsalgia • Intractable plantar keratosis • Morton's neuroma • Freiberg disease • Sesamoid lesions • Lesser toe deformities • Metatarsal osteotomy

Intractable Plantar Keratosis (IPK)

Introduction

Pain localized to the forefoot region on weight bearing, which is called as metatarsalgia, has various etiologies. Etiologies of metatarsalgia can be classified as primary, secondary, and iatrogenic. Metatarsalgia is often accompanied with plantar keratosis (Table 3.1).

Primary metatarsalgia includes conditions that are related to the anatomy of the metatarsals and the metatarsal correlation and the relative relationship of metatarsal with rest of foot and ankle. Many of them may be associated with disorders of the hallux and lesser toes [21]. However, conditions of the midfoot, hindfoot, ankle, and lower leg also can contribute to development of metatarsalgia. Generally, abnormal plantar pressure distribution around forefoot due to anatomical predisposition is thought to be a cause of metatarsalgia. Etiologic factors of primary metatarsalgia proposed include

Table 3.1 Classification of etiologies for metatarsalgia

Primary metatarsalgia
Relatively long lesser MT (2nd or 3rd)
Plantar-flexed lesser MT
Prominent fibular condyle of metatarsal head
Hallux valgus with incompetence of first ray
Cavus foot
Ankle equinus
Forefoot varus
Secondary metatarsalgia
Morton's neuroma
Freiberg disease
Sesamoid lesions
Lesser toe deformities due to inflammatory arthritis or neuromuscular imbalance
Iatrogenic metatarsalgia

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Fig. 3.1 Long 2nd metatarsal is often important etiology for lesser toe metatarsalgia with IPK

incompetence of first ray, a long second metatarsal, excessive plantar flexion of the forefoot, subluxated or dislocated metatarsophalangeal joint, abnormal foot postures, and contracture of the Achilles tendon complex.

The metatarsal formula is based on the relative lengths of the first and second metatarsals [72]. When the first metatarsal is shorter than the second, the foot is known as the "index minus" type; when the first metatarsal is longer than the second, it is of the "index plus" type; and when the first and second metatarsals are of equal length, it is labeled "plus minus." The "index minus" type is the most common metatarsal formula of about 60 % incidence and it forms the most common type of the primary metatarsalgia with relatively long lesser metatarsals. Increased pressure and friction from this long metatarsal occurs during the propulsive phase of gait when the foot is fully loaded and pushing off. The pain is localized in the metatarsal head area and swelling develops with gait, which eventually lead to diffuse intractable plantar keratosis (IPK) (Fig. 3.1). The second most common cause of

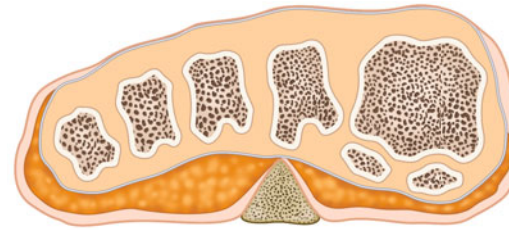


Fig. 3.2 Discrete keratosis. A schematic drawing of focal discrete plantar keratosis caused by prominent fibular condyle of metatarsal head

primary metatarsalgia is plantar-flexed lesser metatarsal, in which pain exerts during the stance phase of gait. The main cause is positional relationship of the metatarsal heads or the plantar condyles. One metatarsal head may be relatively plantar flexed and causes diffuse IPK. In case of abnormally prominent plantar condyle, primary discrete positional IPK develops (Fig. 3.2). Diffuse IPK due to long metatarsal and localized IPK due to prominent lateral condyle can be concomitantly present (Fig. 3.3). Plantar-flexed lesser metatarsal due to contracted hammer toe or

Fig. 3.3 Foot with concomitant diffuse IPK (Left 3rd MT) and discrete localized IPK (right 3rd and left 2nd MT). The *arrow* shows a discrete keratosis while the *arrowhead* shows a diffuse keratosis

Fig. 3.4 (**a**) MTP synovitis with joint subluxation and resultant hammer toe can lead to painful IPK. (**b**) Severe hallux valgus with relatively long 2nd and 3rd metatarsal and poor functioning windlass mechanism by 1st ray often leads to 2nd and 3rd metatarsalgia

subluxated MTP joint with synovitis can develop painful IPK (Fig. 3.4a). Hallux valgus with incompetence of 1st ray due to loss of windlass mechanism leads to transfer weight on the 2nd or 3rd metatarsal bone, leading to diffuse IPK, which aggravates in case it is combined with 1st MTC joint instability (Fig. 3.4b).

Foot posture has to be evaluated in patients with IPK. Abnormal postures that may cause IPK include equinus deformity, cavus foot, flatfoot,

Fig. 3.5 Cavus foot with increased plantar contact pressure at forefoot and heel area that led to IPK

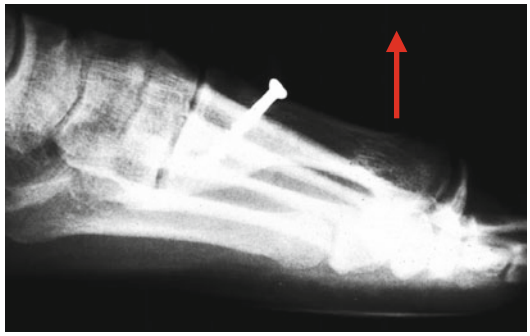


Fig. 3.6 Iatrogenically dorsiflexed 1st metatarsal due to proximal metatarsal osteotomy that led to formation of painful IPK in the lesser metatarsals. The *arrow* indicates the direction of iatrogenic dorsiflexion deformity

varus forefoot, and abnormal alignment of MTP joints. An equinus deformity has localized weight bearing in the forefoot and can produce callus in the lesser metatarsal area. Cavus foot with high arch has decreased contact surface of heel and forefoot leading to diffuse callus in the lesser metatarsal area (Fig. 3.5). Varus forefoot deformity weight bears on the lateral side of the foot leading to callus formation in the same area. There are secondary metatarsalgia due to structural changes by trauma or surgery that lead to iatrogenic short 1st metatarsal or iatrogenic dorsiflexion/plantar flexion of metatarsal (Fig. 3.6).

Also, there are some feet with metatarsalgia where any specific cause cannot be found. However, some of metatarsalgia can be attributed to be a secondary metatarsalgia because they have obvious pathology around the forefoot. Morton's neuroma, Freiberg disease, sesamoid lesions, and lesser toe deformities due to inflammatory arthritis or neuromuscular imbalance can be categorized as etiologic disorders for secondary metatarsalgia [21, 25, 26].

Diagnosis

The evaluation of a patient metatarsalgia and/or plantar keratosis should begin with a careful history taking including history of activities or shoewears which aggravate or alleviate symptoms, previous trauma/surgery, medical comorbidities, and previous treatment. Sometimes, some etiologic causes can be found by physical examination which include hallux valgus deformity, hypermobile first ray, and abnormal foot postures such as cavus foot.

Usually, simple standing foot radiographs can help physicians to define possible etiologies of metatarsalgia and/or IPK. Sesamoid views can help evaluate the plantar-flexed metatarsal (Fig. 3.7). In case of suspicious prominent fibular

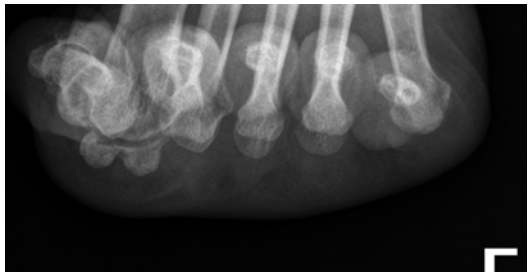


Fig. 3.7 Sesamoid view to evaluate the relative plantarflexion status of the lesser metatarsal

condyle of metatarsal head, CT examination may be helpful for diagnosis. For differential diagnosis, dermatologic etiologies of plantar keratosis such as verrucae (wart, which can be differentiated by an existence of multiple end arteries in a procedure of trimming) and keratosis palmoplantaris nummularis should be ruled out. Pedobarography evaluation with foot pressure scan will be helpful to evaluate the specific plantar foot pressure measurements (Fig. 3.8).

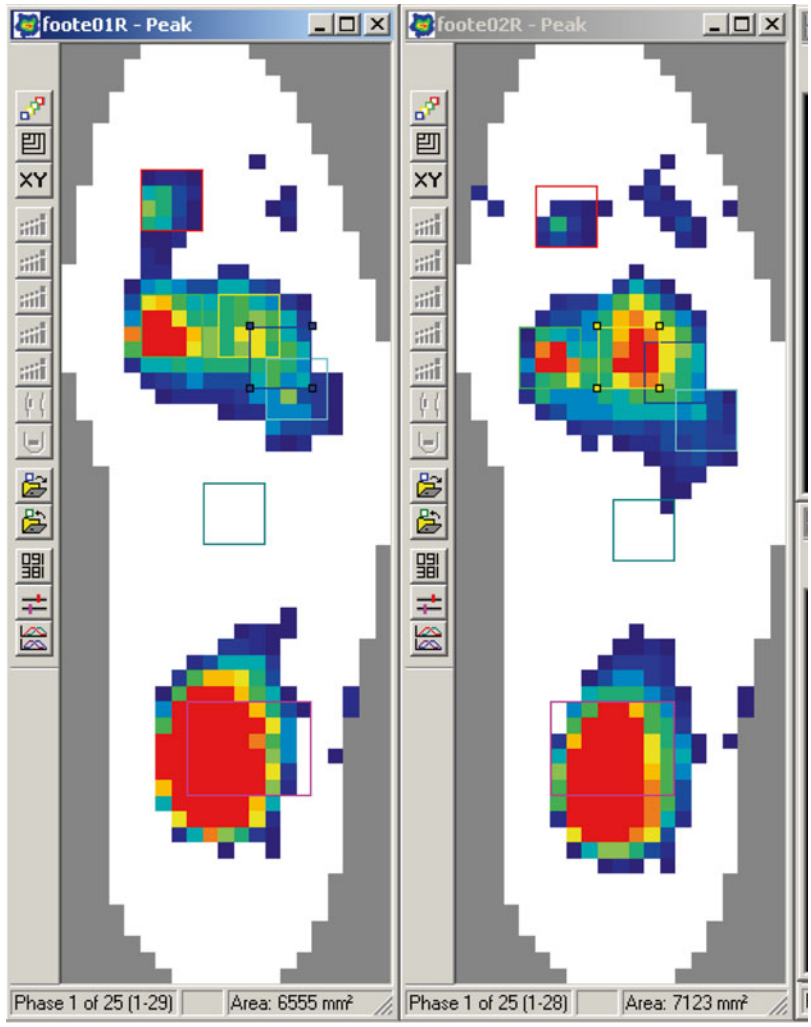


Fig. 3.8 Pedobarography to evaluate the forefoot pressure distribution. Normal foot versus hallux valgus with 3rd metatarsalgia on the right marked with red dot

Treatments

Conservative Treatment

As an initial treatment, plantar keratosis can be trimmed with a sharp knife. By single or repeated attempts, hyperkeratotic tissue and a seed corn can be removed. After trimming of plantar keratosis, metatarsal pads, custom-made insoles, and accommodative shoes may be applied to relieve pressure on the site of keratosis (Fig. 3.9a, b).

Surgical Treatment

Surgical treatment of metatarsalgia and plantar keratosis is based on the osseous etiologies of the plantar keratosis. If a focal discrete keratosis is formed under the metatarsal (usually 2nd or 3rd metatarsal) head, an existence of prominent fibular condyle of metatarsal head should be evaluated. Isolated plantar condylectomy modified from DuVries condylectomy [24] can be used to remove the prominent fibular condyle which

Fig. 3.9 (**a**) Callus shaving to relieve plantar pressure pain. (**b**) Various metatarsal pads and insoles for relieving IPK pain. (**c**) Designated place to elevate metatarsal to relieve plantar pressure of callosity. (**d**) Placement of metatarsal pad on an insole to elevate the metatarsal bone

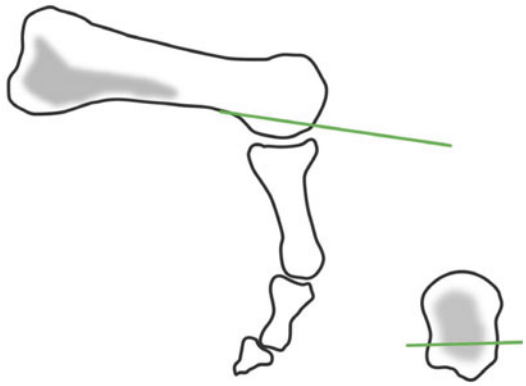


Fig. 3.10 Modified DuVries plantar condylectomy can be done to remove prominent condyle

provokes pressure lesion (Fig. 3.10). Marx and Mizel reported a technique with the use of a power rasp for the condyle resection for elimination of the extra step of condylar retrieval and potential difficulties [48].

If there is a diffuse IPK beneath several metatarsal heads, the 2nd and/or 3rd metatarsal might be long and/or there might be an incompetence of first metatarsal head to bear weight properly. Sometimes, hallux valgus with the callosities under the lesser metatarsals can be addressed with correction of hallux valgus deformity only [41]. We correct such cases of hallux valgus with 2nd metatarsalgia and normal length 2nd metatarsal by performing proximal chevron metatarsal osteotomy (PCMO) with slight plantar flexion of distal metatarsal. However, in case of long 2nd and 3rd metatarsals, some metatarsal shortening procedures should be combined to obtain proper metatarsal cascade. Most widely used procedure to reduce pressure under the metatarsal heads is Weil metatarsal osteotomy (MTO) (Fig. 3.11). Many surgeons utilize the Weil osteotomy for the treatment of a subluxed or dislocated metatarsophalangeal (MTP) joints. The maximum amount of shortening by the Weil osteotomy was reported from 5 to 11 mm [37, 49]. We perform Weil MTO with 1–2 mm metatarsal head bone block resection along with PCMO for moderate to severe hallux valgus with marked symptoms of painful 2nd IPK (Case 3.1).

Besides Weil MTO, many types of metatarsal osteotomy have been introduced for treatment of metatarsalgia and IPK. Helal described a distal

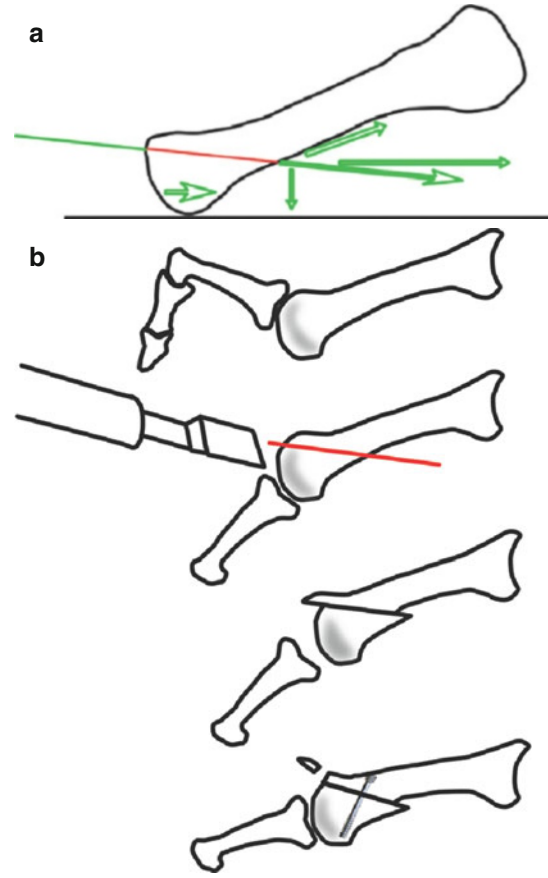


Fig. 3.11 (**a**) By Weil osteotomy and displacement, shortening of the metatarsal and a little plantar displacement of the metatarsal head can be obtained. (**b**) Weil osteotomy procedure

oblique metatarsal osteotomy of the three middle metatarsals, to relieve metatarsalgia [34] (Fig. 3.12a). However, following studies have shown that the outcome after Helal osteotomy is less predictable and less acceptable than the Weil osteotomy [71]. The shortening of metatarsals at the level of diaphysis or base has been described to have acceptable success rate for treating a plantar callus [31, 54]. Barouk et al. introduced modified proximal metatarsal osteotomy (BRT lesser metatarsal osteotomy) to elevate metatarsal head [6]. This metatarsal osteotomy is a dorsal closing wedge with no more than 2 mm wedge resection in order not to elevate too much. The osteotomy angle, aiming proximal-plantar toward TMT joint, must be oblique enough with 60° with horizontal plane. They thought that if a proximal hinge could be

carefully preserved, the BRT oblique osteotomy might provide a good stability and could be solidly secured with a screw [6] (Fig. 3.12b).

Author's Tips We perform BRT osteotomy for painful IPK with relatively plantar-flexed but normal length metatarsal and fix with mini-screw or K-wires, with resultant satisfactory outcome (Cases 3.2 and 3.3) [6]. As for the Weil osteotomy, post-op shoe was applied for 6 weeks postoperatively, while short leg cast was applied for 4 weeks followed by 4 weeks of post-op shoe application after BRT metatarsal osteotomies.

Results

Although the Weil osteotomy is an effective and safe procedure for the treatment of central metatarsalgia, it may be associated with some complications, such as floating-toe deformity and transfer metatarsalgia [49]. Floating toe is a commonly reported complication ranging from 20 to 68 % [7, 35, 45, 49, 55]. Weil suggested taping the toe in 5° of plantar flexion as postoperative care to reduce MTP joint hyperextension [74]. Encouraging aggressive exercise is also recommended for avoiding this complication. Khurana et al. reported that 80 of 86 feet showed good to excellent results clinically, but 6 feet (7 %) had persistent metatarsalgia with callosities [38]. Recently, Trieb et al. reported satisfactory clinical outcome of Weil osteotomy for rheumatoid arthritis patients with metatarsalgia or dislocation [70].

Recurrent metatarsalgia due to inadequate pressure decompression or dorsal elevation and fracture or nonunion of metatarsal osteotomy (BRT or Helal) can also occur. Surgeons should keep in mind that BRT osteotomy does not allow to shorten the metatarsal, but just elevate metatarsal (Table 3.2).

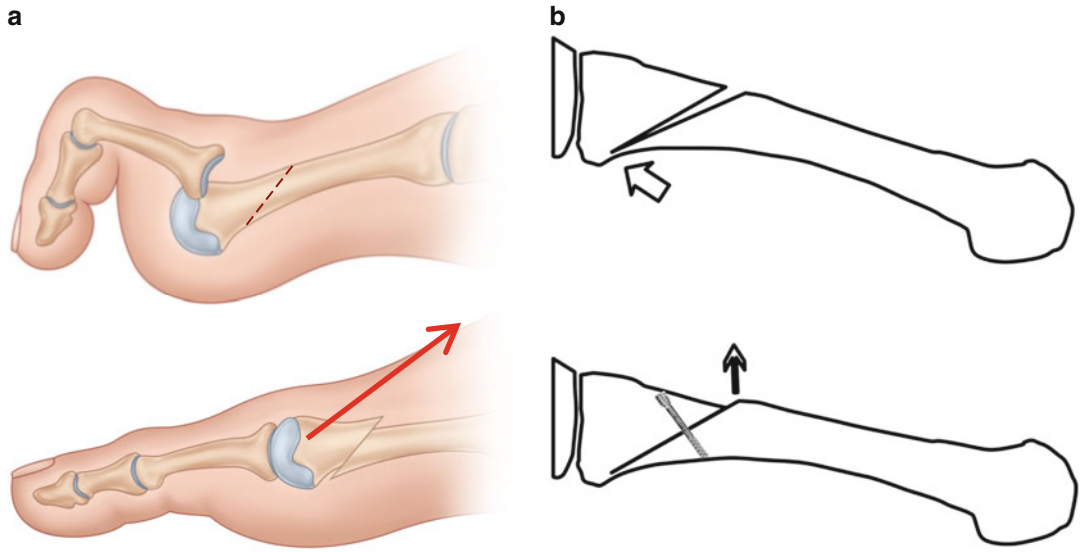


Fig. 3.12 (**a**) Helal distal oblique metatarsal osteotomy. (**b**) BRT proximal metatarsal dorsiflexion osteotomy

Table 3.2 Clinical outcomes of Weil metatarsal osteotomy

Procedure	Papers	No. of patients	Outcomes
Weil osteotomy	Davies et al. [19]	39	8/39 (20 %) some continued pain
			Overall satisfactory level
	Hofstaetter et al. [35]	25	84 % excellent results
			Only 32 % of toes were contacted with the ground
	Khurana et al. [38]	86	93 % excellent results
			7 % persistent metatarsalgia

Cases

Case 3.1 PCMO and Weil MTO: (a, b) Sixty-six-year-old female patient presented with severe hallux valgus with painful 2nd IPK as chief complaint. (c) PCMO with slight plantar flexion and 2nd and 3rd Weil MTO with 1 mm bone block resection were performed. (d) Plantar callosity was resolved at postoperative 3 months.

Case 3.2 BRT MTO: (a, b) Fifty-one-year-old woman presented with painful intractable plantar keratosis (IPK) at 1st and 5th metatarsal head area, bilaterally. The sole thickness was relatively thin and the foot metatarsal parabola appeared normal. (c, d) Dorsal closing wedge osteotomy of 1st and 5th MT shaft and callus shaving were performed for right foot. (e) At postoperative 3 months, most of the initial plantar callosity disappeared with concomitant relief of metatarsalgia.

Case 3.3 Recurrent transfer IPK: (a, b) Thirty-three-year-old male patient had previously 4th Weil metatarsal osteotomy (MTO) for plantar foot pain without symptom relief. He presented with prominent painful IPK at the 3rd MT area instead. (c) Helal midshaft oblique osteotomy for second and third MT was performed to shorten and dorsally elevate the distal metatarsal. (d) As for the 4th MT, metatarsal dorsiflexion osteotomy with plantar condylectomy was also performed. (e, f) The x-ray shows overall shortened 2nd and 3rd metatarsals. (g) The foot plantar aspect shows the disappeared plantar keratosis at postoperative 6 months.

Morton's Neuroma

Introduction

Interdigital (intermetatarsal) neuroma is one of the most frequent causes of metatarsalgia which requires treatment. Although there had been reports describing this conditions, the interdigital neuroma has been named as Morton's neuroma after T.G. Morton had reported a painful condition affecting the fourth metatarsophalangeal joint in 1876. The most frequent location is in the third and fourth metatarsal heads where the branches of the medial and lateral plantar nerves form an anastomosis (Fig. 3.13). Perineural fibrosis has been documented on histological evaluation of surgical specimens [18]. This finding has led many investigators to propose a symptomatic entrapment neuropathy of the interdigital nerve at the deep transverse metatarsal ligament (DTML) as the cause of an interdigital neuroma [18].

Diagnosis

Morton's neuroma is more prevalent in adult women and most frequent time of onset is fifth decade of life. Clinical feature is mainly

characterized by forefoot pain frequently localized in intermetatarsal area and aggravated by weight bearing and wearing constricting type of shoes. On physical examination, a palpable click can be felt with compression of the involved interspace between the examiner's index finger and thumb as the transverse arch is compressed (Mulder's click) while the space is pressed dorsally from plantar aspect [51]. In patients who are not able to discern the specific area of discomfort, exact localization of pain can be assisted with the use of injection of small-dose anesthetics in the intermetatarsal space and the adjacent metatarsophalangeal joints [18].

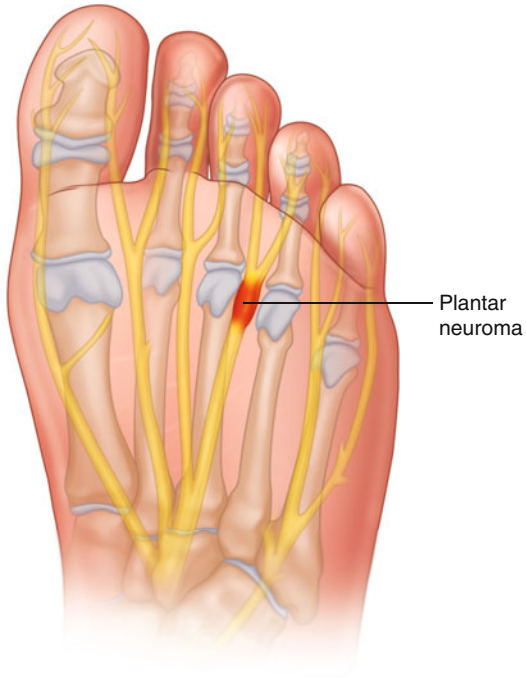


Fig. 3.13 Morton's neuroma anatomy

Although the diagnosis of Morton's neuroma can be made by thorough history and clinical examination, diagnostic methods such as ultrasonography and magnetic resonance imaging can be also helpful to discern the lesion and measure the neuroma size [46]. Ultrasonographic images show the lesion as a hypoechoic round mass in the web space between the metatarsals (Fig. 3.14a, b).

Differential diagnosis includes mechanical metatarsalgia, intermetatarsal bursitis, Freiberg disease, stress fracture, giant cell tumor (GCT) of tendon sheath, and peripheral neuropathy related to metabolic disease or entrapment of nerve at more proximal part of a body (Figs. 3.15 and 3.16) [73].

Treatments

Treatment Algorithm

Although mainstream of initial management for Morton's neuroma is conservative treatment, there is a consensus that surgical treatment might

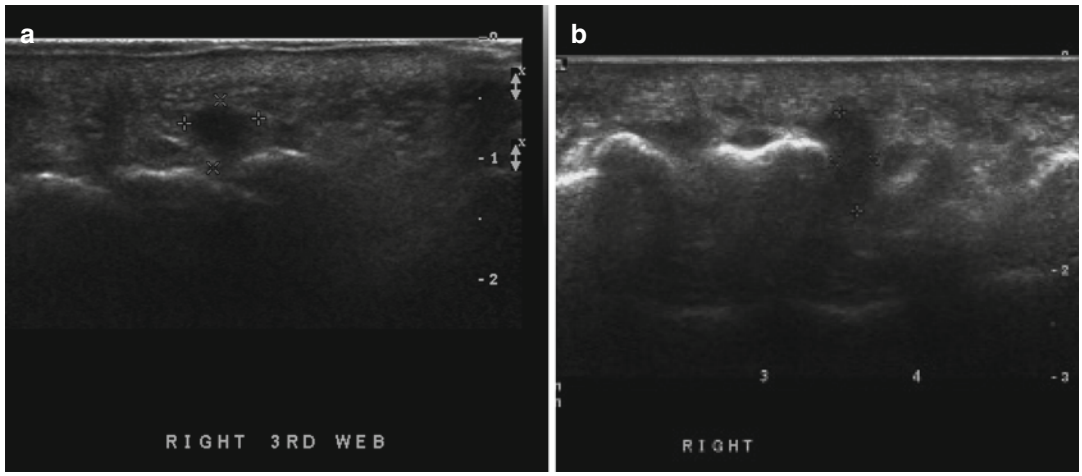


Fig. 3.14 Typical Morton's neuroma in the intermetatarsal space as a hypoechoic mass (**a**, **b**) in ultrasonography

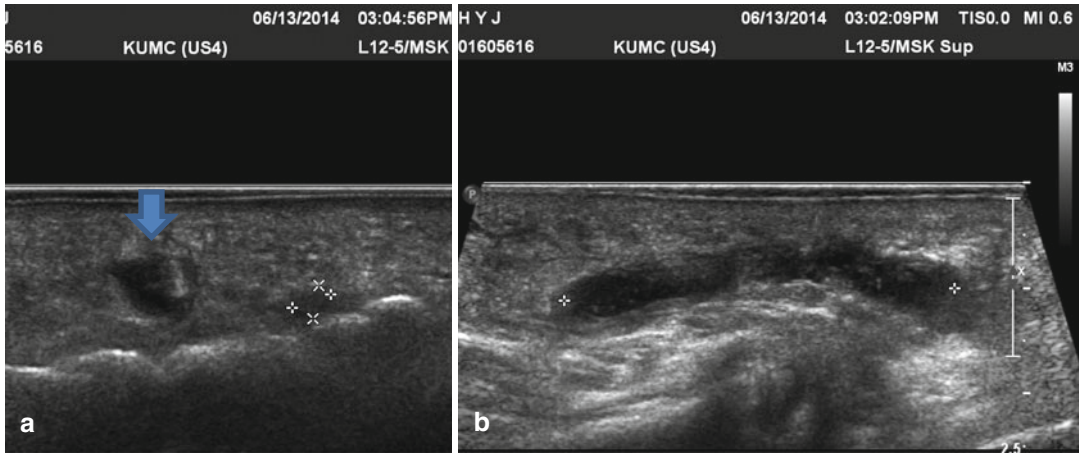


Fig. 3.15 (**a**) Ultrasonography coronal view of intermetatarsal bursitis (*arrow*) and Morton's neuroma coexisting in a hallux valgus patient. (**b**) Intermetatarsal bursitis in the sagittal view (USG)

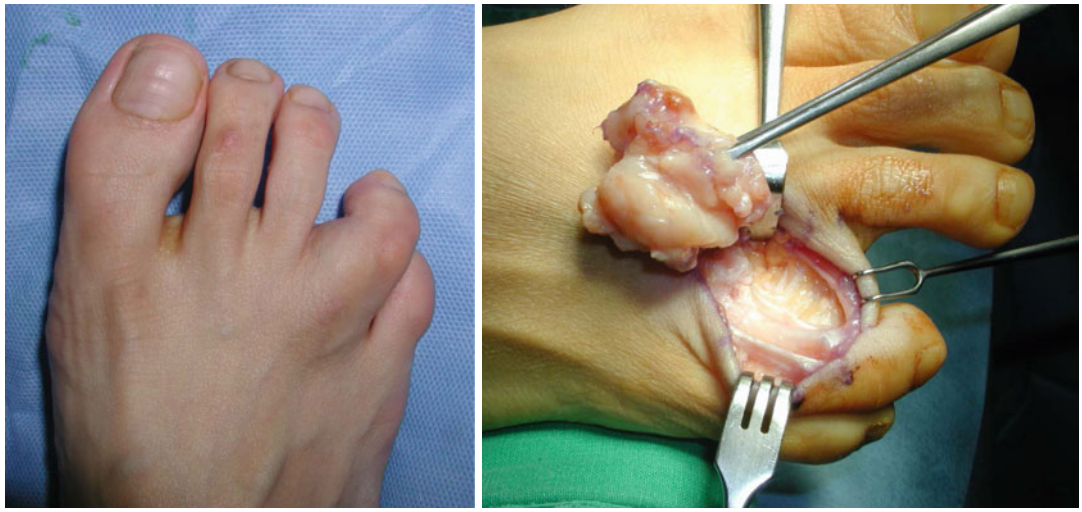


Fig. 3.16 Giant cell tumor (GCT) of tendon sheath in the 3rd web space – another differential diagnosis for Morton's neuroma

be necessary for patients who are (1) confirmed by imaging studies to have interdigital neuroma and are (2) refractory to conservative treatment, (3) complaining high degree of pain that significantly affects the daily activities.

Conservative Treatment

Conservative treatment consists of medications, shoewear modification, orthoses, and local injection of pharmacological agent such as corticosteroid, anesthetics, and alcohols [73]. Activity modifications including footwear modifications and inserts usually are the first step in treatment. We recommend wide-toe box shoes with soft expansile materials and metatarsal pads to alleviate the pressure at the neuroma tender points.

However, it is so difficult to completely avoid conditions which may aggravate symptom in daily activity of living that local injection might be considered as next line of treatment. Corticosteroid may be one of most frequently used drug for local injection in the treatment of

Morton's neuroma [8, 46, 57]. It can be injected with or without ultrasound guidance. However, Makki et al. reported in a prospective study that, although single injection of steroid offered satisfactory pain relief for symptomatic Morton's neuroma, the effects of an injection are likely to be short-lived, around 6 months or so [46, 67]. Complete satisfaction rate around 1 year after injection declined to 15 %. In addition, more prolonged benefit was observed for neuromas of 5 mm or less in size, although the symptom degree does not correlate with neuroma size.

Alcohol ablation is an alternative therapy which has shown positive initial results [36, 52]. Injected ethanol is thought to cause neurolysis by means of dehydration, necrosis, and precipitation of protoplasm. However, although alcohol injection might facilitate a shorter recovery time than surgery, it may require more hospital visits and be less effective than surgery [52].

Surgical Treatment

Coughlin reported in a long-term follow-up study of operative treatment that 85 % had reported a good or excellent result. They suggested that for the high level of satisfactory results, the careful preoperative clinical evaluation in which other, confounding diagnoses could be eliminated was important [18].

One issue on surgical technique is neurectomy versus neurolysis. Although excision is still the most common surgical management of Morton's neuroma, some surgeons believe that Morton's neuroma can be treated by neurolysis with release of deep transverse metatarsal ligament (DTML) without nerve resection and neurectomy should be limited to patients with enlargement of entrapped nerve (pseudoneuroma) because neurectomy leads to loss of sensation of the involved interspace [20, 30, 53, 73].

The other issue is a surgical approach. Both a dorsal and a plantar approach have been recommended for the resection of an interdigital neuroma. Although there is a lack of evidence to determine which approach would be better for neuroma excision [68], some surgeons prefer a dorsal incision because of the low prevalence of wound complications and the increased ability of patients to bear weight immediately postoperatively (Fig. 3.17) [18]. However, Akermark et al. reported in a prospective randomized controlled trial that clinical outcome was not significantly different between two surgical approaches [1]. They postulated that the risk of painful plantar scars and related complaints is limited even in plantar approach group [1, 2].

The excisions of neuromas from adjacent interspaces can be performed simultaneously or in a staged fashion. However, simultaneous adjacent web space exploration was reported to be associated with a much higher dissatisfaction rate and even with a staged operation, a more extensive area of numbness persisted in the foot [18, 29].

Author's Tips We prefer to perform interdigital neuroma excision rather than neurolysis or just DTML release because nerve eradication is more predictable for neurogenic pain relief. We also warn the patients of potential persistence of neurogenic pain postoperatively in 10–20 %. We routinely use dorsal approach for initial neuroma surgery while plantar approach is only used for recurrent or persistent neuroma cases to avoid plantar scar formation and potential pain on weight bearing. It is also important to definitely confirm the neuroma identity before excision to avoid symptom persistence. The neuroma surgery is also recommended only for chronic Morton's neuroma patients with significant degree of neuroma pain.

Results

In cases with a previous history of multiple steroid injections, there is a risk of wound complications, such as delayed healing or infection. If recurrent symptoms develop after resection of an interdigital neuroma, there may be several possibilities. One possible etiology is an insufficient resection of initial neuroma. Because plantar-directed nerve branches tether the common digital nerve to the plantar skin [3], surgeons should try to resect digital nerve as proximal as from the transverse metatarsal ligament. Another possible etiology is formation of a bulb neuroma at the

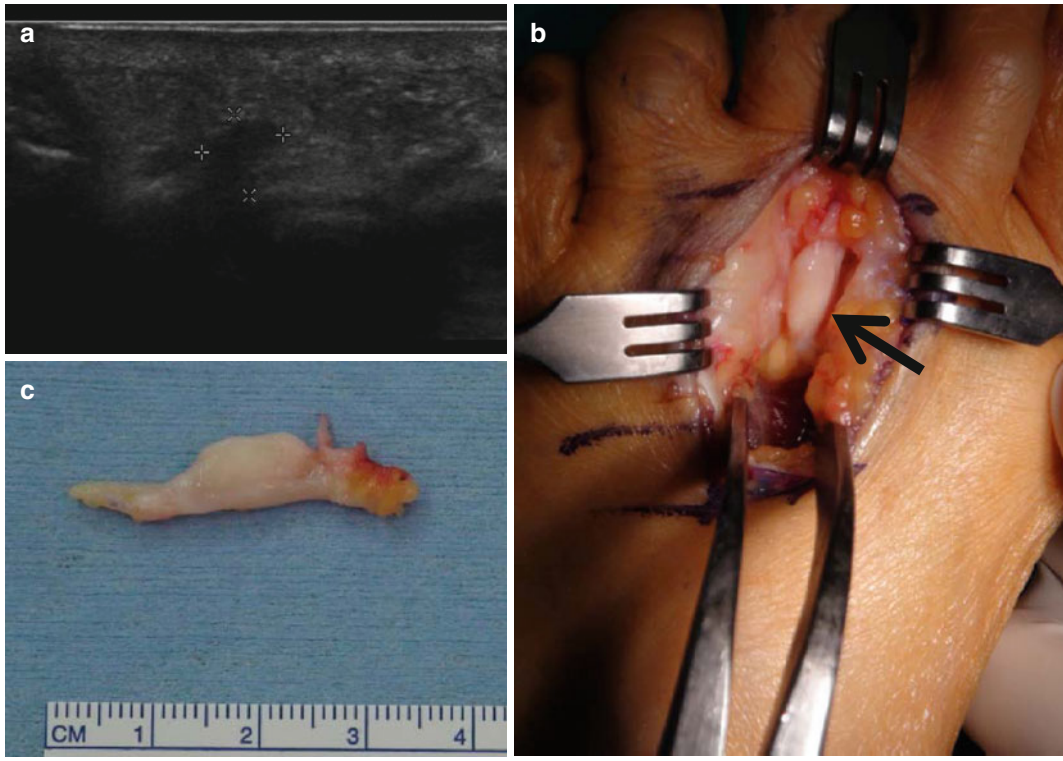


Fig. 3.17 F/69 patient with 2nd and 3rd web Morton's neuroma for 10 years. Mulder's click (+). (**a**) USG finding of 2nd web neuroma. (**b**) Excision of 2nd web interdigital neuroma by dorsal approach. (**c**) Excised enlarged neuroma specimen (2 cm in length)

resected end of the common digital nerve. Although the recurrent neuroma could develop because the initial resection of the nerve was not sufficiently proximal to the metatarsal head, in some cases, it is not easy to find the reasons of recurrence. Overall, the outcome of conservative treatment or reexploration for a recurrent neuroma through either a dorsal or a plantar incision was less satisfactory. Only 30–50 % of cases result in complete symptom relief even after reexploration [9, 63] (Table 3.3).

Sesamoid Lesions

Introduction

The sesamoids of first metatarsophalangeal (MTP) joint lied within the double tendon of the flexor hallucis brevis (Fig. 3.18). They articulate with the plantar facets of the first metatarsal head, absorb the weight of the first ray, and increase the mechanical advantages of the intrinsic muscles. Flexor hallucis longus that courses over the plantar surface of the first metatarsal head can be protected by the presence of sesamoids.

Ossification of the sesamoids often occurs from multiple centers, which is thought to be the reason for the development of multipartite sesamoids which results from predisposing disruption of the synchondrosis with minimal injury. The reported incidence of bipartite sesamoids ranged from 6 to 31 % with predominance of tibial sesamoid [22, 27, 59]. Also, it has not been determined whether some of these partite sesamoids are actually nonunions of fractures.

Diagnosis

Although fractures of sesamoids are relatively rare, it can be difficult to distinguish between a

Table 3.3 Treatment outcomes of Mortons's neuroma

Modality	Papers	No. of feet	Outcomes
Alcohol injection	Hughes et al. [36]	101	Mean 2 years follow-up with average four injections per person
			94 % improved; 84 % was pain-free
			30 % size decreased at sonography of 30 patients
	Musson et al. [52]	87	Mean 14 months follow-up
			66 % achieved partial or total response
			17 (20 %) went on surgery due to persisting pain
Steroid injection	Makki et al. [46]	43	1 year follow-up
			Outcomes at 6 months with size less than 5 mm were superior than those of larger than 5 mm
			6 (14 %) underwent surgical excision due to pain
	Rasmussen et al. [57]	51	Mean 4 years follow-up
			Initial relieved pain in 36 (80 %)
			24 (47 %) ultimately required surgical excision
Neurolysis	Deibold et al. [20]	40	5 years follow-up
			35 (88 %) had excellent outcomes
	Okafor et al. [53]	35	21.4 years follow-up
			29 (83 %) showed complete or near-complete resolution
Neurectomy	Coughlin et al. [18]	82	Average 5.8 years follow-up
			56 (85 %) satisfactory outcomes
			36 (51 %) subjective numbness
	Womack et al. [75]	120	51 % good or excellent; 10 % fair; 40 % poor results
			2nd web neuroma had worse outcomes than 3rd neuroma

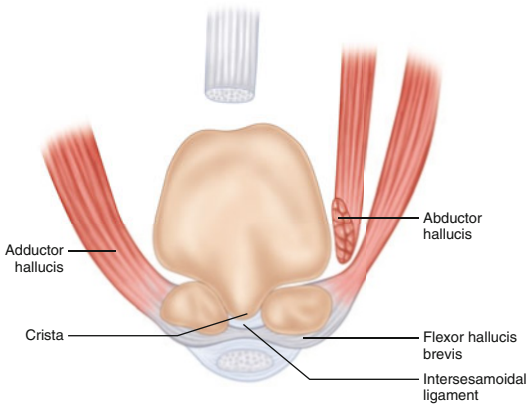


Fig. 3.18 Anatomy of sesamoid bones in the 1st metatarsal

Table 3.4 Differential diagnosis for pain around sesamoids of hallux

Trauma related
Acute fracture of sesamoid
Tibial sesamoid fracture nonunion
Stress fracture
Turf toe
Nontraumatic
Sesamoiditis
Bursitis (under sesamoids) with or without soft tissue mass
Infection
FHL tenosynovitis
Metatarso-sesamoidal arthrosis

fractured sesamoid and a symptomatic bipartite sesamoid. Various etiologies for the sesamoid area metatarsalgia can be present and epidermal cyst in the 1st metatarsal plantar area is a possible diagnosis (Table 3.4 and Fig. 3.19). Sesamoiditis, sesamoid fracture, bipartite sesamoid, and sesamoid avascular necrosis are the important differential diagnosis entities. Besides the clinical symptoms, plain radiograph, CT, and MRI are important diagnostic imaging tools for correct diagnosing and appropriate treatment.

Fig. 3.19 Epidermal cyst mimicking 1st metatarsal sesamoid lesion

Favinger et al. reported that the dominant sesamoid interval ranged from 0 to 2 mm, with an average of 0.79 mm suggesting that sesamoid diastasis should be considered when the sesamoid interval is greater than 2 mm on a routine AP radiograph of the foot [27]. If radiograph seems to be normal in spite of a patient's subjective symptoms, a bone scan may be useful due to high sensitivity. Computed tomography (CT) will be useful to define bony changes such as acute fracture or fragmentation. Magnetic resonance imaging (MRI) can be used to evaluate the status of surrounding soft tissue such as plantar plate injury (turf toe), tendon injury, and enlargement of soft tissue around sesamoids, as well as the status of sesamoid bones before radiographic changes such as sesamoid AVN and sesamoiditis.

Treatments

Treatment Algorithm

For relieving chronic symptom around sesamoid, conservative treatment to relieve pressure and motion of the first metatarsophalangeal joint should be started first. Usually, symptom can be managed in a tolerable amount by appropriate conservative method although it will take substantial time to resolve completely. In cases of acute trauma with apparent disruption of bone or plantar plate and chronic symptoms recalcitrant to conservative treatment, particular surgical treatment can be selected for the treatments.

Conservative Treatment

The main goal of the conservative treatment is to reduce pressure and motion beneath the sesamoids. Decreased walking activities, avoidance of jumping and running activities, the use of metatarsal pads or custom foot orthoses, a stiff-soled shoe, decreasing shoe heel height, and the taping of the great toe in some degree of plantar flexion may reduce weight-bearing pressure and relieve symptoms. NSAIDs can be effective at times.

Surgical Treatment

When symptoms continued after appropriate conservative treatment, surgical decompression can be tried. If intractable plantar keratosis or sesamoid discomfort is combined with a plantarflexed first metatarsal, a dorsiflexion osteotomy might be considered before sesamoid procedures.

Sesamoid Plantar Shaving However, at times, sesamoid shaving with soft tissue resection can alleviate symptoms in case of hypertrophied sesamoids, sustained sesamoiditis, and intractable plantar keratosis (Fig. 3.20). Mann and Wapner [47] reported that majority of patients had no functional limitations and a normal range of motion after tibial sesamoid shaving. They noted one case of recurrent callus formation and four cases of slight recurrence of callosity in 16 cases.

Sesamoid Excision Another surgical option for intractable sesamoid lesions such as infection, osteonecrosis, nonunions, hypertrophied or distorted sesamoids, intractable sesamoiditis, and intractable plantar keratosis is resection of involved sesamoid bone [65]. Either a tibial or fibular sesamoid is thought to be excised without developing a significant deformity unless it is combined with a hallux valgus or hallux varus deformity [14]. However, if both sesamoids are excised, the attachment of the flexor digitorum brevis into the base of the proximal phalanx after passing around the sesamoids may be disrupted (Figs. 3.21 and 3.22).

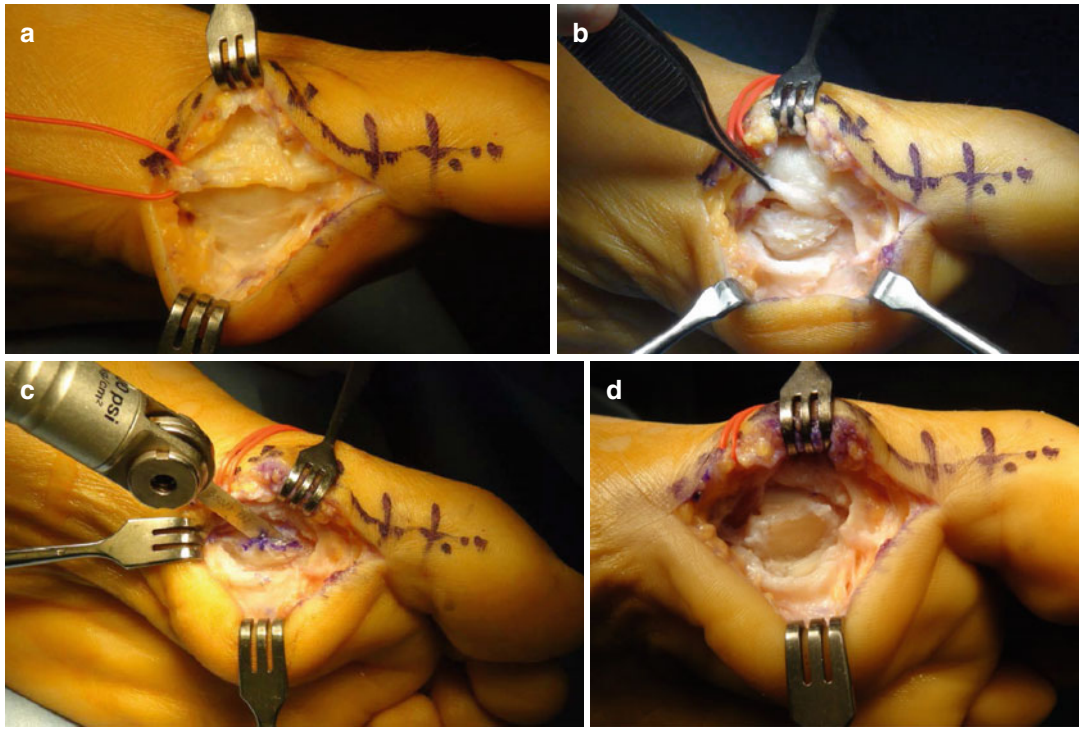


Fig. 3.20 (**a**–**d**) Surgical procedures of the plantar shaving of the medial sesamoid

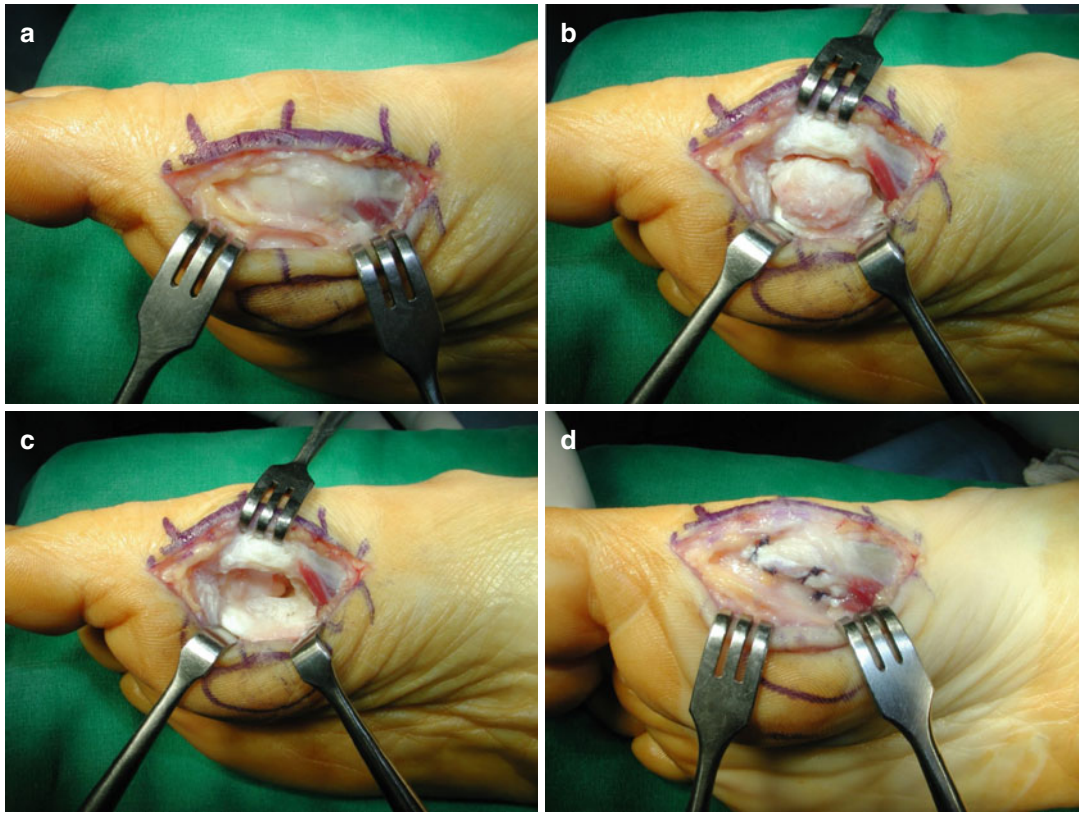


Fig. 3.21 (**a**–**d**) Surgical procedures of the medial sesamoidectomy by medial approach

Fig. 3.22 Hockey stick incision formed sesamoid excision (postoperative)

Approaches While the medial sesamoid is thought to be approached through a medial (medial or plantar-medial) approach, the surgical approach for fibular sesamoid excision is still somewhat controversial. Traditionally, a longitudinal plantar approach directly over fibular sesamoid was advocated [43]. Repair of the short flexor tendon and conjoined tendon after shelling out the sesamoid while protecting the lateral plantar hallucal nerve is thought to be important (Figs. 3.23 and 3.24). However, there has been a concern about postoperative scarring or keloid formation directly beneath the sesamoid excision area which may cause intractable pain. To avoid this possible complication, dorsolateral approach to fibular sesamoid was recommended especially in case with subluxated fibular sesamoid with hallux valgus deformity [28]. However, in case with fibular sesamoid without subluxation, it may be difficult to resect fibular sesamoid through dorsolateral approach. Rodrigues Pinto et al. even described a surgical excision of the lateral sesamoid through an extensive medial approach [58].

If there is a symptomatic nonunion after acute fracture or stress fracture of sesamoids, several authors reported successful results after bone graft [4] with/without internal fixation [12, 56]. However, partial/complete sesamoidectomy with restoration of flexor mechanism is still a viable option for intractable sesamoid nonunions.

Author's Tips As for the symptomatic sesamoid fracture or nonunion, our primary option is partial sesamoidectomy, i.e., excision of smaller fragment and repair of the flexor hallucis brevis and intersesamoid ligaments. We use plantar-medial approach for medial sesamoid and plantar approach for fibular sesamoid. Bone grafting can be performed for stable nonunion with minimal diastasis.

Results

Aquino et al. performed 26 tibial sesamoid shaving for intractable plantar keratoses, and 89 % subjective success rate was reported [5]. With regard to fracture nonunion, Anderson et al. treated symptomatic tibial sesamoid nonunions with curettage and bone grafting the diastasis [4]. Nineteen of them (90 %) had healed at final

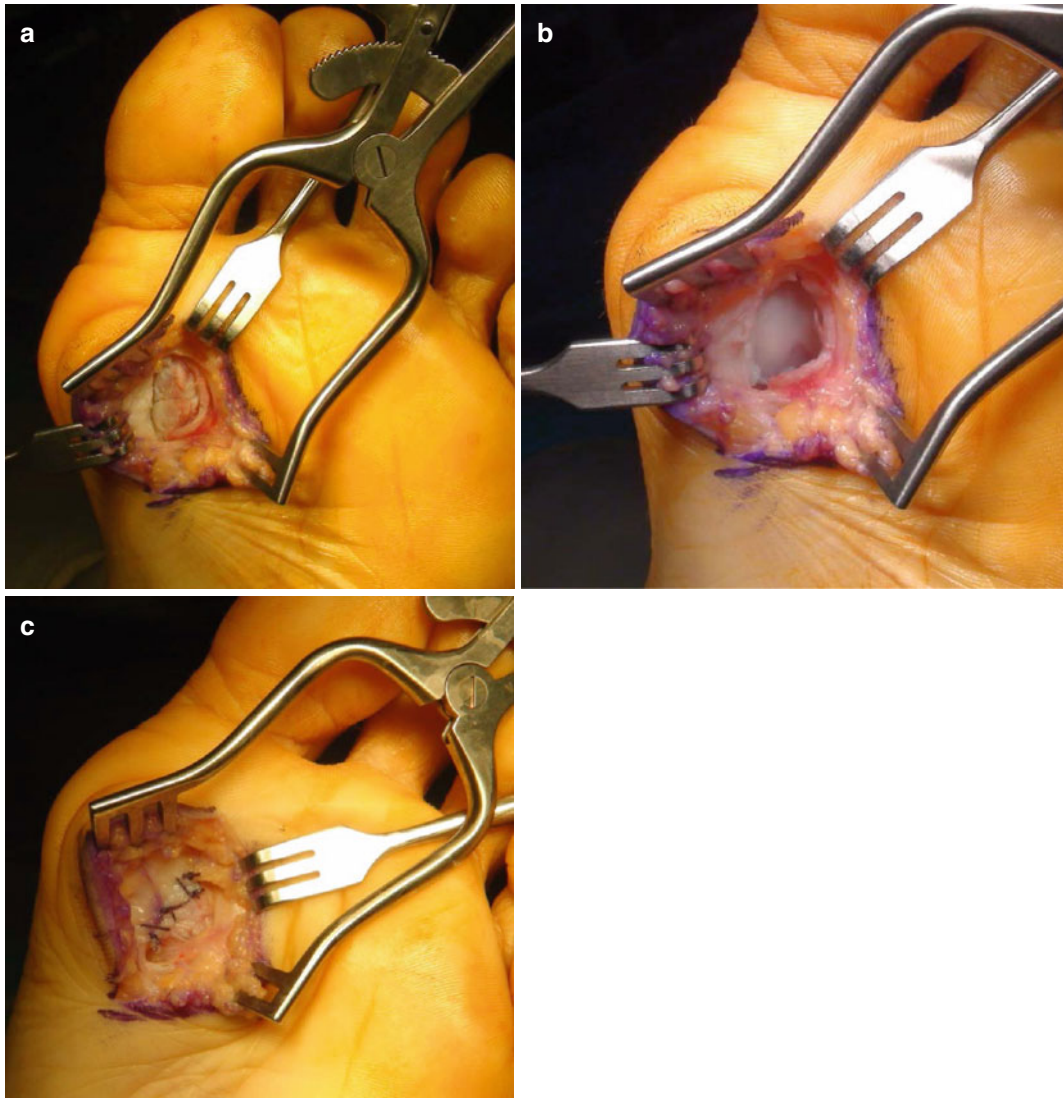


Fig. 3.23 (**a**–**c**) Fibular sesamoid excision and ligament repair by plantar incision for the fibular sesamoid fracture nonunion

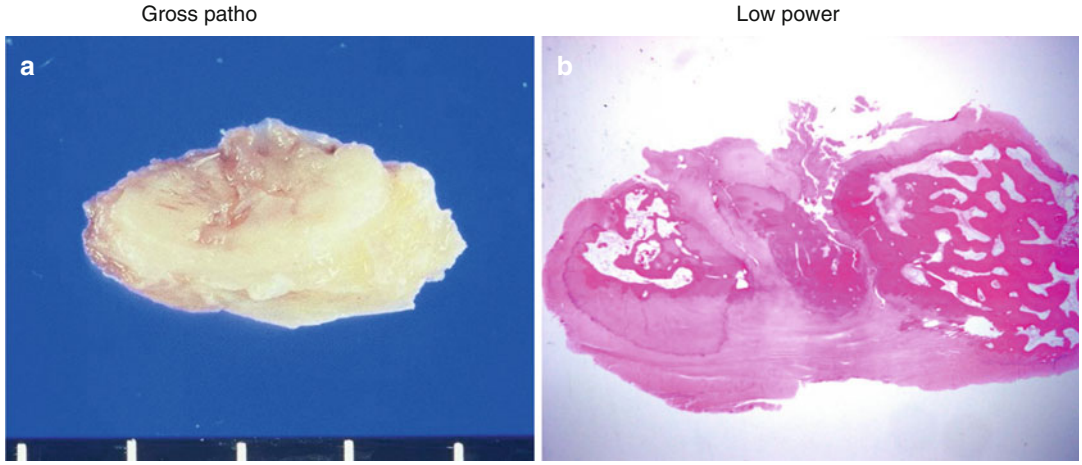


Fig. 3.24 Excised medial sesamoid avascular necrosis (AVN) confirmed with pathology. (**a**) Gross photo. (**b**) Low-power field micro-photo

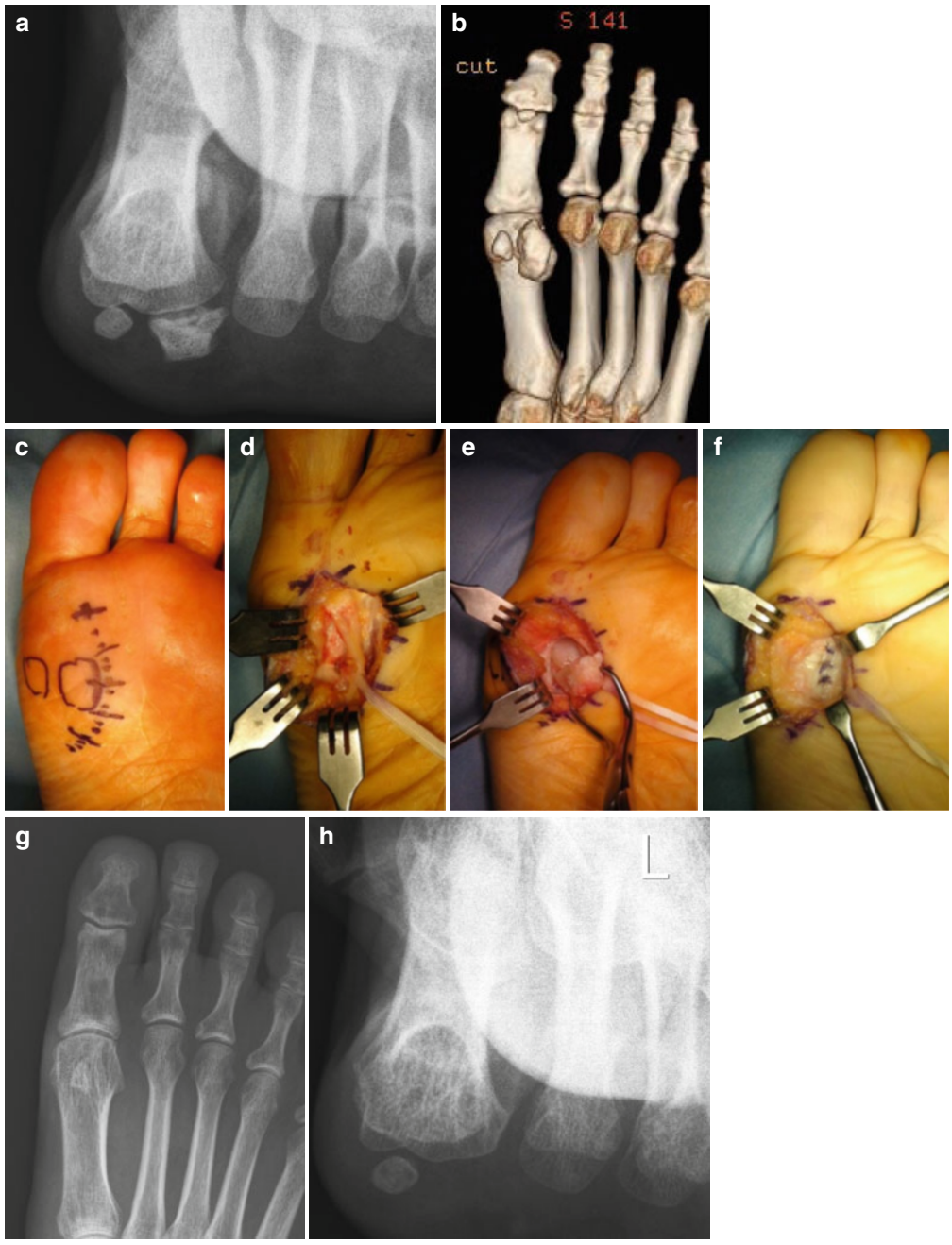
Table 3.5 Treatment for sesamoid fracture

Procedure	Papers	No. of patients	Outcomes
Sesamoidectomy	Bichara et al. [10]	24	Excision of the proximal fragment and repair of FHB
			22/24 (92 %) return to activities at average 3 months
			Pain VAS from 6.2 to 0.7
	Sexena et al. [60]	24	Mean follow-up: 86 months
			10 fibular, 16 tibial sesamoidectomies
			Complication: one varus, one valgus, two neuroma
			Recovery time was longer in tibial sesamoidectomy
Bone graft/or internal fixation	Anderson et al. [4]	21	Bone grafting without internal fixation
			19/21 (90 %) had healed at final follow-up
	Blundell et al. [12]	9	Percutaneous Barouk screw fixation
			AOFAS score from 47 to 81
			Return to previous activity: 3 months

follow-up without internal fixation. Biedert et al. excised the proximal fragment and repaired the flexor hallucis brevis for five athletes who had stress fractures of the medial sesamoids [11]. And they could return to full sports activity after 8 weeks (Table 3.5).

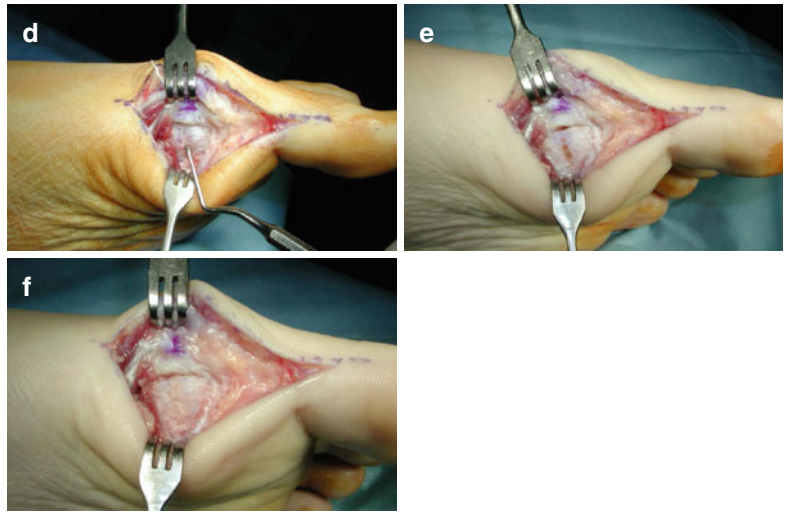
Cases

Case 3.4 Giant fibular sesamoid: Thirty-four-year-old female patient presented with bilateral 1st metatarsalgia for 6 months without previous trauma history. (a, b) Sesamoid view and the CT show huge dysplastic lateral sesamoid about 2 cm in length. (c) Curve linear plantar 1st web space incision. (d) The plantar lateral digital nerve is exposed and mobilized laterally and proximally to expose the lateral sesamoid. (e) The defect after subperiosteal dissection and removal of the fibular sesamoid (in the picture). (f) The periosteal soft tissues are sutured to prevent the postoperative hallux varus complication. (g) Postoperative anteroposterior (AP) radiograph. (h) Postoperative sesamoid view.

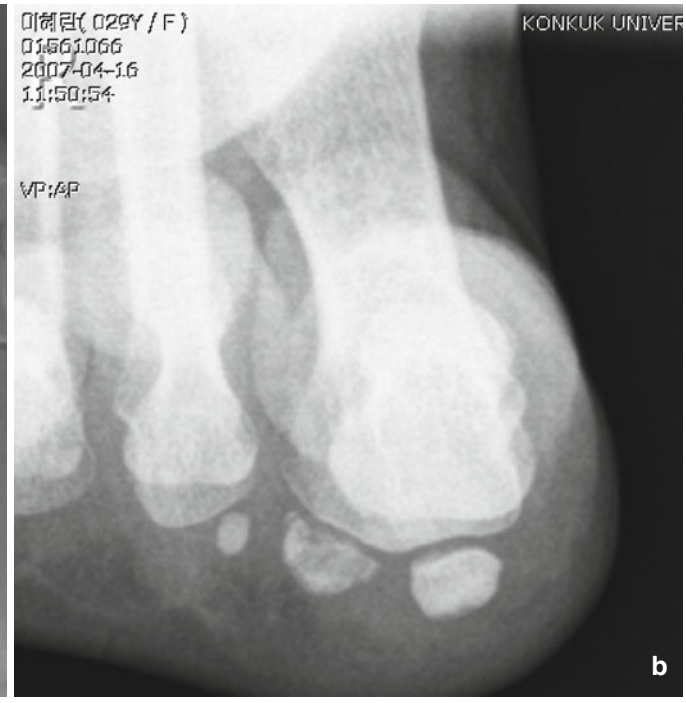


Case 3.5 Sesamoid fracture nonunion: Twenty-year-old college elite baseball player came with bilateral 1st metatarsalgia since 6 months. (a–c) He had cavus feet with bilateral medial sesamoid fracture nonunion. CT showed fracture fragmentation with sclerosis. He was unable to participate in sports. (d, e) Proximal fragment of medial sesamoid excision and BRT MTO was performed to elevate the plantar-flexed 1st MT. Akin osteotomy was performed to address hallux valgus interphalangeus concomitantly.

Case 3.6 Osteosynthesis of sesamoid nonunion: (a–c) Twenty-two-year-old male had pain and tenderness at big toe metatarsal head area since long-distance running in army training 8 months ago. Plain x-ray and CT scan show the sesamoid fracture nonunion with irregular fracture line. (d, e) Osteosynthesis of the medial sesamoid nonunion was performed through medial approach, curettage of fibrotic tissues, and cancellous bone grafting obtained from the metatarsal head with burr. Postoperatively, the foot was immobilized with a short leg cast for 10 weeks. (f) Final intraoperative photo after bone graft insertion in the fracture gap.



Case 3.7 Sesamoid comminuted fracture: (a, b) Twenty-nine-year-old female patient sustained forefoot plantar area pain after some jump down injury. The x-ray of foot in AP and sesamoid view shows sesamoid comminuted fracture. The patient was treated with 5 weeks of cast and 3 weeks of post-op shoe.



Freiberg Disease

Introduction

Freiberg disease is defined as avascular necrosis of the metatarsal head which has been recognized as one of the most frequent site of osteochondrosis development. In 1914, Freiberg initially described this condition using the term "infraction" to explain disorder associated with a history of mild trauma to the foot [15]. Various potential etiologic factors such as trauma, impaired vascularity, and/or systemic disorders are thought to be involved in the development of Freiberg disease. Although isolated trauma was unlikely to be an etiologic factor, chronic repetitive microtrauma might play a role in the disease development. The second metatarsal head has been shown to bear the greatest stresses during walking [23]. The stable configuration of the cuneiform 2nd metatarsal joint enables substantial stability to the second metatarsal base, leading to increasing stress on the metatarsal head distally. Hypothetically, if repetitive micro injury at the site of stress concentration is combined with a critical stage of development when the epiphyseal blood supply is jeopardized, failure of revascularization may happen and the disease process may be initiated [15]. A relative weakness of the metatarsal epiphysis at a certain stage of epiphyseal maturation might be underlying cause for adolescence being the typical time of the disease onset [13].

For epidemiology, the second metatarsal head is the most frequent site of Freiberg disease, followed by the third and then the fourth metatarsals. The fifth metatarsal head is rarely involved. A multiple or bilateral involvement has been reported. There is a female preponderance of involvement and 2nd decade is the most prevalent period.

Diagnosis

The typical presentation is a female adolescent experiencing pain localized to the involved metatarsal head which is worse with weight bearing and activities. On physical examination, the involved MTP joint may be swollen and tender. The range of movement usually would be decreased.

Images of plain radiographs are usually helpful to diagnose and plan a treatment method. However, in early stage of Freiberg disease before definite change such as flattening or subchondral bone collapse of metatarsal head has developed, widening of the joint space can be an only finding which can be observed in plain radiograph. In bone scan, increased signal density will be observed within the metatarsal head. If high-resolution bone scan image can be obtained, a photopenic infarcted area surrounded by a hyperactive uptake zone might be observed [15]. MRI would be helpful for early diagnosis of Freiberg disease and for planning a surgical treatment according to the status of articular cartilage to prevent further deformation and subsequent degeneration in the involved joint [15].

Differential diagnosis should include stress fracture, infective arthritis, tumorous condition, inflammatory arthritis, and various stages of degenerative arthritis. Adequate radiographic and serologic assessment would be required to rule out the other possible diagnosis before confirming Freiberg disease.

Treatment

Treatment Algorithm

Treatment plan for Freiberg disease depends on the stage of disease. If there is no loss of articular cartilage or degenerative changes, no surgical treatment would be required. However, if loss of articular cartilage and/or degenerative osteophyte formation was significant and disabling, various combinations of surgical treatment might be sought to alleviate patient's symptom and to prevent further derangement of the involved joint.

Conservative Treatment

Alike with other osteochondrosis in which the disease process would be self-limiting, alleviation of patient's symptom by using oral analgesics and activity modification would be a primary goal of management in early stage of disease. So

far, no specific treatment or management had been proved to shorten or prevent disease process. However, protected weight bearing with a hard-soled shoe, orthosis, or walking boot might be beneficial to reduce long-term sequelae. Once degenerative change and significant collapse of articular cartilage had initiated, conservative treatment have little effect on the progression of disease process, although it can offer alleviation of symptoms for the patient.

Surgical Treatment

The surgical management for the Freiberg disease includes debridement, corrective osteotomy, core decompression, osteochondral plug transplantation, and resection arthroplasty. In the early stage of the disease, open surgical debridement, osteochondral transplantation as well as osteotomy might be beneficial to prevent progression of deformity and collapse. After the arthritic change progressed, corrective osteotomy has limited potential to improve disease process. If there is advanced arthritic change in involved joint, resection arthroplasty with interposition of soft tissue can be used (Table 3.6) (Figs. 3.25 and 3.26).

Surgical technique can be categorized into two types. One type is procedure focused on restoration of articular surface of metatarsal head, in which corrective metatarsal osteotomy and osteochondral plug transplantation will be included. If there are no advanced degenerative changes around the involved cartilage, articular cartilage may be restored by using osteochondral plug transplantation [33, 50] or by elevation of the depressed articular fragment with bone graft [61]. More widely used procedures to restore metatarsophalangeal articulation using intact portion of metatarsal head cartilage is redirectional metatarsal osteotomy. Although the level of osteotomy can be intra-articular [32, 42, 62] or extra-articular [40], redirection of articular cartilage can be obtained by closing wedge osteotomy with resection of bone wedge based on dorsal metatarsal cortex. Various types of fixation technique have been introduced, which include

Table 3.6 Surgical options for Freiberg disease

1. Debridement
2. Metatarsal corrective osteotomy (dorsal closing wedge osteotomy)
3. Core decompression
4. Osteochondral plug transplantation
5. Resection arthroplasty

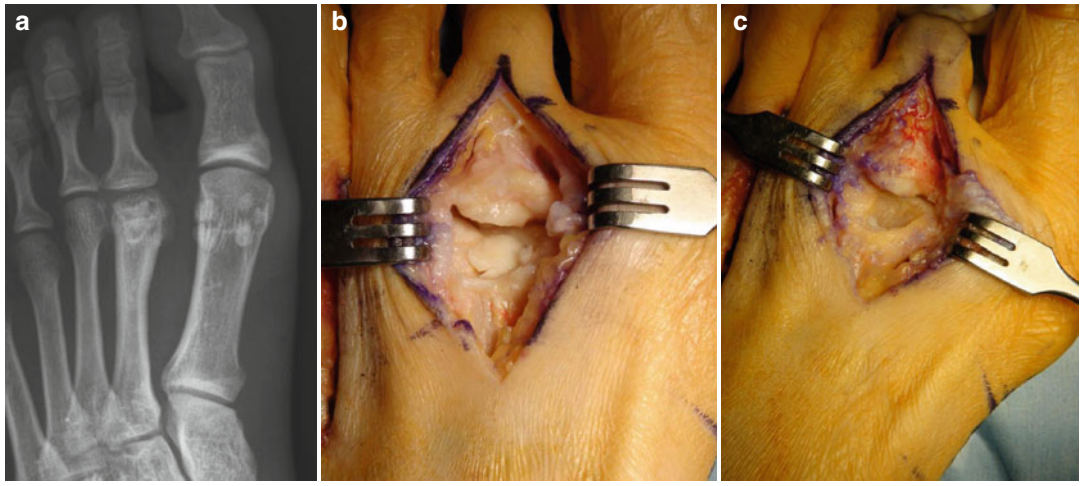


Fig. 3.25 (**a**–**c**) Chronic stage Freiberg disease with fragmented dorsal osteocartilaginous fragment was removed to decompress the pain

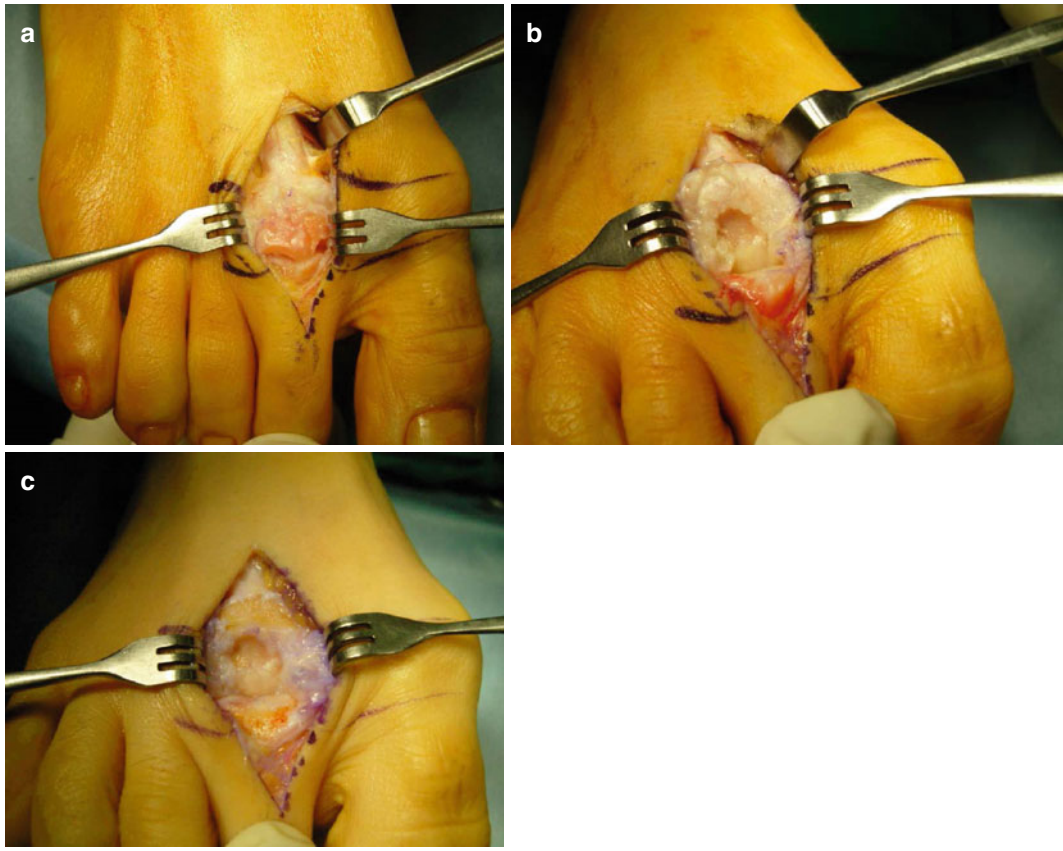


Fig. 3.26 (**a**) Chronic Freiberg disease with 2nd MTP arthritis and dorsal spur. (**b**, **c**) Joint debridement including bony spur excision was performed

Kirschner wires, trans-osseous sutures, and bioabsorbable pins (Fig. 3.27).

The other type is procedure focused on reducing symptoms of the patient with hope of prevention of disease progression, in which decompression with multiple drilling, debridement, bone spur excision, and interpositional arthroplasty will be included. In advanced Freiberg disease, severe degenerative changes with or without MTP joint subluxation may preclude restoration of normal articulation. Sometimes, a shortening osteotomy can offload the metatarsal head, which results in reduction of symptoms. Although too much shortening or excision of metatarsal head may break the integrity of the metatarsal arch, lead to transfer metatarsalgia, and progression of toe deformities, severe degenerative change accompanied with subluxation of MTP joint may not be corrected without resection of metatarsal head (resection arthroplasty). Soft tissue interposition after resection arthroplasty is thought to be beneficial in reducing complication rate after resection of metatarsal head [15].

Author's Comments We usually perform MTP joint debridement which mainly involves the loose cartilaginous and bony fragment excision and spur excision for chronic Freiberg disease. However, in case if more than plantar 2/3 of MTP joint cartilage is preserved, we perform dorsal closing wedge osteotomy and fix with bioabsorbable pin or twist-off mini-screw as Weil osteotomy is performed (Cases 3.8 and 3.10).

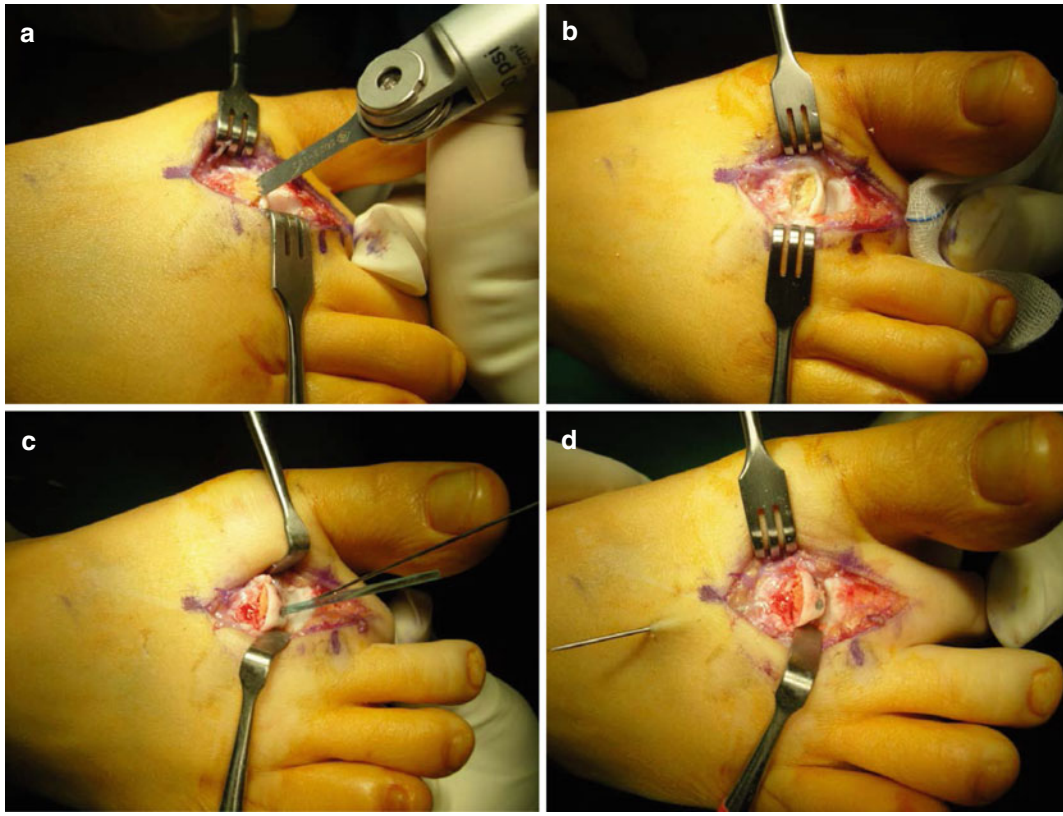


Fig. 3.27 (**a**–**d**) Dorsal closing wedge osteotomy for Freiberg disease with dorsal cartilage degeneration was performed and fixed with bioabsorbable screws

Table 3.7 Results of surgical treatments for Freiberg disease

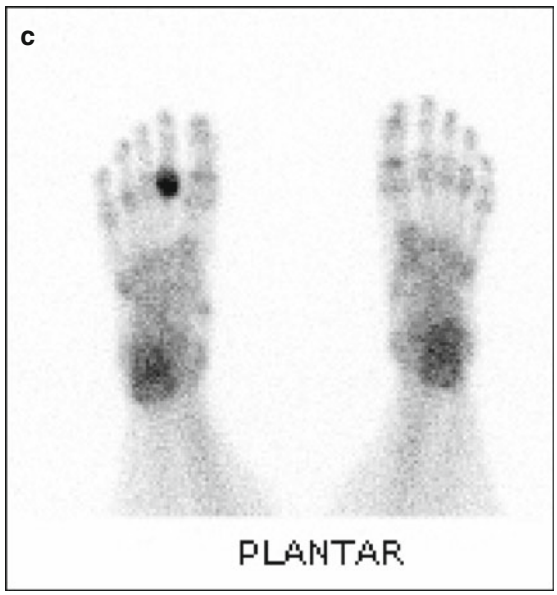
Procedure	Papers	No. of patients	Outcomes
Osteochondral plug transplantation	Hayashi et al. [33]	1 (2 toes)	At one year postoperative, no pain with full activity
			Smooth articular surface on 2nd look arthroscopy
	Miyamoto et al. [50]	4	AOFAS from 71 to 98
			On 2nd look at 1 year, 2 showed normal and 2 nearly
			normal cartilage (ICRS score)
Dorsal wedge osteotomy	Gauthier et al. [30]	53	Only 1 patient (2 %) had persistent pain
	Lee et al. [42]	12	Mean follow-up: 45 months
			Pain VAS from 8.0 to 2.3
			All were satisfied with surgery outcomes
			ROM increased by a mean of 26°
Interpositional arthroplasty	Thompson et al. [66]	12	Split transfer of flexor digitorum longus tendon
			83 % reported excellent outcome
	Lui [44]	2	Arthroscopic surgery using extensor digitorum brevis
			Good analgesic, but range of motion did not improve

Results

Debridement or cheilectomy usually can provide satisfactory symptom relief. Passive motion of MTP joint usually remains although active range of motion does not. As for dorsal wedge osteotomy, many studies report high satisfaction level after surgery. In the early stage, debridement or osteotomies are supported by fair evidence [15]. Resection arthroplasty with soft tissue interposition is also supported by fair evidence in case that the joint has severe arthritic change. However, there remains insufficient evidence of core decompression, perichondral grafting, and arthroplasty with prosthesis such as metal or ceramic [15] (Table 3.7).

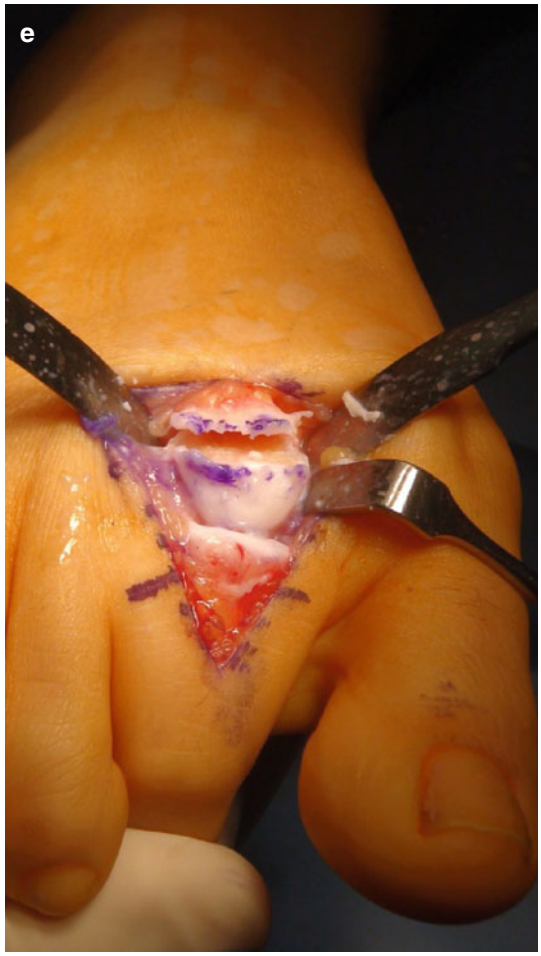
Cases

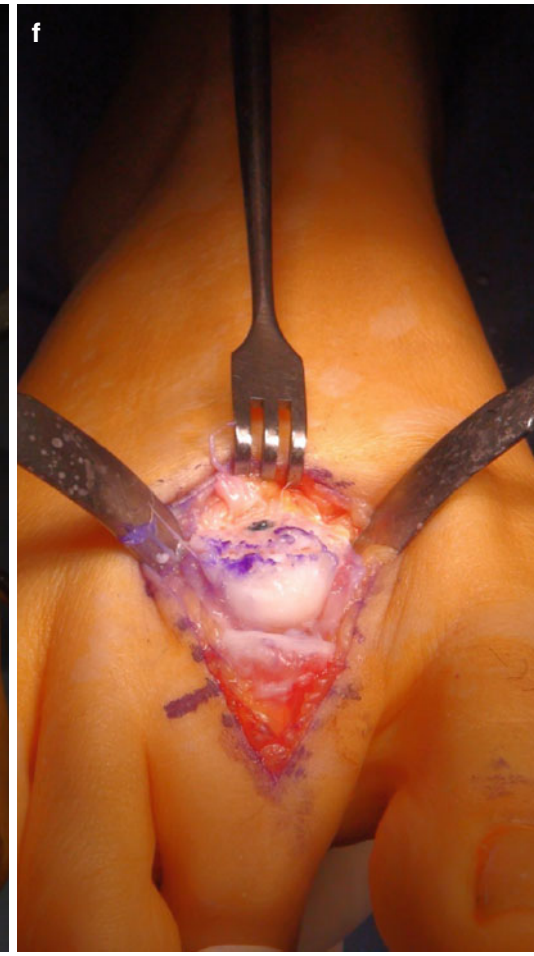
Case 3.8 Freiberg acute stage: Twenty-five-year-old female patient presented with acute severe metatarsalgia in the 2nd MTP joint area for 2 weeks. (a, b) The foot x-ray shows 2nd metatarsal head area sclerosis with cleavage and collapse of the upper metatarsal articular area. (c) The bone scan demonstrates hot uptake in the 2nd metatarsal head area. Under the diagnosis of acute stage of Freiberg's infraction, the patient was immobilized with cast for 6 weeks.



Case 3.9 Chronic Freiberg disease: (a) 19-year-old male elite long-distance runner started to have 2nd metatarsalgia for 5 years after several hours of running. Foot radiograph showed 2nd MT head flattening with arthritis and multiple loose bodies. (b) CT sagittal view revealed excavated MT head with loose body. (c, d) Loose body removal and spur excision were performed with complete relief of preoperative pain and crepitus on motion.

Case 3.10 Freiberg dorsal C/W osteotomy: (a, b) Chronic stage 2nd MT Freiberg disease with dorsal 1/3 joint cartilage destruction with bony spur. (c, d) Dorsal closing wedge osteotomy after wedge resection of arthritic cartilage head portion was performed. It was fixed with twist-off screw. (e, f) Operative pictures of the closing wedge and plantar portion elevation.





Lesser Toe Problems

Introduction

Lesser toe deformities can occur as isolated entities or be associated with deformities of the hallux, midfoot, or hindfoot. Etiology of lesser toe deformities includes congenital, neuromuscular, trauma, familial heritance, and the effect of bad footwear. A mallet toe refers to a condition that the distal phalanx is flexed on the middle phalanx, while a hammer toe refers to a condition that the middle and distal phalanges are flexed on the proximal phalanx. A claw toe involves a hammer toe deformity of the phalanges and dorsiflexion (extension) deformity at the MTP joint.

Hammer Toe/Claw Toe

The cause of a hammer toe/claw toe deformity is often unclear. A constricting toe box may play as a causative factor of these deformities. They may be associated with the neuromuscular diseases, inflammatory arthritis, posttraumatic deformities, and insensate foot associated with diabetes mellitus. Associated hallux valgus deformities are also thought to be a causative factor.

An understanding of the anatomy around the MTP, PIP, and DIP joints and pathomechanism of hammer toe/claw toe deformity is helpful to decide treatment option. The significant stabilizing factors of the MTP joint are the collateral ligaments and the plantar plate with a combination

of the plantar aponeurosis and plantar capsule. The main function of the extensor digitorum longus (EDL) is to dorsiflex the proximal phalanx. However, EDL tendon functions as an extensor of the PIP joint only when the proximal phalanx is held in a neutral or flexed position at the MTP joint. If the MTP joint is in extended position, the function of EDL tendon on the PIP joint would be weakened. Because there is no insertion of flexor digitorum longus (FDL) and brevis (FDB) tendon into the proximal phalanx, FDL and FDB exert minimal flexion force at the MTP joint. As a result, with the MTP joint in an extended position, there are no major extensor antagonists to the flexors, resulting in flexion of the DIP joint and the PIP joint. Tendons of the interosseous and lumbrical muscles pass plantar to the axis of motion of the MTP joint, flexing the MTP joint, and pass dorsal to the axis of the PIP joint and DIP joint, extending these joints. However, with progression of dorsiflexion at the MTP joint, the lumbrical's flexion power becomes limited because its insertion on the extensor sling cannot pull effectively. So, the hyperextended proximal phalanx is the key to the production of hammer toe/claw toe deformities. With chronic progression of the MTP joint extension, the EDL tendon loses its function on the PIP joint, the FDL and FDB tendons increases the flexion deformity at the PIP joint, and the plantar structures gradually become stretched and inefficient.

Flexible Hammer/Claw Toe

When the patients have a flexible hammer/claw toe deformity, the deformity is present when they are standing and becomes absent when they sit with the foot in an equinus position. Then, the deformity can then be reproduced if the ankle joint is dorsiflexed and the metatarsal heads are pushed from beneath. The deformity is thought to be caused by a contracture of the FDL tendon. Flexor tendon transfer can be a treatment option for a flexible hammer toe. For flexor tendon transfer, the FDL tendon is released from its insertion into the distal phalanx, split longitudinally, and passed dorsally to the extensor hood at midportion of the proximal phalanx. Then, the flexor tendon is sutured to the EDL tendon. The outcome of the FDL transfer was reported to be controversial as recurrent deformity, poor alignment, and postoperative stiffness might cause dissatisfaction. If a fixed contracture is present, this procedure alone usually does not produce a satisfactory result. In patients with a dynamic claw toe deformity, a release of the EDL tendon and simultaneous MTP capsulotomies may be performed. Temporary fixation with a K-wire can be accompanied in case of some rigidity.

Fixed Hammer Toe Deformity

If the hammer toe deformity is rigid, joint contractures preclude passive correction of the deformity so that the isolated FDL tenotomy or FDL transfer would be insufficient. Most widely used procedures for fixed hammer toe deformity without claw toe deformity would be resection arthroplasty of the proximal phalanx head (the DuVries arthroplasty). The FDL tendon can be identified and transected though the operating wound.

Recently, instead of the resection arthroplasty, permanent fusion of PIP joint using intramedullary devices or other fixation method becomes more widely used. If hyperextension of MTP joint exists, soft tissue release such as dorsal capsular release of the MTP joint and/or extensor tendon lengthening should be accompanied.

Fixed Claw Toe Deformity

If a fixed hyperextension deformity of the MTP joint (fixed claw toe deformity) exists, surgical correction of this deformity would be mandatory. In cases of a moderate deformity, an EDL Z-lengthening and MTP dorsal capsule release may be necessary. However, if severe subluxation or dislocation of the MTP joint happens, the soft tissue procedures would be insufficient so that a metatarsal osteotomy might be required. Usually, distal metatarsal osteotomy (e.g., Weil osteotomy) along with soft tissue release around the MTP joint would be performed to realign MTP joints. If the MTP joint is not realigned after the osteotomy, plantar plate repair and/or flexor tendon transfer can be considered to reduce the MTP joint. In case with fixed claw toe deformity, the authors prefer PIP joint fusion rather than PIP resection arthroplasty to solve the hammer toe problems.

Case 3.11 Fixed claw toe*:* (a–c) Forty-one-year-old male patient presented with posttraumatic 2nd rigid claw toe with severe toe tip pain on standing. (d, e) Proximal interphalangeal joint arthrodesis with two 1.2 mm K-wire fixation was performed to straighten the toe.

Mallet Toe Deformity

Mostly, the specific cause of a mallet toe is unknown, although pressure of the toe against the toe box of shoe is thought to be major contributing factors. A mallet toe occurs frequently in toe longer than the adjacent toes and may develop after a trauma or be associated with inflammatory arthritis. Although the FDL tendon might be tight in patients with a mallet toe deformity, whether this tightness is a cause or a secondary change is not proven yet.

If there is a flexible mallet toe deformity, the FDL tenotomy may be performed (Fig. 3.28). However, in case with a fixed mallet toe deformity, the condylectomy of middle phalanx with or without FDL tenotomy should be performed to reduce the DIP joint. The reduced joint may be temporarily fixated using Kirschner wire.

Case 3.12 Long 2nd toe*:* (a) Sixty-five-year-old female hallux valgus patient with long 2nd toe with toe tip pain. (b) Second toe proximal phalanx shortening osteotomy was performed and fixed with two 1.2 mm K-wires along with PCMO and Akin osteotomy. (c) At postoperative 3 months, good bony union was achieved with complete pain relief.

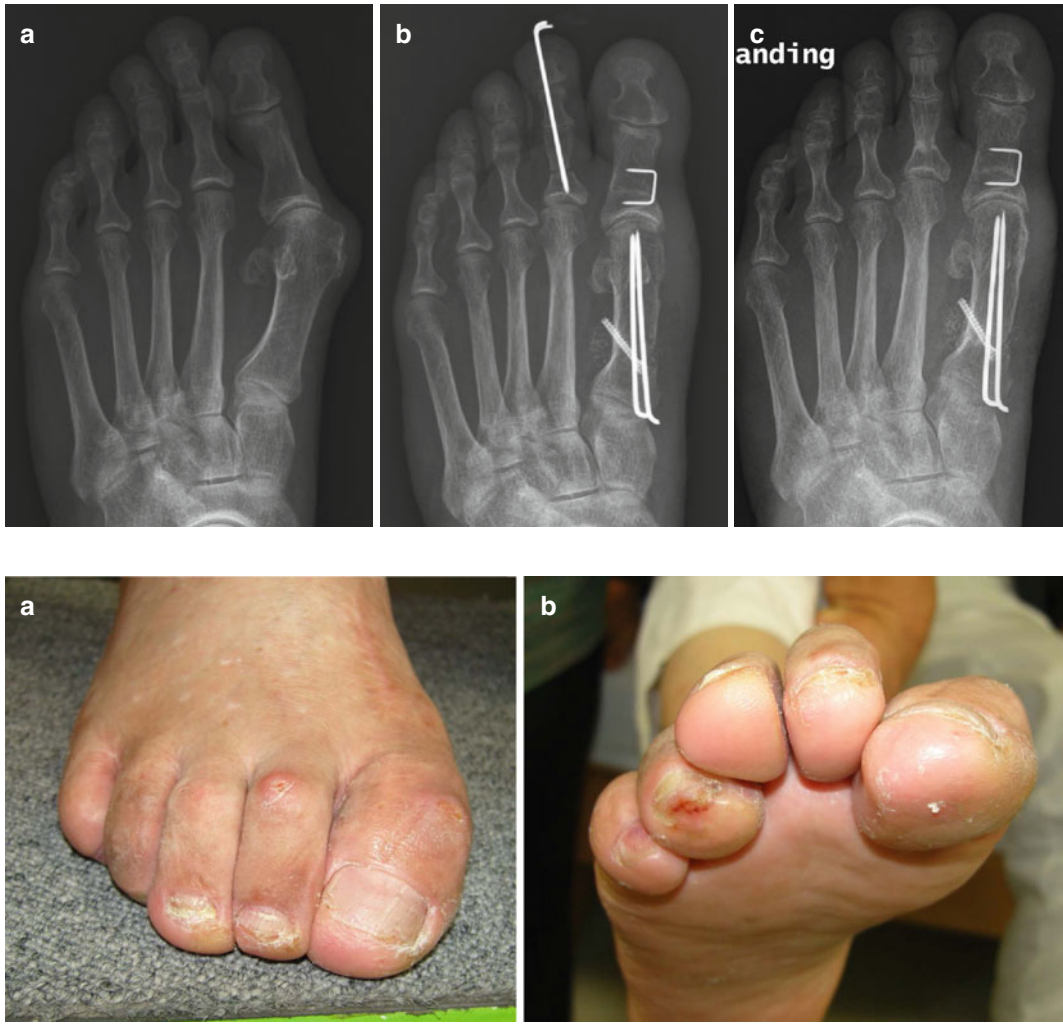


Fig. 3.28 (**a**, **b**) Mallet toe deformity with toe tip pain on weight bearing. FDL percutaneous tenotomy was performed and the pain was relieved

Disorders of 5th Toe

Hard Corns

A corn is a thickening of keratotic layers of epidermis over a bony or soft tissue prominence and a hard corn usually develops at the lateral aspect of 5th toe as a result of extrinsic pressure from footwear and prominence. Sometimes, an interdigital corn may develop over a condyle of the phalanx between the toes. Generally conservative management, such as change of footwear with a soft and large toe box, reduction of the keratotic thickening, and appropriate padding of the symptomatic area, can relieve pressure and symptoms. If conservative treatment fails, surgical decompression may be tried. For lateral hard corn with hammer toe deformity, the flexor tenotomy combined with lateral condylectomy can solve the problem. For interdigital corns, after macerated soft corn is healed, excising the condyles of the proximal phalanx combined with a corresponding condyle of the middle phalanx can be performed.

Rotational Deformity of 5th Toe

Rotational deformity of the 5th toe is usually a congenital deformity and may result to pressure corn at plantar lateral aspect of IP joint. If the 5th toe is externally rotated and a dorsal contracture at the MTP joint is present, the overlapping may develop and it may be uncomfortable because of pressure from footwear against the toe. If the 5th toe is externally rotated and a plantar contracture at the MTP joint is present, it may be located beneath the 4th toe [64].

In case of rotational deformity of 5th toe without overlapping/underlapping, rotational osteotomy at the midshaft level of proximal phalanx may be performed and fixated with two 1.2 mm Kirschner wires. However, in case of moderate/severe overlapping deformity, soft tissue release around the 5th MTP joint including the extensor tendon, the medial collateral ligament, and MTP joint capsule (DuVries procedure) or tendon transfer of the extensor digitorum longus tendon into the abductor digiti quinti (Lapidus procedure) may be performed. For underlapping deformity, operative intervention may consist of osteoclasis, percutaneous flexor tenotomy, capsulotomy, tissue rearrangements, tendon transfers, removal of symptomatic spurs, and corrective osteotomies [64]. In case of severe underlapping deformity, an excisional realignment arthroplasty (Thompson procedure) can be used.

Case 3.13 5th toe rotational deformity: (a, b) Twenty-two-year-old male with 5th toe rotational deformity with lateral painful callus. (c, d) Derotational osteotomy at the midshaft of proximal phalanx and fixation with two 1.2 mm K-wires was performed. The painful callus was resolved.

Bunionette

A bunionette deformity (tailor's bunion) refers to a condition with a painful prominence of the lateral eminence of the fifth metatarsal head. Four types of bunionette have been described [17, 39]. Type 1 was the enlargement of the lateral surface of the fifth metatarsal. The enlargement could be secondary to exostosis, a prominent lateral condyle, or a round or dumbbell-shaped metatarsal head. Type 2 was the lateral bowing of the distal aspect of the fifth metatarsal without hypertrophy of the metatarsal head. Type 3 was an increase in the fourth to fifth intermetatarsal angle (splay foot). Type 4 bunionette represented a condition with a combination of type 1, 2, or 3 deformities.

For initial treatment, conservative management, such as change of footwear with large toe box, shaving the callus, and appropriate padding of the symptomatic area, can reduce pressure and symptoms significantly. For intractable painful keratoses, surgical treatment may be necessary. For large 5th metatarsal head (type 1), lateral condylectomy or distal 5th metatarsal osteotomy (chevron, oblique, transverse, or Weil) can be performed. For lateral 5th metatarsal bowing, distal metatarsal osteotomy can be tried if deformity is not severe. If bowing is severe or there is widening of 4th–5th intermetatarsal angle (type 3), midshaft osteotomy (scarf or oblique) or proximal chevron metatarsal osteotomy would be necessary. If a lateral condylectomy or corrective osteotomy fails to relieve pressure symptoms, more extensive resection such as the 5th metatarsal head resection may be recommended.

Curly Toe

Curly toe is a relatively common deformity characterized by flexion and varus deformity of the interphalangeal joints. It occurs most frequently in the 4th and 5th toes. Although asymptomatic curly toes are more common and spontaneous correction can be observed in children, a curly toe in adults may become a fixed deformity which can provoke pain. In pediatric patients, flexor tenotomy may be used to correct a moderate deformity [69]. However, flexor tenotomy only is insufficient to correct the fixed deformity in adult patients. Choi et al. reported in their series of 32 cases that fixed curly deformity presented more frequently at the PIP (19 of 32 cases) joint and dorsolateral closing wedge-shaped resection arthroplasty as a simple, effective, and powerful option for treating fixed, long-standing fourth curly toe deformity in adults [16].

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