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Midshaft Metatarsal Segmental Osteotomy With Plate Fixation

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The biomechanical distribution of weight bearing and excessive load transmission through the forefoot has made the treatment of metatarsalgia challenging. In addition, structural pathology of the lesser toes and first ray mechanics often complicate the clinical evaluation and intraoperative assessment. Metatarsal shortening and elevating procedures provide an excellent treatment modality when conservative therapy options fail. Metatarsal osteotomies without internal fixation have accounted for high incidences of nonunion and pseudoarthrosis, whereas excessive bone resection causes a shift in metatarsal parabola, leading to alternative stress patterns and complications. The midshaft segmental osteotomy is a shortening procedure used for developing reliability and predictability in the treatment of metatarsalgia. Distal oblique osteotomies with single lag screw fixation are effective means to enhance stability, but can be technically demanding. The midshaft osteotomy with plate fixation is a simple procedure, with excellent union rates, preservation of metatarsophalangeal range of motion, and stable management of shortening. In its preliminary investigation, it has proved to be compliant with its overall objective to improve the predictability of metatarsal shortening and elevation, decreasing complications, and enhancing quality of life. First ray stabilization procedures, gastrocnemius recession, and hammer toe realignments may all influence outcome because metatarsalgia rarely occurs as an isolated condition.

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Lesser metatarsal symptomatology encompasses a myriad of complex pathological conditions affecting one or more metatarsal heads and metatarsophalangeal (MTP) joints. The differential diagnosis includes mechanical, arthritic, neurologic, neoplastic, idiopathic, and multifactorial conditions.

The extensive nature has led to the development of classification systems that are used to describe etiology and guide treatment principles. Helal et al[1] divided metatarsalgia into primary, secondary, and disease unrelated to weight distribution. Primary refers to pain localized to the MTP joints, and includes mechanical problems associated with a short first metatarsal, hallux valgus, hallux rigidus, traumatic, iatrogenic, and plantar keratoses. Secondary metatarsalgia is defined by systemic disease, such as rheumatoid arthritis. Metatarsalgia unrelated to load distribution refers to vascular insufficiency and neuropathic disorders. Most classification schemes attribute lesser toe pathology to structural components, functional components, or a combination of both. Despite the variation among classifications, disturbances in foot biomechanics, anatomic function, systemic involvement, and issues unrelated to weight-bearing serve as key initiators in symptomatic development. The customary insult is excessive load transmission through one or more metatarsal heads, leading to pain, deterioration in the fat pad, and reactive proliferation of the epithelial layer.[2,3] The pain of metatarsalgia, a common ailment, is an incapacitating and debilitating condition that is often refractory to therapy.

Historical Perspective

Precise load-bearing properties of the metatarsals and differences in metatarsal length and stress patterns have made successful management of metatarsalgia challenging. When

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unmanageable with conservative treatment, lesser metatarsal osteotomies have long been accepted as mainstay treatment for metatarsal overload, which theoretically reduces pressure at the metatarsal head. With more than 20 different variations cited in published articles and success rates varying from 57% to 100%, the metatarsal osteotomy can be directed proximally, midshaft, and distally, with planes oriented transverse, oblique, and step-cut.[4]

Historically, Meisenbach[5] in 1916 is credited with being an innovator in the treatment of intractable keratoma. He described a transverse midshaft osteotomy 3 cm proximal to the MTP joint of lesser metatarsals, without the use of internal fixation. A year later, Davis advocated metatarsal head resection, and in 1948 Dickinson supported total ray resection at the level of the proximal metaphysis.[6] The surgery was designed for the management of forefoot pain because of intractable plantar warts and tumors of the metatarsal head.[4,6] McKeever[7] performed a subcapital osteotomy with screw fixation in 1952 for the resolution of pain at the MTP joints. Condylectomy, described by Du Vries[8] in 1953, involved resection of the plantar condyles at the metatarsal head and was later modified to include MTP joint arthroplasty. In 1973, Mann and Du Vries[9] published a long-term follow-up of this procedure in the treatment of intractable keratoses. A study that included 142 symptomatic metatarsals secondary to improper shoe wear showed a 93% patient satisfaction rate, excellent results in 79%, 13% development of a new lesion, and recurrence of the original lesion in 5% of patients.[9,10] Giannestras[11] reported excellent results in 82.5% of patients, good results in 10%, and failure in 7.5% of patients after performing a step-cut midshaft shortening osteotomy. The management for metatarsalgia shifted with osteoclasis, created by Addante,[12] which was an osteotomy of the metatarsal neck directed from dorsal-proximal to distal-plantar, and in 1971 Sgarlato[13] described a dorsal wedge proximal osteotomy. In 1975, Helal[14] illustrated a proximal to distal oblique osteotomy without internal fixation, and in 1990 Spence et al[15] recorded the proximal segmental osteotomy, with 89% good-to-excellent results and 12% transfer lesions when performed as an isolated procedure. Since the institute of the Weil osteotomy technique, osteotomies with internal fixation have been advocated to control metatarsal positioning and to diminish the risk of transfer metatarsalgia.[6]

Biomechanical Considerations

Optimizing operative treatment for lesser metatarsal pain remains on the forefront of foot and ankle reconstruction. The objectives of lesser metatarsal surgery are to alleviate pressure beneath the symptomatic metatarsal by shortening and dorsally elevating the metatarsal head. The pathomechanics of the foot that contribute to metatarsalgia include forefoot overload, secondary to malposition and abnormal distribution of metatarsal load. High-heeled shoes with a narrow toe box overload the forefoot by dorsiflexing the toes and increasing pressure over the metatarsal heads throughout the stance phase. Structural malpositions such as ankle equinus, cavus foot, forefoot varus, and MTP pathology also lead to the development of abnormal head pressures. Ankle equinus dramatically increases metatarsal head load by directing hindfoot weight-bearing allocation to the forefoot. A cavus foot abnormally positions the hindfoot into varus. This results in distribution of lower limb weight-bearing to the lateral aspect of the heel, as well as the first and fifth metatarsal heads, eliminating support from the lateral plantar midfoot.[16] Forefoot varus increases load bearing on the lateral aspect of the foot, leading to excess pressure under the fourth and fifth metatarsal heads. Hallux valgus, hallux rigidus, Morton's foot, and lesser toe pathology can all contribute to an abnormal local distribution of metatarsal load. Interruption of the windlass mechanism and an alteration of first ray mechanics because of hallux valgus produce decreased hallux flexion and transfer metatarsalgia. First ray hypermobility decreases stability across the weight-bearing medial forefoot, exposing the lesser toes to greater weight-bearing forces. Treatment algorithms are designed to target these biomechanical concepts. Studies have shown that metatarsal head resection can lead to digital instability and transfer metatarsalgia.[4] In addition, excessive recession during osteotomy leads to an unfavorable shift in the metatarsal parabola. This leads to alternative toe stress patterns and complications. Techniques performed without the use of internal fixation have accounted for delayed union, malunion, nonunion, and pseudoarthrosis. Moreover, the lack of rigid internal fixation, such as the use of K-wires and external fixators delay the initiation of postoperative physical therapy, return to shoe wear, and potentiate infection.[10] These factors have ignited advancements in surgical procedures with the hopes of controlling rotational stability, biomechanical function, and alleviation of symptoms, while decreasing complications. The midshaft segmental osteotomy aims at using rigid internal fixation to control shortening, to produce anatomic alignment, and to restore functional biomechanics as a means for developing reliability and predictability in the treatment of lesser metatarsal forefoot pain.

History and Physical Examination

Evaluation of the patient starts with a stepwise history and physical examination. History is focused on pain location, onset, and alleviating or aggravating factors. Alterations in symptoms associated with shoe wear, accompanying foot disorders, and comorbid conditions should also be documented. Physical examination usually begins with inspection of the foot in non-weight-bearing phases, weight-bearing phases, and progresses to examination during gait cycles. It is important to note skin changes and deformities, such as claw toes, hammertoes, and hallux deformities, as they increase metatarsal head pressure.[17] Palpation begins systematically from front to rear compartmentalizing the hindfoot, midfoot, and forefoot. The goal of palpation is the assessment of topographic anatomy and recognition of any deviations. All bony prominences, anatomical regions, and intermetatarsal spaces should be palpated. The plantar aspect of the foot along with