The Cheilectomy and its Modifications

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KEYWORDS

- Hallux limitus • Hallux rigidus • Modified cheilectomy
- Dorsiflexory wedge osteotomy Q7

Depending on the age group of assessed adults, middle-age women, or the elderly, hallux abducto valgus (HAV) deformity has been reported to represent as much as 33%, 38%, and 70% of the population, respectively.[1–3] Meanwhile hallux rigidus may represent only as much as 10% of persons aged 20 to 34 years but as much as 44% of people older than 80 years.[4,5] Despite HAV deformity seeming to be the more prevalent condition, Hallux rigidus seems to cause more important impairment and pain.[6] Due to the severity of the impairment that this condition can cause, surgical intervention has been suggested for cases that have failed using conservative methods. The modified cheilectomy is considered by many the first-line treatment for this disease, given the procedure's inherent ability to eliminate degenerate bone and cartilage and decompress the intra-articular space, while sparing considerable cubic content of bone.[7–10] Once the cheilectomy has been performed, there remains a sufficient volume of bone to perform a more definitive reconstruction, such as an arthrodesis of the first metatarsophalangeal joint, should that ever be required.[11,12]

HISTORICAL REVIEW

In 1887 Davies-Colley coined the term *hallux flexus* in defining the degenerative condition of the great toe resulting in stiffness and swelling of the first metatarsophalangeal joint (MTPJ).[13] Cotterill would later lay claim to the term *hallux rigidus* for pain associated with attempted dorsiflexion of the phalanx on the first metatarsal.[14] It is presumed that these conditions actually represent 2 phases of the same process involving injury, chronic inflammation, and degenerative change of the chondral surface and underlying subchondral bone that yields progressive joint restriction and chronic pain.

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The condition likened to osteochondritis desiccans is a wearing process that results in cartilage degeneration and ultimately eburation of subchondral bone.

As the condition was reported more frequently, the mechanics of the condition became a source of discussion and debate. In 1895 the term *hallux dolorosus* was proposed by Walsham and Hughes, given the Latin adjective meaning intensely sad or painful.[15] In 1937 Hiss described this joint restriction as *hallux limitus* and that term is most commonly used today. In the following year Lambrinudi coined the term metatarsus primus elevatus, and described its ability to contribute to hallux rigidus. The mechanics of this structural deformity; an elevated position of the first metatarsal and hallux equinus, are commonly understood and are believed to incite this chronic degenerative joint disease. Lapidus introduced the term dorsal bunion in 1940. Despite the multitude of terms used to describe arthritis and decreased motion of the first MTPJ, *hallux limitus* and *hallux rigidus* remain the most commonly used in the current literature.

ETIOLOGY OF HALLUX LIMITUS/HALLUX RIGIDUS

Regarding the ultimate culprit for hallux limitus and hallux rigidus, the senior author (M.S.J.) subscribes to an early description of the disease provided by Goodfellow,[16] who relates the condition to osteochondritis desiccans. The precursor of this condition is not readily apparent on plain radiographs, and not until the condition undergoes repair is the evidence of prior damage and disease revealed. It can be extrapolated from this that the chronic inflammation associated with repair causes fibrosis of the soft tissue structures of the joint periphery and so capsular adhesion, sesamoid degenerative change, and fibrosis contribute to joint restriction as a consequence. Although there are multiple biomechanical factors thought to contribute to the development of hallux rigidus, the pathology that progresses subsequent to joint damage, whether it be acute injury or chronic wear from repetitive cyclic loading, most closely approximates the dysvascular and progressively degenerative change of osteochondritis desiccans. Nilsonne[17] defined primary and secondary hallux rigidus subtypes to annotate the epidemiology of the disease. The term *primary* hallux rigidus described the condition with adolescent onset, whereas *secondary* hallux rigidus was described as an adult variety that is chronic and long-standing. Further, the condition can be subdivided into *functional hallux limitus* (weight bearing) and *structural hallux limitus* (non–weight bearing). It is suggested that functional hallux limitus is associated with an uncompensated forefoot varus with or without hallux equinus. Often a contracture of the extensor hallucis longus is a concomitant finding. By contrast, structural hallux limitus is associated with an elevated first metatarsal. The nature of hallux equinus has been correlated with first MTPJ limitation, and consequently primary and secondary hallux equinus has been described. Primary hallux equinus is associated with flexible forefoot varus and muscular spasticity, whereas secondary hallux equinus is associated with metatarsal equinus and uncompensated forefoot varus.[18]

The following are some of the more common structural conditions suggested as a cause of hallux limitus/rigidus: short or long first metatarsal, elevated first metatarsal (iatrogenic or congenital), flat foot, osteoarthritis of the sesamoid apparatus, hypermobile first ray, metabolic conditions (eg, rheumatoid arthritis and gout), and acute and repetitive trauma.[15,17,19–27] The cause of this joint restriction is commonly multifactorial, and includes physical factors such as age, habitus, shoe gear, activities of daily living, trauma, and family history of osteoarthritis. In 2002 Grady and colleagues[28] retrospectively reviewed 772 patients treated for hallux rigidus. Of these patients, 43% had more than one contributing factor and 55% were associated with trauma.

CLASSIFICATION OF HALLUX LIMITUS/HALLUX RIGIDUS

Although the precise etiology of this condition remains obscure, the focus of practitioners remains in the diagnosis and treatment of the disease. Classification systems developed over time are numerous; however, the most useful of these provide a means to correlate clinical and radiographic findings with potential treatment options.

In 1986 Regnauld[29] developed and reported a classification system based on clinical findings and radiographic deformity of the first MTPJ, and this has remained popular for decades. In this system, first-degree through third-degree hallux rigidus defines the progression of pain and joint limitation along with the tell-tale radiographic changes that affect the joint and sesamoid apparatus. First-degree hallux rigidus includes the clinical findings of pain at end range of motion (ROM) with 40° of dorsiflexion and 20° of plantar flexion, while on plain radiographs there is slight narrowing of the joint space with loss of the normal convexity of the metatarsal head mirroring the loss of the phalangeal base concavity. Evidence of generalized forefoot osteopenia and slight sesamoid hypertrophy are also noted. Second-degree hallux rigidus reveals more important clinical changes, such as intermittent pain that may be noticed on and off weight bearing, with more significant limitation of joint motion and noticeable loss of suppleness in adjacent soft tissues. A dorsal exostosis is associated with this phase of the disease, and a noticeable hygroma or cystic-type swelling about the plantar joint soft tissues may become apparent. With derangement of the joint, lateral transfer of load, resulting in lesser metatarsalgia and discomfort from compensations affecting the Lis Franc joint complex, evolves. On radiography there is continued narrowing of joint space, flattening of the metatarsal head with osteophytic borders, and hypertrophy of the sesamoids. Eburnation of the metatarsal head is evidenced by loss of the metatarsal head contours, including flattening of the central aspect with an associated fine sclerotic rim as evidence of the bone impaction and hardening. Finally, in the third degree joint limitation becomes incapacitating, and extensive spurring and ankylosis of the parts are associated with bone bossing. Regnauld described a loss of joint pain in third-degree hallux rigidus, due to the immobility of the MTPJ; this could be associated with sesamoid hypertrophy, causing contracture and traction at the phalangeal base with distortion of its normal morphology. Contracture of the flexor hallucis longus results in plantar keratosis beneath the hallux interphalangeal joint, and the foot assumes a varus configuration. Pain in third-degree hallux rigidus was felt to be caused by neuritis within the first intermetatarsal space and dorsal exostosis, with bursal formations at risk for ulceration.[29] More recent updated classification schemes have been developed and discussed over time; however, none have successfully correlated clinical and radiographic findings with intraoperative findings.[30–34] Coughlin and Shurnas[30,31,33] developed a 5-stage classification after following patients for a 19-year period. Their classification consists of both radiographic and clinical findings for which grades 1 to 3 are very similar to Regnauld's classification, but include more detailed descriptions of dorsiflexory capacity of the joint. In this system grade 0 indicates dorsiflexion of 40° to 60° with stiffness and/or restriction of 10% to 20% (compared with the contralateral limb) and stage 4, which is equivalent to stage 3 with the addition of pain at mid ROM. The importance of this classification system is that it correlates the dorsiflexion capacity of the joint with the severity of the condition.

Roukis and colleagues[34] further developed a 4-stage radiographic classification as an off-shoot of the Coughlin classification, whereby grade IV takes into consideration degenerative changes within the first and second metatarsal cuneiform joints.

CONSIDERATIONS IN CONSERVATIVE MANAGEMENT

Regardless of the classification system used or the grade assigned to patients, the condition should be treated conservatively to failure. Conservative measures often include oral or topical nonsteroidal anti-inflammatories, orthoses modified with Morton's extension, shoe gear modifications (rocker sole shoe, metatarsal roll bar, and so forth), and lifestyle and activity modifications. Whereas some contend that intra-articular steroid injections have a role in the conservative treatment of hallux limitus/rigidus, given its anti-inflammatory effect the senior author does not subscribe to this method as it can carry potential side effects that risk higher degrees of morbidity. In the category of supplemental therapy more recent consideration includes the use of injected hyaluronate sodium, a viscous solution touted to slow down, if not halt, the progression of the degenerative disease and to encourage healing. The visco-elastic properties of this solution provide mechanical protection for tissues by providing a shock-absorbing buffer, and facilitate wound healing. Hyaluronate sodium is believed to facilitate transport of peptide growth factors to a site of action. Once at the site the hyaluronan is degraded and active proteins are released, promoting tissue repair. To date this therapy is considered as a last stage in conservative therapy, and has been used for conditions including hallux rigidus, stenosing tenosynovitis, and osteoarthritis of the knee and ankle joints among others. Of note, there are published reactions associated with this sodium salt of hyaluronan, and these reactions for the most part seem to be well localized and include injection site pain or rash, pruritus, headache, joint swelling, and joint effusion. This agent, however, does not carry the potential ill effects that long-acting steroids impose. For example, the published potential side effects of triamcinolone acetanide are numerous and include musculo-skeletal reactions such as aseptic necrosis, Charcot-like arthropathy, calcinosis, muscle weakness, steroid-induced myopathy, tendon rupture, osteoporosis, and pathologic fracture, to mention but a few. Other adverse reactions are possible and may be even more severe depending on the location, dosage applied, and frequency of injections. Perhaps the most commonly discussed ill effects of steroid compounds are their potential to blunt the natural immune response, dermal atrophy, and increased risk of infection.

Another method that would seem to be a more physiologic approach to joint supple-mentation is the use of autologous platelet-derived growth factor (PDGF) application; however, such has not been borne out of the current literature. Given the notion that PDGF has the potential to stimulate if not enhance the healing process, it further seems intuitive that this would promote a healthier environment for bone and cartilage as opposed to intra-articular steroid application, which is considered the more tradi-tional approach. Although the use of PDGF would not be considered curative, it does carry the potential to stimulate a cellular response that is believed to be beneficial to both bone and joint health.

SURGICAL PROCEDURES FOR HALLUX LIMITUS/RIGIDUS

When conservative measures fail then surgery can be entertained, beginning with detailed patient education and informed consent. The corrective procedures designed for hallux limitus are as numerous as the terms used to describe the condition. Begin-ning in 1887, Davies and Colley proposed resection of the proximal half of the proximal phalanx. Collier[35] performed a first metatarsal head resection to decompress the joint. In 1927 Watermann described a resection of the dorsal spur combined with a dorsal wedge osteotomy to rotate the plantar cartilage dorsally. Multiple investigators beginning in the 1950s proposed fusion of the first MTPJ.[22,36,37] In 1958 Kessel and

Bonney[38] performed a dorsal wedge resection on the base of the proximal phalanx. Throughout the years various investigators have promoted the use of the cheilectomy, and several modifications have been advocated in the literature. Beginning in 1927, Cochrane[39] recommended an exostectomy, but was of the opinion that a plantar capsulotomy and incision to release the plantar intrinsic musculature at the base of the proximal phalanx was required. Later, Nilsonne[17] reported performing an exostectomy on 2 patients. He discontinued the surgical technique because of concern that the procedure did not provide a definitive result. Almost 30 years later, in 1959, DuVries[12] described in detail the surgical technique of the cheilectomy. He advocated that the cheilectomy should be the initial surgical treatment of choice for hallux rigidus. Since that time many investigators have advocated the use of cheilectomy for stage I and II hallux rigidus.[8,9,31–34,40–46]

In 1987 at a surgical seminar in Hershey, Pennsylvania, Valenti described a resection of bone on both the first metatarsal and the proximal phalanx. Within the last 20 years investigators have reported on modifications of the cheilectomy, but as yet few have attempted to document a direct correlation of these methods with functional outcome. Modifications include alteration to the incisional approach, subchondral drilling of cartilage defects, plantar capsule release, and dorsiflexory wedge osteotomy combined with a cheilectomy.[9,46–49] There has been widespread use of the cheilectomy despite one article's description of the ill effect of this technique on the biomechanics of the joint in a cadaveric study. This study looked at 5 cadaveric specimens (10 feet) and evaluated the effects of the first MTPJ cheilectomy, and described abnormal compression created across the residual metatarsal head cartilage due to the altered morphology and function of the first MTPJ.[50] It is interesting that some of the best articles written on the use of the modified cheilectomy appeared after this experiment was published.[11,30,31,33,41,43,51–53]

FUNDAMENTALS OF THE CHEILECTOMY

In 1979 Mann and colleagues[9] reviewed the cheilectomy as originally reported by DuVries. Aside from detailing DuVries' surgical technique, they reviewed the outcome for 20 patients who underwent cheilectomy. At an average of 67.6 months' follow-up, patients were capable of 30° of first MTPJ dorsiflexion on average. The investigators reported little or no progression of the degenerative process at the time of long-term follow-up. Subjectively there was "uniform" satisfaction among patients, ranging from 7 months to 156 months post procedure. This result suggests that early patient satisfaction after the cheilectomy does not seem to reduce over time, which is a powerful implication of this research. In 1988 Mann and Clanton[54] performed cheilectomies on 25 patients, with an average follow-up of 56 months. In this study a total of 31 procedures were reviewed. Twenty-two joints had complete relief. Six of the remaining joints had relief most of the time with an occasional episode of pain. Despite relatively small patient populations, these articles provide positive functional results in support of using the modified cheilectomy for joint salvage. These findings are consistent with a meta-analysis performed by Roukis[11] suggesting that the cheilectomy is a useful procedure appropriate as first-line surgical treatment for hallux rigidus, and has a low overall incidence of the need for revisional surgery.

Coughlin and Shurnas[31] further examined 110 patients with long-term follow-up of hallux rigidus treatment. Of these 110, 80 patients underwent cheilectomy. The mean follow-up for this group was 9.6 years. Patients treated by cheilectomy demonstrated significant improvement in ROM, pain, and American Orthopaedic Foot and Ankle Society (AOFAS) scores. Of note, the scoring and results did not correlate with radiographic appearance of the joint at time of follow-up. Of the 80 patients who underwent cheilectomies, 92% were considered successes. Most of the cheilectomies were performed on hallux rigidus grades I and II. In 9 patients with grade IV disease cheilectomy was performed and later, at an average of 6.9 years status post cheilectomy, underwent a first MTPJ arthrodesis.[31] It is important that the investigators did not recommend cheilectomy for patients with grade IV disease, so the failure of treatment in these 5 patients who ultimately required arthrodesis was not surprising.

Multiple other investigators have advocated that cheilectomy be reserved for hallux rigidus grades I and II. In 1986 Hattrup and Johnson[44] reported on 58 patients with hallux rigidus. Overall satisfaction for the patients was 53.4% completely satisfied, 19% mostly satisfied, and 27.6% unsatisfied. Average follow-up for this study was 37 months. It was noted that with grade I hallux rigidus (Regnauld classification) there was 15% failure rate of the cheilectomy. With grades II and III a 31.8% and 37.5% failure rate, respectively, was noted. Similar to Hattrup and Johnson, in 1997 Mackay and colleagues[55] evaluated 34 patients with hallux rigidus and reported outcomes based on grade. Patients were evaluated on postoperative pain, activity levels, shoe gear, ability to walk on tiptoe, and ROM. Consistent with studies previously mentioned, patients with lower grades of hallux rigidus demonstrated the most improvement. Overall satisfactory outcome achieved for grades I, II, and III was 94%, 100%, and 66%, respectively. The investigators concluded that for grades I and II hallux limitus, cheilectomy should be the treatment of choice. This study had a small population for grade III; subsequently, the investigators could not make a definitive statement regarding that degree of disease and outcome following the cheilectomy procedure.

In considering the studies reviewed in the current literature it becomes apparent that surgical selection hinges on more than clinical and radiographic grade, and that other factors can affect decision making. Two factors affecting surgical selection are activity level and the age of the patient. In 1999 Mulier and colleagues[43] chose to evaluate the effects of cheilectomy on athletes with either Regnauld grade I or II hallux limitus. Cheilectomies were performed on 22 feet and evaluated at a mean 5-year follow-up. Patients were functionally graded postoperatively as 14 excellent, 7 good, and 1 fair. Thirteen patients were evaluated for longer than 4 years. Of these 13 patients, 7 had increasing radiographic changes despite good functional outcomes. Of the 22 patients, 75% returned to athletic activity at previous level or higher. Of note, the functional outcomes in 5 of the 7 remaining patients who did not return to previous athletic activity were not related to the surgery. The investigators concluded that cheilectomy is a viable option for an elite-level athlete.

Feltham and colleagues[8] reported on 67 patients receiving cheilectomies for hallux rigidus. Patients were evaluated using the Regnauld classification. The patients were then further subdivided by age. Overall 78% of the patients were satisfied with the cheilectomy at an average follow-up of 65-months. The investigators found no statistical correlation between the Regnauld classification and satisfaction rate. However, in patients older than 60 years there was a significantly higher satisfaction rate of 91%. Regardless of age and athletic ability, there was approximately an 80% to 90% success rate with the cheilectomy procedure. While outcomes may vary when considering age groups, athletic activity, and radiographic and clinical grade, there remains an advantage to using the cheilectomy, as it remains a joint salvage procedure that does not “burn any bridges” with regard to cubic content of bone available once the procedure has been performed.

Surgical approaches have varied since DuVries first described it. He described a dorsal incision. Two groups have attempted different incisional approaches and have examined whether they provide any benefits.

Lin and Murphy[45] examined 20 cheilectomies performed with a dorsal lateral approach versus the standard dorsal approach. The investigators' modification of the procedure employed an incision over the lateral edge of the first MTPJ. Cheilectomy was performed by removing the dorsal bump as well as osteophytes from the proximal phalanx. The most common complication was numbness in the first web space, which occurred in 40% of the patients. The average age of the patients was 53.8 years and the average follow-up was 2.8 years. At long-term follow-up there was a significant improvement in the clinical-radiographic staging. The patients' average AOFAS Score improved from 53.5 to 84. Age, increase in staging, and AOFAS score results were similar to other reports, and the investigators concluded that there was no advantage to the use of a lateral incision. By contrast, Easely and colleagues[41] explored using a medial approach to the cheilectomy in 68 feet with an average follow-up of 3 years. In addition to the dorsal cheilectomy, a plantar release was performed. The plantar release has been mentioned in passing in only few articles, and has never been directly compared with cheilectomies performed without a plantar release. Using the AOFAS scoring system the average improvement was from 45 to 85 points, with an increase in dorsiflexion and total ROM. The feet that were examined and treated were subdivided by grade. There were 17 grade I, 39 grade II, and 12 grade III feet. Of the 68 feet examined, 38 had worsened by at least one grade at follow-up. Of the 68 patients, 9 were symptomatic. Eight of the 9 symptomatic feet were grade III. The medial approach with a plantar release for a cheilectomy provides reliable results for hallux rigidus grades I and II, with less reliable results noted for grade III. The investigators noted that only 2 of the 12 grade III cheilectomies required fusion, in contrast to the Coughlin study. However, this may be due to the fact that the average follow-up was less than half that presented in the Coughlin report.[31]

Several investigators have studied the effects of cheilectomy on plantar pressures. Despite the fact that the cheilectomy does not surgically address deforming forces that may have caused the disease, it is hypothesized that plantar pressures would be restored with successful joint decompression. In 2008 Nawoczenski and colleagues[52] undertook an in vivo evaluation of the biomechanical affects of a cheilectomy. Twenty patients in the study were evaluated preoperatively, at 1.7 years and 6 years after the index procedure. At final evaluation only 15 patients were available, and it was found that the cheilectomy increased abduction and dorsiflexion at the first MTPJ in all while reestablishing functional plantar pressures. Despite these improvements, the average increase in ROM and abduction was less than the required 45° necessary for daily activities. Further, it was noted that the hallux equinus remained essentially unchanged after the cheilectomy procedure, suggesting that the abnormal mechanics also remained unchanged.

CHEILECTOMY AND DORSIFLEXORY WEDGE OSTEOTOMY

A modification of the cheilectomy with the addition of a dorsiflexory wedge osteotomy was first reported by Desai and colleagues[47] as an alternative to joint-destructive procedures. An advantage to this modification is that it does not limit alternative surgical options if a revision becomes necessary. Recently, Roukis undertook a systematic review of the cheilectomy with dorsiflexory osteotomy of the proximal phalanx.[11] His search results and inclusion criteria took into consideration 11 studies. In this meta-analysis there was a total of 167 procedures performed with follow-up. Forty-one experienced complete relief, 108 had improvement in symptoms, and 18 were either unchanged or worse. Eighteen patients required revisional surgeries. Six of the 11 studies included in the review listed the number of procedures performed and at what grade. For grades I, II, and III there were 18, 128, and 31 procedures performed, respectively. Unfortunately, there were multiple variables addressed within the 11 studies reviewed. Because of the multiple variables, Roukis concluded that it was difficult to ascertain the corrections that provided relief. Some of the variables included biplanar osteotomy to correct hallux interphalangeous, difference between grading scales used, omission of dorsiflexory osteotomy unless 70° dorsiflexion or less was gained from cheilectomy, and differences in the adjunctive procedures performed. Despite the multiple variables identified, there was only a 4.8% surgical revision rate. By comparison, systematic reviews for the cheilectomy and the Valenti procedure had an 8.8% and 4.6% surgical revisional rate, respectively.

CHEILECTOMY AND MICROFRACTURE

Further modifications include the addition of subchondral drilling to the first metatarsal head, and this procedure and its outcomes were discussed in two articles.[46,48] The first article, published in 2004, focused on the technique of cheilectomy with the addition of a plantar release and microfracture of the metatarsal head using a dorsal medial approach to gain access to the joint. Approximately 25% of the head was resected using an oscillating saw in this technique. Next the plantar structures were freed with a McGlamry elevator; attention was paid to release the plantar capsule and insertion of the short flexor muscles on the proximal phalanx. Any cartilage lesions were then microfractured with an awl regardless of whether they were on the metatarsal head or the proximal phalanx. Thirty-seven cases of hallux limitus receiving the treatment with this technique were reported.[46] The subsequent article, a prospective case series wherein 28 patients and 32 feet underwent the procedure of the combination of cheilectomy, plantar release, and the microfracture technique for the treatment of hallux rigidus, was published in 2005.[48] Using evaluation of radiographs and magnetic resonance imaging, 18 patients were classified as stage II and 14 as stage III according to Hattrup and Johnson.[44] Postoperatively the investigators noted a significant improvement in pain, function (an average increase of 19° of motion), and patient satisfaction at an average of 23 months' follow-up. Like most previous studies involving cheilectomy alone, poorer results were noted within patients classified as grade III hallux rigidus. It is unclear whether there was an overlap between the clinical groups reported in these two articles. There was no comparison provided between their described technique and cheilectomy alone or cheilectomy combined with release of plantar structures.

PEARLS IN PRACTICE USING THE MODIFIED CHEILECTOMY FOR HALLUX RIGIDUS

The senior author uses the modified cheilectomy as a primary tool for intervention in the case of hallux limitus or hallux rigidus that proves recalcitrant to conservative methods and interferes with a patient's quality of life (**Fig. 1**). The technique used is essentially that described by DuVries, and rarely includes adjunctive procedures. Over time this procedure has brought significant relief to patients suffering from joint restriction and pain imposed by hallux rigidus.

The preoperative radiographic assessment includes standard dorsal plantar and lateral foot views in addition to special views; a stress lateral foot view to demonstrate the patient's functional capacity in weight bearing, and in most patients the forefoot axial view, obtained to best evaluate the condition of the cristae and the sesamoid apparatus (**Fig. 2**). Despite the preoperative effort made in classifying the stage of hallux rigidus, it is the contention of the senior author that the intraoperative findings web 4C/FPO

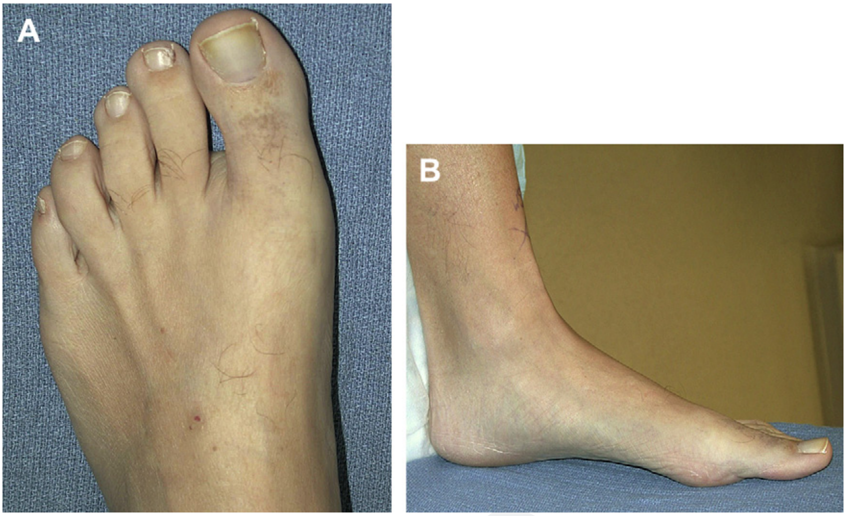

Fig. 1. ■ Q15

continually prove to be more significant than anticipated from the clinical and radiographic classifications (Figs. 3 and 4). Q8

Throughout the prospective series of surgeries detailed in the next section, the procedure of cheilectomy was performed essentially as described by DuVries.[12] The procedure is referred to as a modified cheilectomy, as the senior author performed this technique in a manner that excised diseased bone completely and did not simply restore the normal contours of the ball and socket of the first MTPJ. The procedure begins with an incision made dorsally from the proximal mid shaft of the first metatarsal and extending distally beyond the mid shaft of the proximal phalanx. After dissecting down to the capsule, the extensor hallucis is retracted and an incision made through the capsule of the same length as the skin incision

Fig. 2. ■

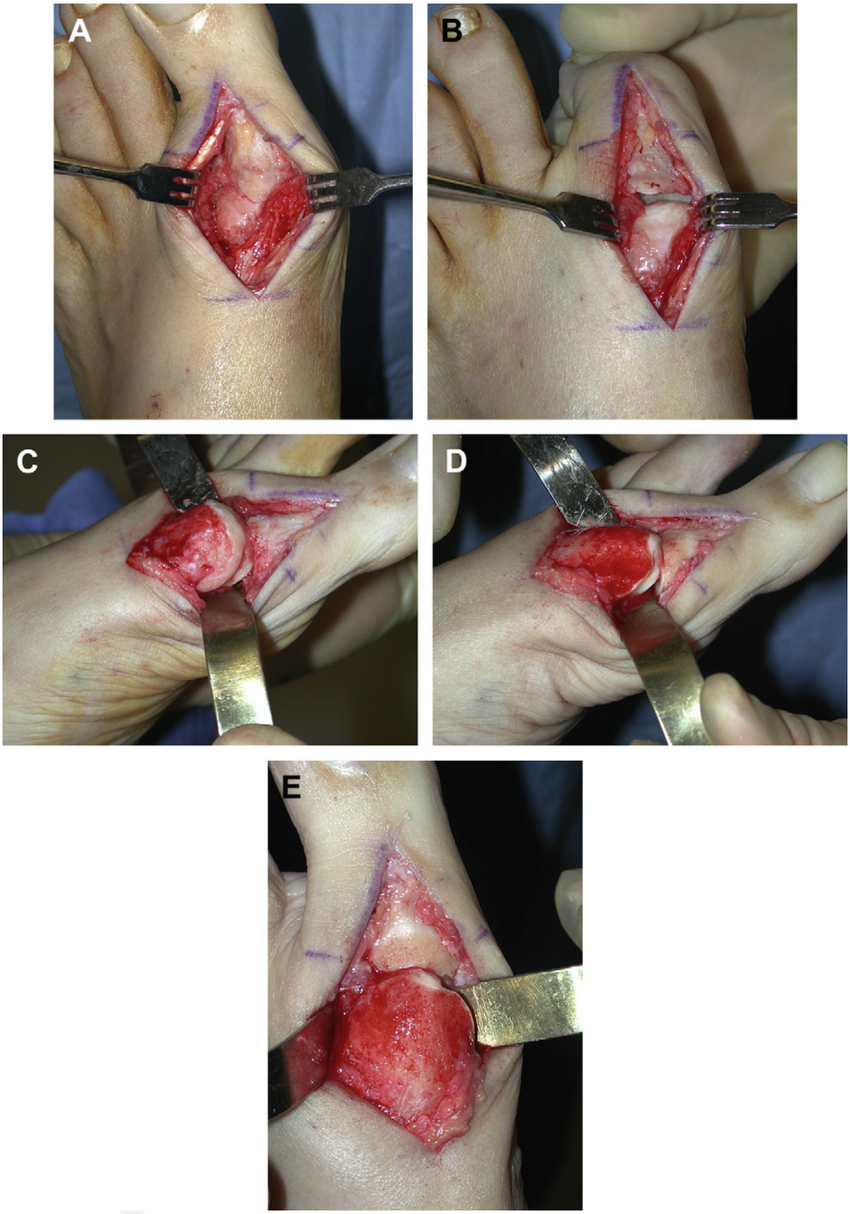

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Fig. 3. ■

(see **Fig. 3**A). Plantarflexion of the proximal phalanx is performed to aid in visualization of the first metatarsal head (see **Fig. 3**B). Excision of the exostosis is performed dorsal, medial, and lateral about the joint (see **Fig. 3**C); a traditional cheilectomy restoring the normal rounded contour to the first MTPJ. The traditional procedure is modified to resect enough bone to double the range of dorsiflexion that was evident in the preoperative clinical assessment (and typically more). Once adequate

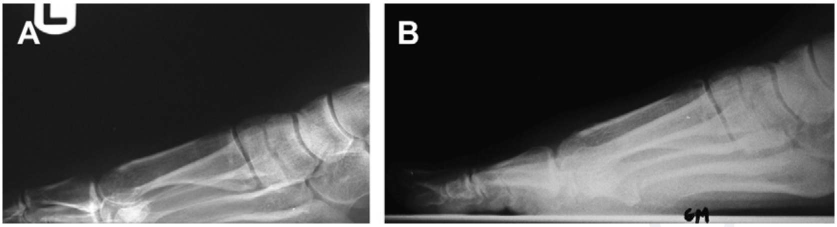

Fig. 4. ■

bone is resected (often one-fourth to one-third of the metatarsal head), the surface is recontoured with a rasp (see **Fig. 3**D and E). Postoperatively the patient is allowed passive ROM when it becomes tolerable, usually within the first week after surgery. Preoperative training for the use of an ortho wedge (heel weight-bearing) shoe is provided, and limited ambulation is allowed on the first postoperative day. After 2 weeks sutures are removed, and the patient is typically placed into a short leg-compression stocking once the incision is completely dry. Passive ROM exercises are performed throughout the early postoperative period, usually the first 10 days to 2 weeks, and active ROM exercises are performed thereafter as tolerated. The patient is instructed on in-home exercise; by simply sitting in a chair with the foot flat on the floor and then raising the heel, the foot is forced through a roll-off maneuver dorsiflexing the first MTPJ with the weight of the leg on the foot. This action is performed while wearing a short leg-compression stocking on the affected limb. The stocking provides a mild degree of compression and support for the joint while allowing active stretching maneuvers about the joint. Using an exercise that allows the patient to sit improves the patient's ability to control the degree of stress placed through the joint and titrate the motion to tolerance without eliciting unusual discomfort or anxiety. The first MTPJ is dorsiflexed to a maximum as tolerated, and this position is sustained for 10 seconds. Once the sustained stretch is performed on the affected foot, the patient performs the same maneuver for the contralateral foot. This action demonstrates to the patient the full motion of the normal (baseline) first MTPJ and serves as an example of the functional goal. Once the patient understands and is competent to perform the active ROM exercise, he or she can advance to the more aggressive daily activities that are important to the quality of life. This titration of activities is advanced quickly in most patients, who are typically able to return to their usual firm-soled athletic shoe gear within the first 3 to 6 weeks. It is not uncommon for the more physically active patients to return to the majority of their usual daily activities within the first month after surgery (**Fig. 5**).

If there are social issues such as accrued personal time off work (often more time than the recovery period requires) or employee's compensation claims, then the time to full recovery is predictably longer. For this reason it is important to have a means of benchmarking the patient's functional recovery and subjective impression of his or her progress. Consequently, it is important to obtain the stress lateral radiograph in addition to standard radiograph views to demonstrate the radiographic and functional changes that have occurred since the time of surgery (**Figs. 6–9**). Further, clinical survey forms are provided before surgery, within the first 8 weeks and periodically until final follow-up, to document the patient's own impression of his or her progress. This process facilitates dialog between the patient and the surgeon and keeps the lines of communication open, allowing for continual discussion and question-and-answer sessions that are integral to the patient's subjective satisfaction.

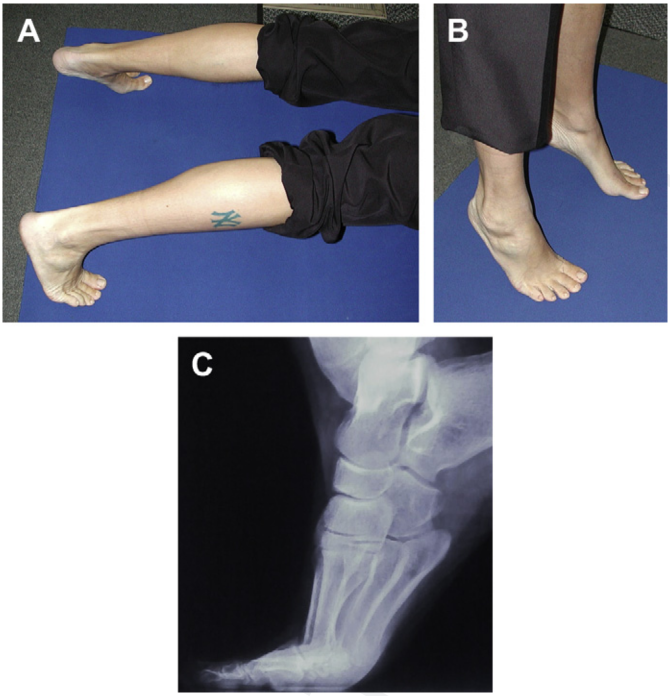

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Fig. 5. ■

PROSPECTIVE CLINICAL DATA IN HALLUX LIMITUS AND HALLUX RIGIDUS

The following is a summary of a prospective study of 19 consecutive hallux rigidus/hallux limitus patients (21 feet) treated with the modified cheilectomy technique. It was the authors' intention to exclude patients with peripheral neuropathy and those with ulcerations in the area of the first ray; however, ultimately no patients had to be excluded from the study. There were 10 females and 9 males, with 2 bilateral cases, both in females. Using the Regnauld classification system for hallux limitus there were 3 feet graded as Regnauld grade I, 15 grade II, and 3 grade III. For the 21 feet examined, the length pattern of the first metatarsal was evaluated on dorsal plantar radiographs. The first metatarsal length was assessed by measuring the length differential (in millimeters) by comparison of the centroid of the distal aspect of the first and second metatarsal heads. The first metatarsal was found to be shorter than the second metatarsal in 17 feet, longer than the second in 2, and equal to the second metatarsal in 2. There was no evidence of metatarsus primus elevatus in any patient entered into this study. Despite the majority of patient radiographs being assessed as a grade II hallux limitus, the surgical inspection in each of the 21 feet had articular cartilage damage affecting 50% or more of the metatarsal head in addition to the peripheral hypertrophic bone and osteophytes about the medial, lateral, or both borders of the joint. In 13 of 21 feet there was subtle evidence of medial subluxation at the second MTPJ whereas only 5 of 21 of the second MTPJs were rectus. The chart of vital statistics from this patient series is shown in Table 1.

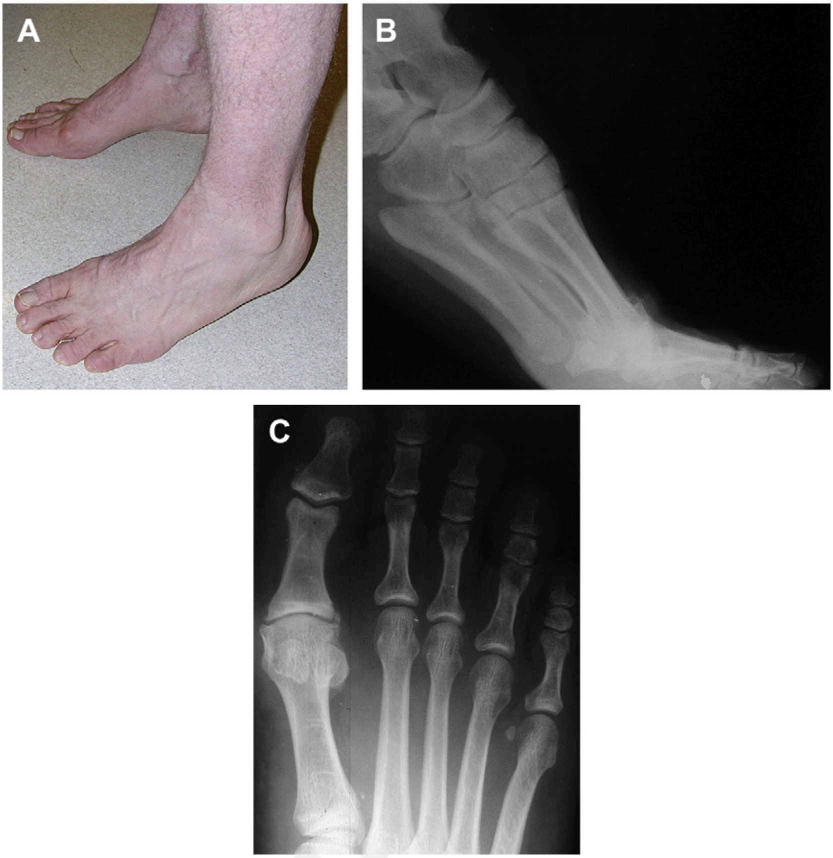

Fig. 6. ■

DISCUSSION ON THE UTILITY OF THE MODIFIED CHEILECTOMY

Although a specific etiology cannot be applied to every case of hallux limitus/rigidus, it is conceivable that this is a matter of an isolated osteochondritis identical to that seen elsewhere in the skeleton. The literature reveals numerous investigators discussing specific mechanics as the culprit for this condition; long or short first metatarsal, medial arch insufficiency, hypermobility of the first ray, and metatarsus primus elevatus, among others. If this comprises the progress of osteochondritis, monitoring the progression of the disease and intervening as early as possible with joint-sparing orthotic devices should be the mainstay of therapy; this leaves the intense debate about the mechanics of the syndrome by the wayside. Further, in discussing the staging of this condition there has been an extensive amount of literature with the belief that the stage of the disease is correlated with the development of an appropriate treatment plan. Current literature has delivered information regarding groups of hallux limitus/rigidus patients that calls some of this dogma into question, specifically the difference between the clinical and radiographic grades of hallux rigidus as compared with the surgical grades of the disease. Although it may seem intuitive that the highest grades of the condition would be associated with the worst outcomes, this correlation has not been borne out from the literature, nor has it been seen from

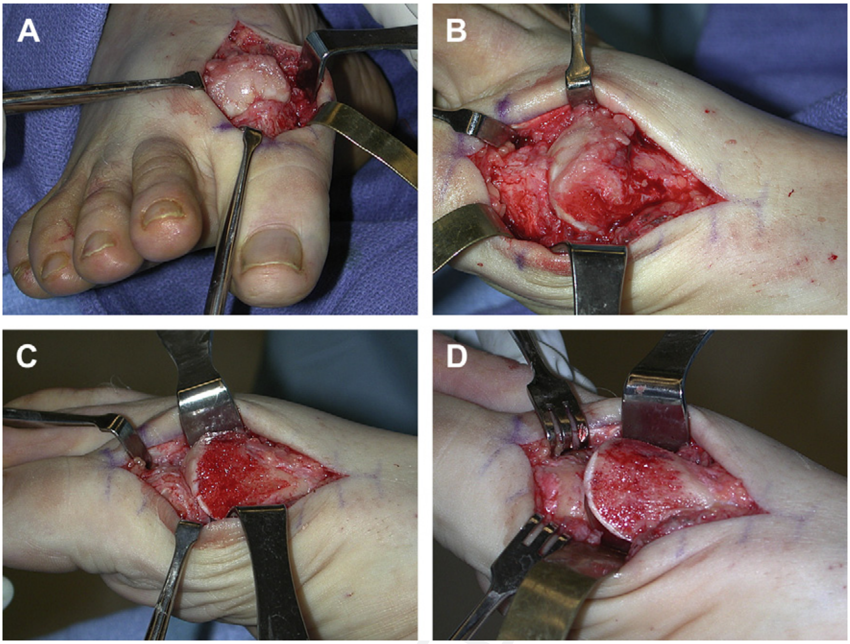

Fig. 7. ■

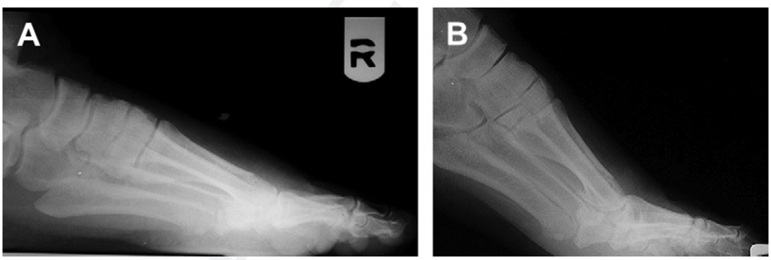

Fig. 8. ■

Fig. 9. ■

Table 1
Prospective series of 21 cases of hallux limitus/hallux rigidus treated with the modified cheilectomy

Number of patients: 19	Number of feet: 21
Gender: 10 females, 9 males	Two bilateral cases in female patients
Regnauld classification: Grade I: 3; Grade II: 15; Grade III: 3	
Second MTPJ position: 5 rectus, 13 medial subluxation, 3 lateral subluxation	
First metatarsal length: 17 shorter, 2 longer, 2 equal in length as compared with the second metatarsal	
Average age: 57.38 y	Age range: 41–70 y
Average follow-up reported: 85.9 wk	Follow-up range: 4–270 wk
Preoperative American College of Foot and Ankle Surgeons (ACFAS) scoring system average: 45.08	Preoperative ACFAS scoring range: 32–71
Postoperative ACFAS scoring system average: 76.57	Postoperative ACFAS scoring range: 62–91
Preoperative visual analog scale (VAS): 8.60	Preoperative VAS range: 5.00–10.00
Postoperative VAS: 1.38	Preoperative VAS range: 0.00–7.00
Average percentage change in VAS score: 89.20	Percentage change range: 30.00–100
Limp preoperatively: 14 patients	Limp postoperatively: 2 patients

the personal experience of the senior author in using the modified cheilectomy technique. In fact, the 4 patients who scored the lowest overall satisfaction in this study were associated with the development of sesamoiditis subsequent to noncompliance in orthotic therapy. Of these 4 patients, 2 were first-degree, 1was second-degree, and one was third-degree hallux rigidus using the Regnauld classification scheme.

Beyond this fact is that the utility of the modified cheilectomy has been supported by the medical literature since the 1920s when Cochrane described his approach that included release of plantar contractures of the long flexor and extrinsic musculature about the base of the phalanx. The technique of the cheilectomy, regardless of its modifications, was not truly embraced as a first-line therapy in the treatment of hallux rigidus until the 1950s. Since that time its utility for decompressing the joint and providing an improved ROM has been wholeheartedly supported by many.[7–9,40–45,51–62]

The senior author is among those who believe the modified cheilectomy, performed to eliminate degenerate bone and cartilage from the superior one-third of the joint, plays an important role in cases of severe and recalcitrant functional hallux limitus. In light of the joint decompression achieved by removal of this cubic content of bone, there is a virtual or functional lengthening of the dorsal soft tissue structures, which provides additional liberty to the joint. A cadaveric study of the change in motion vectors was undertaken comparing motion before and after cheilectomy of 30% and 50% of the metatarsal head diameter, which was found to improve the ROM in hallux rigidus specimens by 33%. Further, this study revealed that after cheilectomy, the proximal phalanx pivots rather than glides on the metatarsal head, yielding increased peak pressures at the end range of dorsiflexion and resulting in joint compression.[50] It is the senior author's contention that resection of the dorsal surfaces (modified cheilectomy) cannot be expected to restore normal gliding motion, as it merely decompresses the joint and leaves the axis of motion essentially unchanged. In fact, hallux limitus and hallux rigidus conditions often equate to an irreversible change in the axis of motion about the first MTPJ. (Cases of metatarsus primus elevatus with first MTPJ dysfunction are an obvious exception, as this structural abnormality is able to be reversed in most circumstances.) For this reason the patient should be educated preoperatively that the modified cheilectomy does not change the abnormal mechanics that exist, but rather decompresses and relaxes dorsal joint structures, reducing intra-articular pressure and subsequently reducing pain with joint motion. Cochrane[39] originally described release of plantar contractures to improve function of the first MTPJ, and intuitively this is a reasonable consideration should the need for a plantar release become apparent intraoperatively. Hallux limitus is considered by some to be a condition limiting joint dorsiflexion to less than 65° (but more than 20°) and hallux rigidus as joint limitation less than 20° in total ROM at the first MTPJ.[63] In the prospective study reported herein, a majority of cases fell into the realm of hallux limitus from a clinical standpoint. It is interesting that despite the fact that these patients typically exhibited hallux limitus, the intraoperative changes of degenerate bone and cartilage uniformly affected greater than 50% of the articular surface of the metatarsal heads, for which the authors provides illustrative evidence. Further, in the majority of these cases there has been a discord between the radiographic classification and the intraoperative findings, suggesting that the clinical and radiographic findings often fall short of the actual degenerative joint disease. This finding is supported by a host of articles that fail to correlate severity of the condition with clinical outcome after cheilectomy; the majority of patients respond favorably after this procedure despite the severity of preoperative clinical and radiographic grade or longevity of symptoms.[8,9,31,39–42,45,47] Further, in this series of patients requiring the modified cheilectomy procedure there was nearly an equal proportion of males and females, which differs from other reports in which females are considered the predominate gender affected by this condition.[8,9,17,21,38,64,65]

Of interest, in 13 of 21 feet there was subtle evidence of medial subluxation at the second MTPJ whereas only 5 of 21 of the second MTPJs were rectus. This is evidence that the dysfunction of the first MTPJ results in lateral transfer of load, and is the likely culprit for dysfunction with in the second MTPJ. Using the Regnauld classification system for hallux limitus, there were 3 feet graded as first degree, 15 as second degree, and 3 as third degree. Despite the majority of patients being graded as an intermediate stage of bone and joint degeneration (15/21 feet; 71.43%; Regnauld second degree), the intraoperative findings suggested more severe destruction of the joint whereby the patients in this study all seemed to have at least 50% of the articular cartilage defective, if not more. Perhaps this is a matter of radiographic changes lagging behind the clinical progression of the disease. It is understood that 50% to 70% of bone demineralization takes place before radiographic evidence of this resorptive change manifests, so the concept of radiographs lagging behind the clinical picture is not a new one. It is interesting that in 2 of the 3 feet graded as third-degree hallux limitus, stress radiographs revealed preoperative ROM as greater than 40°. After the benefit of the modified cheilectomy, the ROM as documented in the lateral stress was less impressive than the pain reduction and the patient's ability to return to earlier activities including kneeling, squatting, and crawling. This outcome may be explained by the joint decompression reducing peak intra-articular pressures during the propulsive phase of gait while preserving the minimum ROM necessary to propagate through the propulsive phase.[66]

In the 21 feet treated with the modified cheilectomy, the length pattern of the first metatarsal was evaluated and found to be shorter than the second metatarsal in 17 feet, longer than the second metatarsal in 2, and equal to the second metatarsal in 2.

In this small group, this does suggest a positive correlation between a short first metatarsal length as compared with the second and hallux limitus. It stands to reason that dysfunction or insufficiency about the first MTPJ would result in lateral transfer of load and stress syndromes within the second ray, which may manifest as second MTPJ instability if not fatigue fracture of the second metatarsal.

SUMMARY

While there are several theories as to why hallux limitus/rigidus develops, it is clear that painful joint restriction can be alleviated in many cases by the modified cheilectomy. The historical literature reviews a myriad of mechanical influences that may propagate the disease. Foremost, the conditions of medial column dysfunction (often associated with pronatory changes in the rearfoot), metatarsus primus elevatus, and abnormal length patterns of the first metatarsal are considered more than just coincident with the disease. Although these structural and mechanical influences are important, understanding the disease should not be subordinate to such functional discussions. Given the reports of patients requiring surgical intervention for this condition, it is clear that the clinical and radiographic information studied often falls short of the extent of the disease seen in surgery. It is important to understand this discord when developing prognostic information for the patient. To this end it has been realized that the modified cheilectomy has great utility in providing pain relief and improved functional capacity, and in some patients this proves to be a long-standing result. Because the modified cheilectomy has withstood the test of time, it is not unreasonable to use this method as a first stage in surgical intervention in those patients for whom it is reasonable that first MTPJ function can and should be restored. Patient selection, taking into consideration functional demand, realistic goals, and the patient's physical well-being, is an integral key to success. It is reasonable to surmise that anything that contributes to instability or hypermobility within the first ray will increase the risk of recurrence after even the most meticulous of cheilectomies. Long-term management with the benefit of a prescription orthotic device cannot be understated, given current understanding of the mechanics contributing to the progression of the condition. While outcomes may vary when considering age groups, athletic activity, and radiographic and clinical grade, there remains an advantage to using the cheilectomy, as it remains a joint-salvage procedure that does not "burn any bridges" with regard to cubic content of bone available once the procedure has been performed. Should this procedure fail, there are others that can be undertaken as a second stage in therapy, and the spectrum of joint-destructive techniques is discussed elsewhere in this issue. Q9

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