CHAPTER **15**

SURGICAL MANAGEMENT OF THE LIS FRANC JOINT COMPLEX

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INDICATIONS /CONTRAINDICATIONS

The tarso-metatarsal (Lis Franc) region of the midfoot is a complex functional joint consisting of medial, central, and lateral articulations conjoining the cuneiforms, cuboid, and respective metatarsal bases of the human foot (Figures 1, 2). Globally, the tarso-metatarsal (Lis Franc) joint of the foot is composed of functionally independent adjoined "columns," supported by robust plantar and relatively weak dorsal ligamentous restraints. An appreciation of the complex functional anatomy of the tarso-metatarsal (Lis Franc) joint complex is essential towards evaluation and management of tarsometatarsal pathology. In addition, a density of dorsally positioned sensory and motor nerves, extensor tendons, and arterial and venous plexus are noted overlying the tarso-metatarsal (Lis Franc) region. The topographical context of this region of the midfoot is also prerequisite towards successful surgical intervention within the Lis Franc joint.

Surgical pathology involving the tarso-metatarsal (Lis Franc) joint complex may include a variety of pathologic scenarios. Excision of bone and/or soft tissue lesions such as ganglion cyst(s), and correction of select metatarsus adductus and advanced hallux abducto valgus deformities may require surgical intervention in the tarso-metatarsal (Lis Franc) region. Total or partial tarso-metatarsal (Lis Franc) joint arthrodesis is an established salvage procedure in inflammatory, degenerative and traumatic arthritides, as well as neuroarthropathic (Charcot) deformities.

Open reduction and/or percutaneous directed fixation and stabilization for management of Lis Franc fracture/dislocations are common indications for surgical intervention. Functional outcomes following displaced fracture/dislocations of the tarsometatarsal joint are improved significantly if precise anatomic relocation and stabilization of the Lis Franc joint complex is achieved. Realignment arthrodesis is indicated for definitive salvage in those patients with continued pain, disability, and malposition. The problematic sequelae of traumatic injury, Charcot neuroarthropathy and degenerative arthrosis may require surgical fusion. Salvage of these deformities is predicated on obtaining a stable plantar-grade foot and is the primary objective of operative treatment.

Contraindications to surgical intervention of the tarso-metatarsal (Lis Franc) joint include inadequate peripheral arterial perfusion, a poor soft tissue envelope, and relevant precluding medical co-morbidities. Extensive

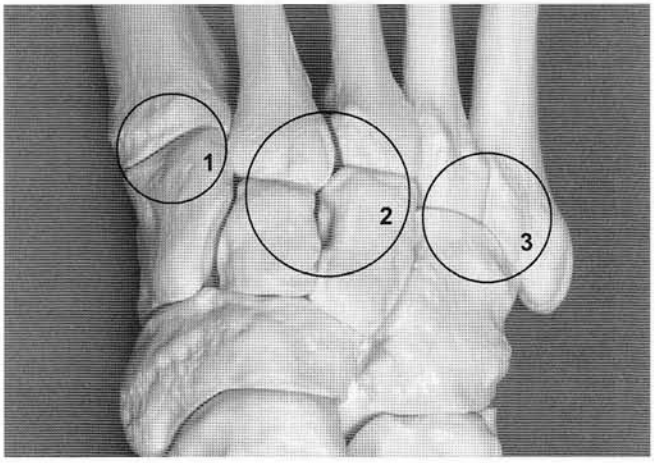

Figure 1. Bone model illustrating the respective medial, central and lateral functional "columns" of the Lis Franc joint complex.

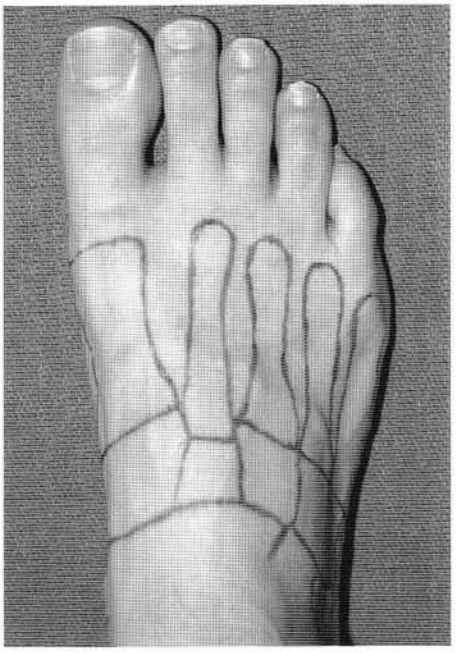

Figure 2. Topographical clinical line drawing of metatarsal-cuneiform joint complex.

or regionalized soft tissue edema, traumatic (fracture) blister formation, severe crush injury, fibrosis from previous surgical intervention including fasciotomy sites, and associated thermal and/or chemical injury may be considered relative contraindications to surgical intervention overlying the Lis Franc joint (Figures 4, 5). Abuse of tobacco products may also be considered a relative contraindication to elective primary and/or revision arthrodesis of the Lis Franc joint.

PREOPERATIVE CONSIDERATIONS

Generally an initial conservative treatment algorithm is considered for Lis Franc joint related pathology, and is recommended as appropriate prior to elective surgical intervention. Traumatic fracture/dislocation of the Tarsometatarsal (Lis Franc) joint complex represents a significant injury associated with potential morbidity. As such, timely surgical intervention is recommended as the treatment of choice to provide adequate stabilization and optimize functional outcome in most Lis Franc fracture/dislocations. Seemingly "subtle" initial clinical and radiographic findings often indicate a significant level of disruption of the tarso-metatarsal joint and have historically often been under diagnosed as "sprains" of the midfoot. A high index of suspicion and a standardized algorithmic approach is critical towards appropriate

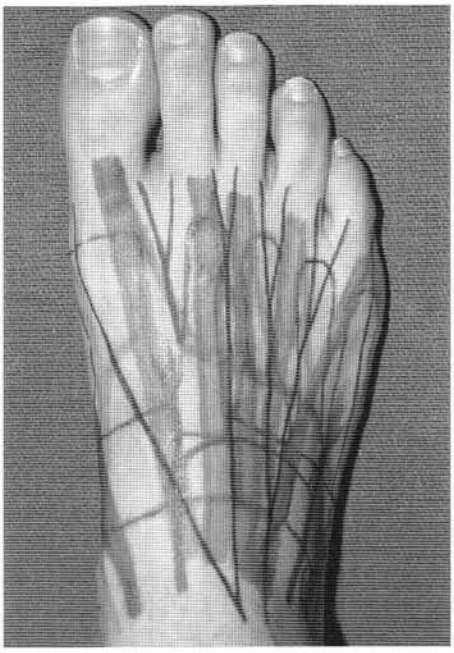

Figure 3. Topographical clinical line drawing with overlying neurovascular bundle, extensor tendon network and sensory nerve distribution.

Figure 4. Significant soft tissue edema following acute Lis Franc joint fracture dislocation – (a contraindication to immediate surgical intervention).

Figure 5. Fasciotomy site and subsequent STSG placement following closed Lis Franc joint fracture/dislocation, crush injury and associated compartment syndrome.

evaluation, diagnosis and treatment of Lis Franc fracture/dislocations. Traumatic arthrosis may develop and require definitive arthrodesis if associated with significant disability, pain and/or fatigue, despite early recognition, appropriate treatment and anatomic restoration.

Peripheral arterial perfusion of the foot is important to qualify prior to surgical consideration to the tarso-metatarsal joint complex. Direct palpation demonstrative of adequate pedal pulses (posterior tibial and dorsalis pedis) is standard. Hand held arterial Doppler examination; an ankle/brachial index measurement and further non-invasive evaluation of the arterial supply to the lower extremity are indicated studies if pedal pulses are absent or initial Doppler examination are equivocal.

Once an adequate medial history and vascular assessment is deemed satisfactory a detailed clinical examination is undertaken to identify the specific degree and location and involvement of the Lis Franc joint and related structures. Observation of gross or subtle deformity and malposition with particular attention to the symptomatic and contralateral foot is mandatory. Identification of a soft tissue lesion or mass is generally evident by observation and direct palpation. Illumination of the lesion or mass, if present, may also provide further characteristics regarding its potential origin. These can include lesions from direct extension of the Lis Franc joint complex or originate from overlying extensor tendons in the midfoot. Passive range of motion of the hallux and lessor digits and active resistive manual muscle (tendon) testing is undertaken to assess the possibility of primary or secondary tendinopathy of the dorsally positioned EHL and EDL tendon slips overlying the Lis Franc joint. Ancillary imaging such as ultrasound or MR is considered based upon "added value" towards accurate diagnosis and definitive treatment planning. Surgical aspiration or excision as deemed appropriate is then planned and executed.

Astute observation and careful clinical examination of the involved foot and leg as well as the contralateral extremity is especially critical in a setting of traumatic injury. Such care will assist the examiner in identification of subtle differences of dimension, presence of edema, variation of texture, turgor and condition of the integument, and temperature gradients of the involved Lis Franc joint region. Care is taken to identify clinical signs and symptoms and correlation of these findings are noted in context to specific "columns" of the tarsometatarsal joint complex. Quality of motion, position and overall stability of each component of the Lis Franc joint complex is assessed towards identification of specific site and the degree of involvement. Clinical stress examination is appropriate to confirm suspicion of ligamentous disruption and is well served under fluoroscopic guidance or plain film to quantify subluxation. Diastasis of the first and second metatarsal and respective cuneiforms is a hallmark of structural disruption of the medial and central column of the tarso-metatarsal (Lis Franc) joint. Owing to the increased incidence of chronic instability, pain and prevalence of subsequent arthrosis, surgical intervention in recognized diastasis injuries involving the Lis Franc joint is recommended.

Relative sagittal and frontal plane motion of specific components of the Lis Franc (tarsometatarsal) joint complex are recognized to be distinct and of functional importance (Figure 6). Generally, arthrodesis of the first, second and third metatarsal-cuneiform joints will minimally affect or compromise foot function provided appropriate metatarsal length and position is maintained or achieved. The lateral column (fourth and fifth metatarsal – cuboid articulation) is best preserved in principle, owing to its important function of load bearing, weight transfer and its relative importance of functional motion in gait. An isolated fourth and/or fifth metatarsal cuboid arthrodesis may be indicated purely as a salvage procedure for recalcitrant pain and disability involving the lateral column of the tarso-metatarsal (Lis Franc) joint (Figure 7). Arthroplasty techniques have recently gained promise as a favored approach to surgical management of the arthritic "lateral column" of the tarsometatarsal joint. Arthrodesis of the fourth and fifth cuboid articulation must be considered cautiously, owing to the relative increase and vital importance of maintained functional motion throughout the lateral component of the tarso-metatarsal (Lis Franc) joint complex.

The presence of gastrocnemius, gastrocsoleus, or osseous equinus condition may precipitate or contribute to untoward stress and breakdown of the Lis Franc

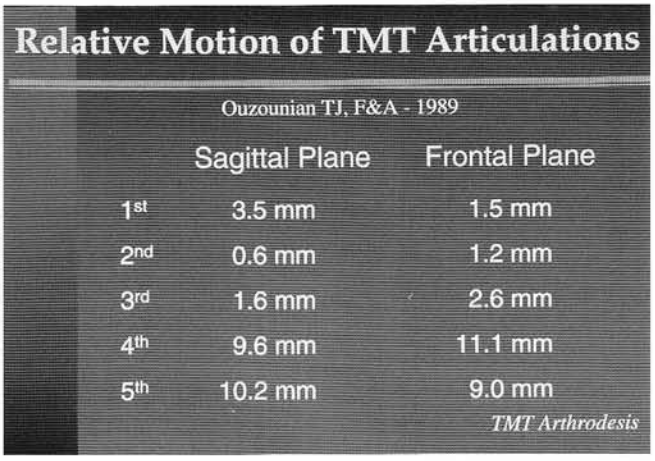

Figure 6. Relative sagittal and frontal plane motion of the Lis Franc joint complex.

arthrodesis or adjacent joint degeneration following arthrodesis. A functionally relevant concomitant equinus deformity is important to appropriately evaluate and manage, and especially critical in long-standing Charcot neuroarthropathy requiring a tarso-metatarsal arthrodesis (Figure 8).

Clinically, each proximal component of the tarso-metatarsal (Lis Franc) joint (cuneiform(s) or cuboid) is stabilized and the respective metatarsals are passively manipulated to simulate normal biomechanics. Pain, instability, and/or crepitus is identified and documented. The contralateral foot is examined in a similar manner in a non-weightbearing (open kinetic chain) assessment. Manual muscle testing (MMT) is also performed bilaterally with attention made to establish a baseline of functional strength and any existing deficit. Deep tendon reflexes are also elicited in the involved and contralateral extremity. Presenting evidence of any underlying sensory/motor or autonomic neuropathic change is determined and quantified as possible. Additionally, any existing hindfoot and/or forefoot deformity is also important to evaluate in context of assessing Tarso-Metatarsal (Lis Franc) joint pathology. Infiltration of local anesthetics under fluoroscopic guidance may further assist in evaluation of each region of the tarso-metatarsal joint and may prove helpful to further determine or exclude a nidus of pain, instability and/or arthrosis.

Weightbearing stance and gait evaluation (closed kinetic chain) is evaluated.

Figure 7. Isolated fourth and fifth metatarsal-cuboid arthrodesis, attempts to preserve lateral column motion via a "joint arthroplasty" if surgical intervention is considered.

Observation specific to foot architecture and structure and the angle and base of gait is made. Correlation of findings to the non-weightbearing clinical exam is also determined. Specific movement(s) which produce or exacerbate symptoms such as toe walking, squatting, climbing or descending stairs, and rotational motion can also be helpful in assessing and characterizing Lis Franc joint "columns" responsible for mediated pain and relative disability.

As noted, plain radiographs are required and additional imaging studies are considered and correlated to the clinical assessment. Plain radiographs should be routinely obtained in a functional full weightbearing position as possible. The foot and leg should be supported and maintained in as close to a functional position as possible in the context of radiographic evaluation of an acute traumatic injury suspected in the Tarso-metatarsal joint complex. Dorsoplantar, lateral, lateral oblique, and medial oblique views of the foot as well as AP, mortise, and lateral views of the ankle are standard. Comparison views are especially helpful to evaluate subtle or occult injuries involving the Lis Franc joint. Table 1 is included as a reference for the radiographic assessment of normal relationships within the tarso-metatarsal complex.

Additionally, stress radiographs and fluoroscopic guided assessment may be of value especially to determine functional stability of the tarso-metatarsal (Lis Franc) joint in purely ligamentous injuries. Subtle radiographic findings of malposition without fracture should prompt consideration for stress manipulation of the tarso-metatarsal (Lis Franc) joint. The timing of tarso-metatarsal (Lis Franc) stress examination may be influenced by post-injury pain and/or persistent edema. Regional or

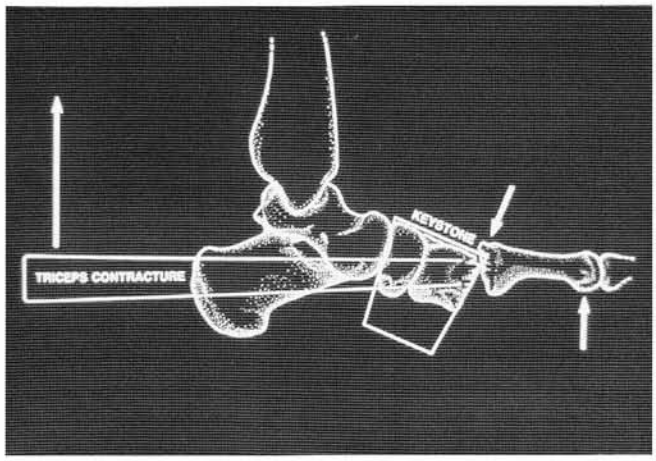

Figure 8. "Keystone" effect of an associated ankle equinus deformity influencing Lis Franc joint subluxation and potential for continued disruption.

general anesthesia may be necessary towards a quality stress exam and assessment. In this context, a degree of noted diastasis in excess of two millimeters is a standard criteria to guide surgical intervention, based upon plain films, stress radiographic examination and/or computerized tomography (CT). CT is a useful modality to assess the small joint articulations of the Tarso-metatarsal region, and provides valuable spatial orientation towards operative reduction.

Acute fracture/dislocation of the tarso-metatarsal (Lis Franc) joint necessitates specific preoperative planning towards achieving anatomic reduction and stability. Open injuries are considered surgical emergencies and principles applicable to open fracture management algorithms are instituted. Appropriate planning for the initial stabilization of open tarso-metatarsal (Lis Franc) fracture/dislocations includes operative reduction and application of external fixation devices and percutaneous delivery of internal fixation devices. Considerations specific to fixation techniques include the relative site and characteristic of the soft tissue and osseous lesion(s), existence and severity of an associated crush component, degree of comminution of bone/joint structure, resultant soft tissue edema, passage of time from initial insult to presentation, and degree of actual or perceived contamination amongst others. Open and closed injuries of the tarso-metatarsal joint require meticulous attention to the soft tissue envelope overlying the dorsum of the midfoot. Associated polytrauma likely may influence pre-operative planning and provisional treatment as well.

The majority of tarso-metatarsal fracture/dislocations are closed injuries. These injuries mandate a thorough history, careful clinical exam, and thorough evaluation of plain radiographs. Computed tomography is a useful imaging modality in identifying subtle fracture fragments and malposition not readily appreciated or evident on plain film. Evaluation of each individual cuneiform and metatarsal as well as the cuboid articulation with the fourth and fifth metatarsal is evaluated thoroughly with computerized tomography and imaging enhancement software. Attention is also required to clinically assess and correlate radiographic findings involving the midtarsal, subtalar, and distal leg for pain, quality and degree of freedom of range of motion, and acquired deformity in comparison to the contralateral extremity.

General recommendations for displaced tarso-metatarsal (Lis Franc) fracture/dislocation clearly support open reduction and internal fixation to optimize restoration of the joint anatomy and maximize long-term functional outcome. Appropriately positioned fully threaded cortical or cancellous screws via either direct or percutaneous delivery are preferred. Primary and/or supplemental Kirschner wire fixation is also acceptable and should be utilized in a construct to promote maximal stability to the tarso-metatarsal (Lis Franc) joint. Internal fixation devices should be ideally planned and placed for each column involved. This is applicable in the context of restoration of fracture/dislocation and towards achieving arthrodesis. Usage of absorbable screw fixation has been shown to be viable in the context of surgical repair involving Lis Franc fracture/dislocation injury, with an obvious secondary benefit to negate internal fixation removal prior to initiation of weightbearing activities. Considerations for type and position of fixation devices include the tarso-metatarsal joint complex injury pattern characteristic(s), bone quality, body mass index (BMI), physical demand, potential risk for internal fixation failure, known sensitivities to bio-materials, cost, availability and expertise in utility.

The presence of a soft tissue and/or osseous equinus deformity may precipitate and contribute to tarsometatarsal dysfunction. An associated equinus deformity, if present, must be appropriately evaluated and managed in the context of tarso-metatarsal (Lis Franc) arthrodesis. This is especially critical in the neuroarthropathic patient requiring tarsometatarsal arthrodesis. The effective and powerful lever arm of a contracted heel cord can be a continued deforming force and disrupt the arthrodesis site and/or contribute to

Table 1

GUIDELINES FOR RADIOGRAPHIC ASSESSMENT

DP VIEW – Medial cortical margin of the medial cuneiform is contiguous with the medial cortical margin of the second metatarsal base on plain and stress views

LATERAL OBLIQUE VIEW – Medial cortical margin of the cuboid is contiguous with the medial cortical margin of the fourth metatarsal base on plain and stress views

LATERAL VIEW – No existing dorsal and/or plantar translocation or displacement of the respective cuneiforms or cuboid is noted in relationship to the respective metatarsal bases

DP STRESS VIEW – No greater than 1- 2mm of displacement is noted on forced abduction/adduction of the tarsometatarsal articulation

Figure 9. Neglected Lis Franc lateral dislocation diagnosed as foot sprain. Gross malposition and chronic instability are indications for realignment arthrodesis.

Figure 11. Small external fixator utilized to "neutralize" lateral contracture of peroneus brevis influence in neglected mal-positioned Lis Franc injures.

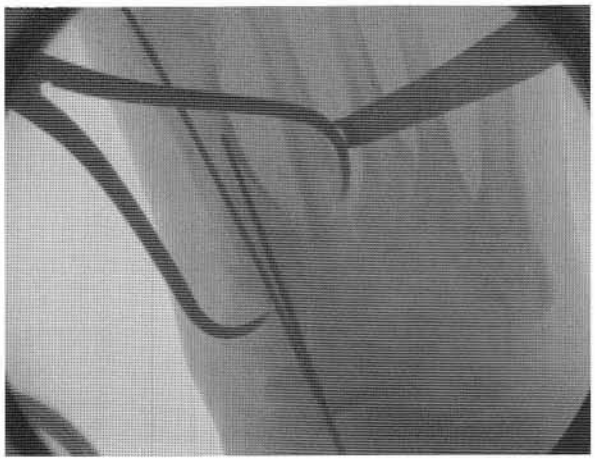

Figure 10. Stepwise reduction of provisional fixation of the medial "column" and utilization of a large bone reduction forceps to reduce diastasis.

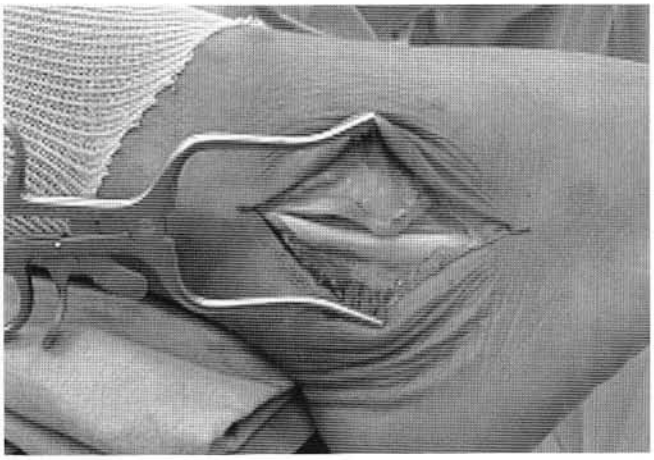

Figure 12. Lengthening of peroneal brevis tendon and anastomosis sometimes indicated to reduce lateral contracture and gain anatomic or near anatomic reduction.

adjacent joint breakdown throughout the midfoot, hindfoot or ankle (Figure 8).

Neglected tarsometatarsal injury and long standing deformity are especially prone to chronic pain, disability and other undesirable sequelae. Furthermore, chronic malposition of the tarso-metatarsal (Lis Franc) joint may secondarily lead to adaptive soft tissue contracture, specifically involving the peroneal brevis tendon. Realignment arthrodesis is necessarily considered as a salvage procedure, as early as three to four months post injury owing to the poor prognosis of late open reduction and internal fixation of neglected tarso-metatarsal fracture/dislocations. Neglected fracture/dislocations that remain symptomatic and disabling are often difficult to surgically reduce to exacting anatomic reduction (Figures 9-12).

All patients with significant soft tissue and osseous injury and severe crush injuries with or without fracture are evaluated and monitored to exclude the potential of impending compartment syndrome and other untoward neurogenic mediated sequelae.

Prominent exostosis overlying the dorsal margins of the respective tarsometatarsal joints may serve as a nidus for pain and/or a sensory nerve compression syndrome with or without significant arthrosis or displacement evident to the tarso-metatarsal (Lis Franc) joint. Reduction of such prominences may be helpful in alleviating the nidus of pain from shoe wear irritation and associated neurogenic mediated compression syndromes of the dorsum of the foot should conservative measures be unsuccessful.

An index of suspicion and significant clinical findings, such as allodynia, may support an underlying diagnosis of Complex Regional Pain Syndrome (CRPS). A thorough clinical assessment and examination is to be qualified and documented. Appropriate specialty consultation and medical treatment, combined with aggressive physical therapy and regional nerve block(s) is prudent when a presumptive diagnosis of CRPS is considered. Proactive and early aggressive management in a multi-disciplinary approach will optimize treatment.

SURGICAL TECHNIQUE

Most procedures involving the tarso-metatarsal joint are performed with the patient in the supine position. General or monitored regional anesthesia techniques with local infiltration and nerve blocks are utilized. The surgical approach to the tarso-metatarsal (Lis Franc) joint complex utilizes a standardized incision plan and an "anatomic dissection" technique. This standardization in surgical exposure is reproducible and applicable to most pathology encountered in this region of the midfoot. Tarsometatarsal fracture/dislocation, as well as arthrodesis of the Tarsometatarsal (Lis Franc) joint generally requires two or three incisions for adequate exposure. The specific condition requiring surgical intervention, such as total or sub-total fracture/dislocation, and/or degenerative arthrosis within the Tarso-metatarsal joint complex is identified and surgical intervention directed in a "columnar" approach according to specific location, respectively. In context, a reproducible surgical exposure affords appropriate access to each of the three respective columns of the Tarsometatarsal (Lis Franc) joint with a safe corridor. Modification of the "standardized" surgical approach is based upon the level and extent of injury, arthrosis and/or deformity involving the Lis Franc joint complex, local soft tissue considerations, and the nature and degree of malposition. Preservation of vital neurovascular and tendinous structures overlying the Lis Franc joint complex is optimized utilizing an anatomic based surgical technique. The technique outlined provides selective exposure to each individual column within the Tarsometatarsal joint, thereby optimizing relocation and reduction towards precise joint alignment and/or arthrodesis. Adequate soft tissue "islands" are maintained between incisions via appropriately distanced longitudinal incisions respective to each column.

Percutaneous delivery of cannulated guide pins, Kirschner wires, and/or Schanz (half) pins can be strategically positioned following direct and/or indirect reduction of tarsometatarsal fracture/dislocation to afford stability. Preparation and alignment of adjacent joint surfaces within the Lis Franc joint requiring arthrodesis is similarly accomplished. This "standardized" anatomic approach is considered a key element towards optimizing outcomes in both traumatic and elective surgical intervention specific to the Tarsometatarsal (Lis Franc) joint complex.

A medial, dorsal-central, and dorsal-lateral incision is planned and outlined as necessary for access to each respective component of the Tarsometatarsal (Lis Franc) joint. The incisions are respectively planned based on access to the medial column (first metatarsal – cuneiform joint, medial incision), the central column (second and third metatarsal – cuneiform joint, dorsal-central incision), and the lateral column (fourth and fifth metatarsal – cuboid joint, lateral incision). Topographical landmarks including position of neurovascular and tendinous structures serve to ensure accurate planning and placement of each respective incision required. A standardized three-incision approach to the tarso-metatarsal joint is illustrated in the figures below.

"Anatomic Dissection" as a specific principle in foot and ankle surgery is attributed to John A. Ruch, DPM, and is based upon identification and preservation of well-defined tissue layers enveloping the foot and leg. The concept of meticulous tissue handling, identification and preservation of key tissue planes, and protection and control of neurovascular elements within the superficial fascia is routinely employed and considered a cornerstone of foot and ankle surgery. Application of this surgical principle to the tarso-metatarsal (Lis Franc) joint is based upon the inherent anatomic considerations of the Lis Franc joint, as well as the functionally relevant overlying structures encountered within the midfoot. A standardized and reproducible "anatomic dissection" technique is illustrated in the surgical management of tarso-metatarsal (Lis Franc) joint pathology.

Prior to commencement of surgical intervention

within the tarso-metatarsal (Lis Franc) joint complex, care is taken to identify and mark the course of the dorsalis pedis artery to prevent disruption to the neurovascular bundle. Dorso-medially, an incision is placed to access the first metatarsal - cuneiform joint, (medial column) which is positioned at the bisection of the dorsal and plantar extent of the first metatarsal – cuneiform joint line. The length of the incision (5-6 centimeters) is determined as suitable for adequate exposure to the joint and applicable access to the osseous segment of the "medial column" of the Lis Franc joint. Care is taken to deepen the incision in a controlled fashion, and identification of the superficial fascia (subcutaneous layer) is accomplished. Coursing veins or tributaries within the incision line are identified and controlled for ligation and/or electrocautery. A "moistened" sponge serves as a reliable and atraumatic means of dissecting and cleanly separating the superficial and deep fascial tissue layer. Care is taken to identify the medial dorso-cutaneous sensory nerve distribution commonly encountered at the proximal portion of the incision at the first metatarsal base and medial cuneiform joint line. Once identified and preserved, the medial dorso-cutaneous nerve is protected throughout the procedure to avoid disruption. The deep fascia and periosteal layer is identified overlying the medial aspect of the first metatarsal base and medial cuneiform is incised. A linear incision is made through the deep fascia and periosteum collectively in accordance and alignment with the original skin incision. Reflection of the periosteum is begun distally overlying the diaphyseal-metaphyseal junction of the first metatarsal base, as the periosteal fibers are loosely attached at this level providing a starting point for proximal reflection and preservation of this tissue plane overlying the first metatarsal – cuneiform joint line. Sharp dissection is continued to reflect and preserve the capsular tissue and periosteum overlying the joint line and exposure to the first metatarsal-cuneiform joint is accomplished. Various methods of joint distraction are available to ensure direct visualization of the joint structure, appreciation of the considerable depth of the first metatarsal - cuneiform joint, and intra-articular inspection. Joint preparation techniques utilized in Lis Franc arthrodesis such as removal of articular cartilage via a curettage technique, abrasion chondroplasty, subchondral drilling, and reciprocal planing are enhanced via distraction of each segment of the tarso-metatarsal joint complex.

The dorso-central incision is placed to optimize surgical exposure to the second and third metatarsal bases and the respective middle (central) and lateral cuneiform. The dorso-central incision should maximize surgical exposure to the central column, and prevent untoward disruption of the overlying extensor tendons to the lesser digits. Identification of the distal portion of the second and third metatarsals are marked utilizing a skin scribe by direct palpation. Palpation is continued proximally over the respective second and third metatarsal bases and the incision is ideally centered between the metatarsal shafts. Care is taken to place the incision in a slight oblique fashion corresponding to the obliquity of the metatarsals based upon a DP weightbearing radiograph. The incision is deepened in a controlled fashion through the dermis.

A relatively thin layer of superficial fascia (subcutaneous tissue) is found overlying the dorsum of the foot. Care is taken to cleanly glean the superficial layer from the deep fascia investing the extensor tendon slips to the lesser toes. An important soft tissue landmark for the appropriate position and execution of the deep fascial incision is identification of the medial aspect of the extensor digitorum longus tendon to the second digit. At this level, a small stab incision is made producing a rent within the deep fascia. A Metzenbaum scissor is introduced into this "access portal" and directed proximally beneath the deep fascia coursing parallel to the extensor digitorum longus tendon to the second toe as proximal as possible. A sharp incision is then made overlying the instrument controlling its depth of penetration and dividing the deep fascia at this level. Preservation of the deep fascia layer overlying the extensor tendon apparatus provides for anatomic closure overlying the central column of the tarso-metatarsal joint, preservation of extensor digitorum function and reduction of iatrogenic adhesions. The extensor tendons are retracted laterally, exposing the extensor digitorum brevis tendons and underlying periosteum of the second and third metatarsal bases and respective cuneiforms. Care is then taken to perform individual dorsal incisions sharply through the periosteum and joint capsule of the respective second and third metatarsal cuneiform joint for exposure, identification of joint subluxation, intra-articular involvement and joint preparation on a case-by-case basis.

The lateral column is often accessed with a dorso-lateral incision centered overlying the bisection of the fourth and fifth metatarsals. Palpation of the fourth and fifth metatarsal neck is performed and a skin scribes identifies the position distally. A similar method of palpation and proximal palpation to the respective fourth and fifth metatarsal is performed. Care is taken to place the incision superior to the anticipated course of the sural nerve distribution overlying the lateral forefoot. Anatomic dissection techniques are performed as outlined to the level of the deep fascia. Linear incisions overlying the periosteum of the fourth and fifth metatarsal cuboid joint

are accomplished with sharp dissection in a similar fashion to the medial and central approaches to the tarso-metatarsal joint. Care is taken to preserve the insertion of the peroneus brevis tendon at the base of the fifth metatarsal when surgical intervention involving the fourth/fifth cuboid joint is required. Often percutaneous stabilization of the lateral column of the Lis Franc joint is performed following open reduction and internal fixation of medial and central components of the tarso-metatarsal joint fracture/dislocation. A stepwise illustration of reduction of a complete Lis Franc dislocation demonstrates the sequential reduction sequence and fixation technique. Ideally, the fourth and fifth metatarsal base cuboid joint is approached percutaneously in the context of fracture repair and the joint preserved via an "arthroplastic" procedure as possible should arthrosis and recalcitrant pain ensure (Figures 13-48).

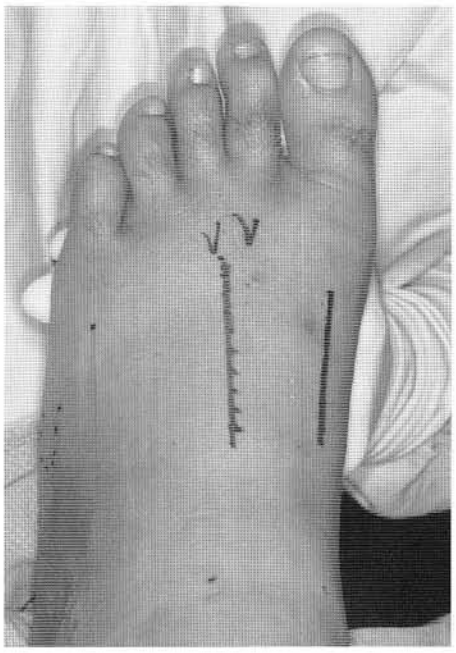

Figure 13. Placement of medial incision for access to the first metatarsal – cuneiform joint (medial "column of the Lis Franc joint complex).

Figure 14. Placement of dorso-central incision for access to the second and third metatarsal – cuneiform joint (central "column" of the Lis Franc joint complex).

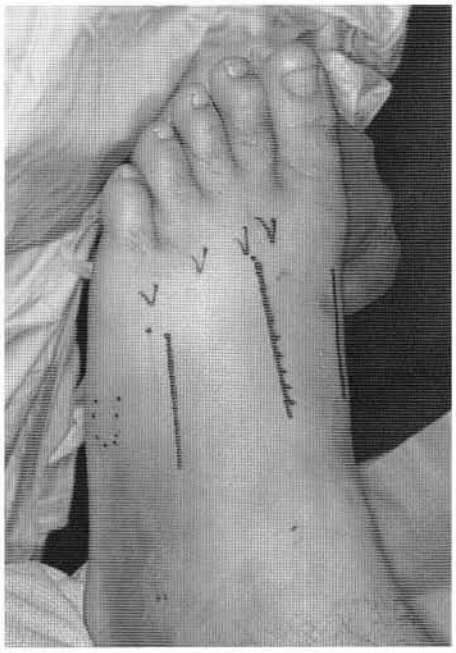

Figure 15. Appropriate placement of the dorso-lateral incision for access to the fourth and fifth metatarsal base-cuboid joint (lateral "column") of the Lis Franc joint complex.

Figure 16. A dorso-medial incision is outlined by bisecting the first metatarsal–cuneiform joint in the sagittal plane.

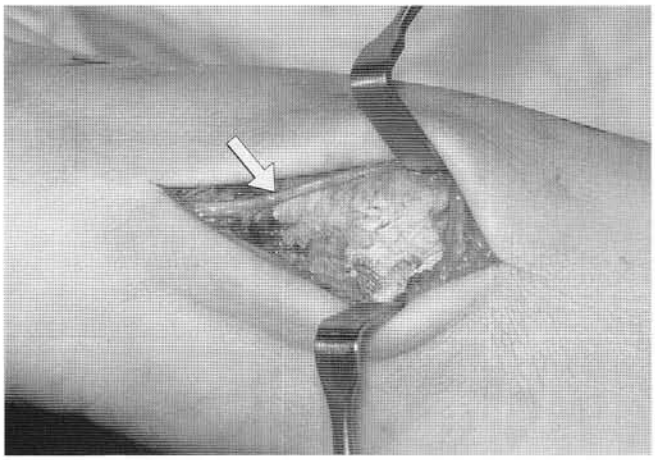

Figure 18. Note the course of the medial dorsal cutaneous nerve within the superficial fascia of the medial incision site.

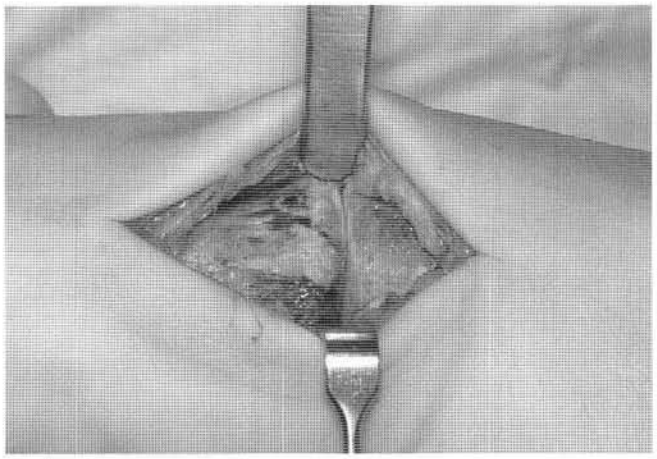

Figure 20. Create adequate exposure of the first metatarsal – cuneiform joint to allow joint distraction and direct visualization while preserving the periosteum via an "anatomic dissection" technique.

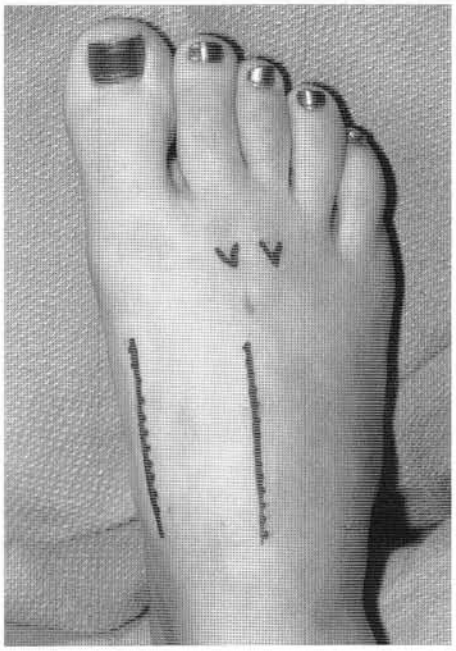

Figure 17. Identification of the second and third metatarsal necks by palpation and marked with skin scribe providing landmark for dorso-central incision placed. An adequate soft tissue island, preserving the neurovascular bundle is created between the medial and central incision.

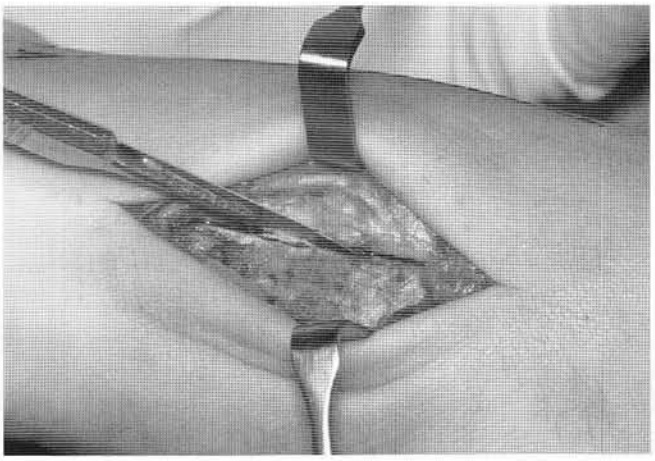

Figure 19. A sharp incision is made through the deep fascia and periosteum overlying the first metatarsal-cuneiform joint.

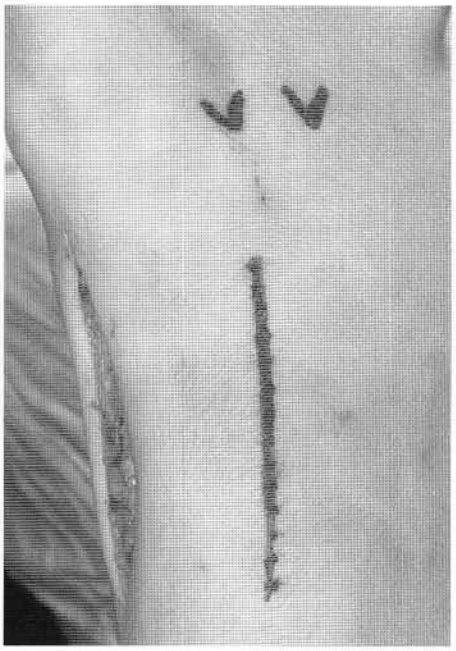

Figure 21. Modification of position of the dorsocentral incision can be further assessed following direct visualization and probe through the completed medial incision.

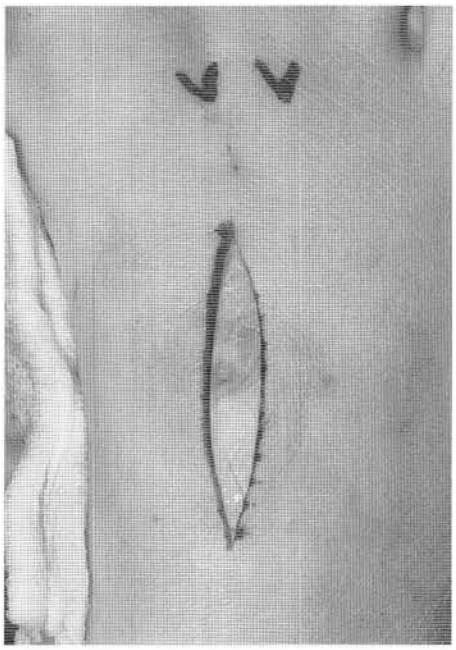

Figure 22. Incision development through the dermis to the superficial fascia is noted.

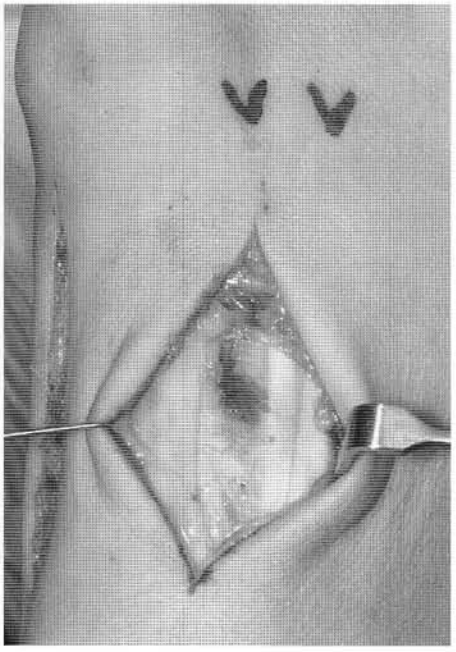

Figure 23. Care is taken to identify the deep fascia overlying the EDL tendon slip to the second digit and the coursing superficial peroneal nerve distribution as marked.

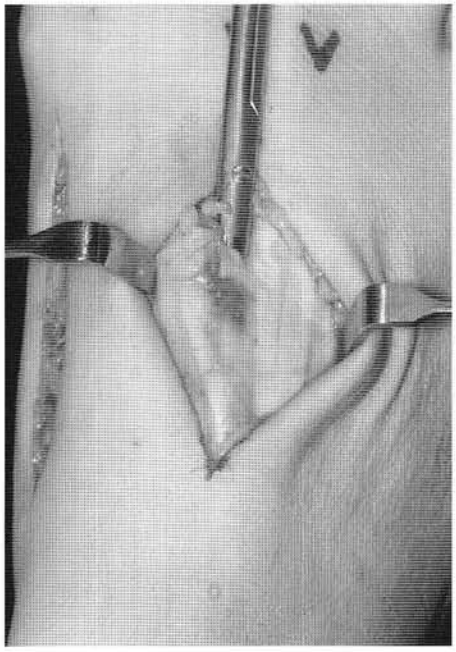

Figure 24. Create a small stab incision and guide a Metzenbaum scissor just medial to the EDL tendon to the second digit and the Extensor Hallucis Longus.

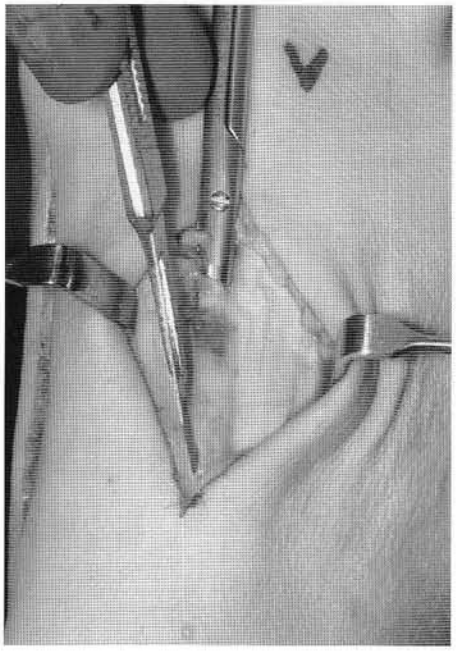

Figure 25. Direct sharp dissection overlying the scissor creating a deep fascial incision for direct repair following surgical correction providing protection of the extensor tendon slips and sheath.

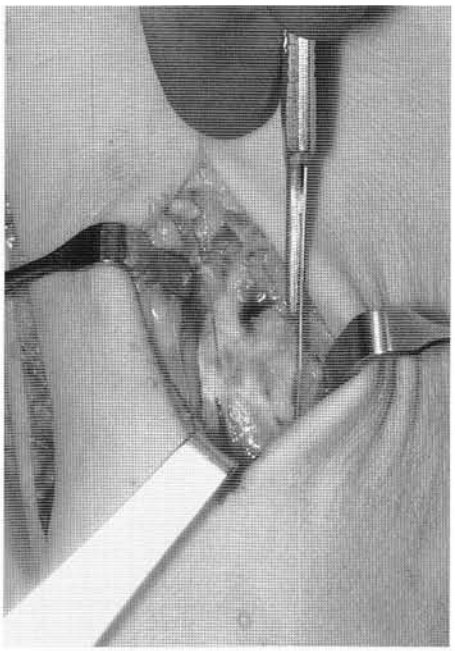

Figure 26. The extensor tendons are retracted laterally as a group. A linear incision has been made overlying the second metatarsal. Access to the third metatarsal base and respective cuneiform is demonstrated.

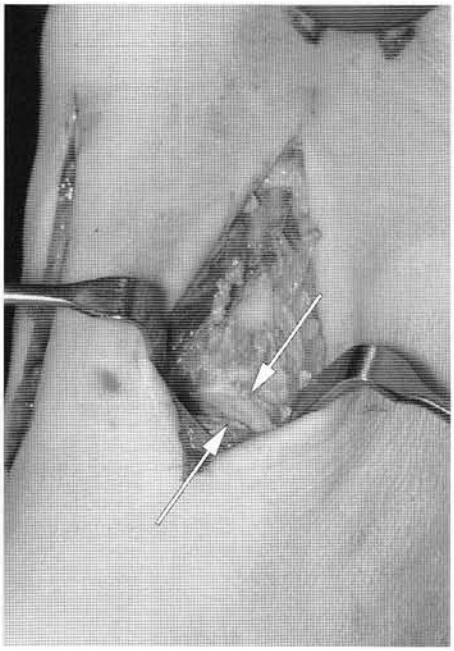

Figure 27. Note the dorsal and lateral subluxation of the second metatarsal cuneiform joint indicative of Lis Franc fracture instability and malposition.

Figure 28. Anatomic reduction is maintained with provisional fixation allowing definitive internal fixation stabilization under direct visualization.

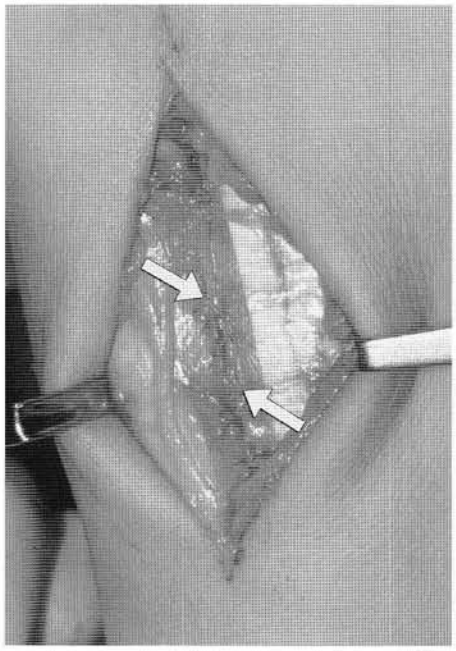

Figure 29. Care is taken to close the central incision first towards achieving an anatomic layered closure. Note the approximation of the preserved deep fascial layer adjacent to the EDL tendon slips.

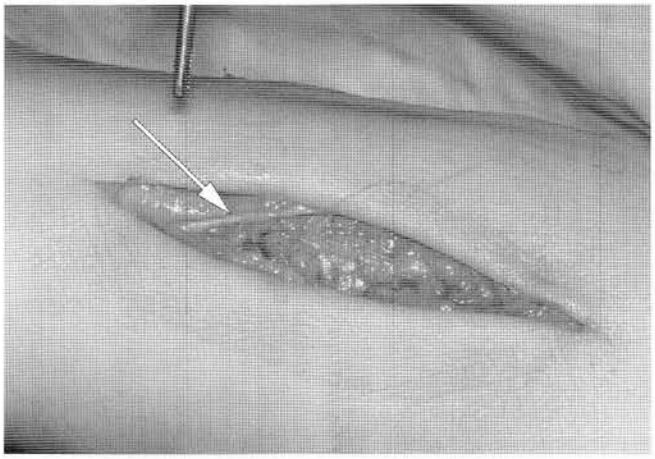

Figure 30. The deep fascia and periosteum is closed overlying the medial incision with care to identify and protect the medial dorso-cutaneous nerve distribution.

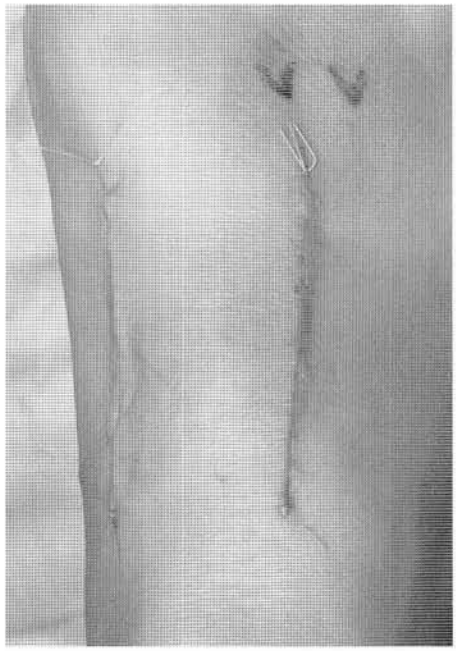

Figure 31. Final post-operative view demonstrating anatomic layered closure of medial and central incisions following ORIF.

Figure 32. DP radiograph indicative of complete laterally deviated "global" Lis Franc joint dislocation.

Figure 33. Lateral Oblique radiograph of same injury.

Figure 34. Incision plan for access to the medial and central "column" of the Lis Franc joint complex.

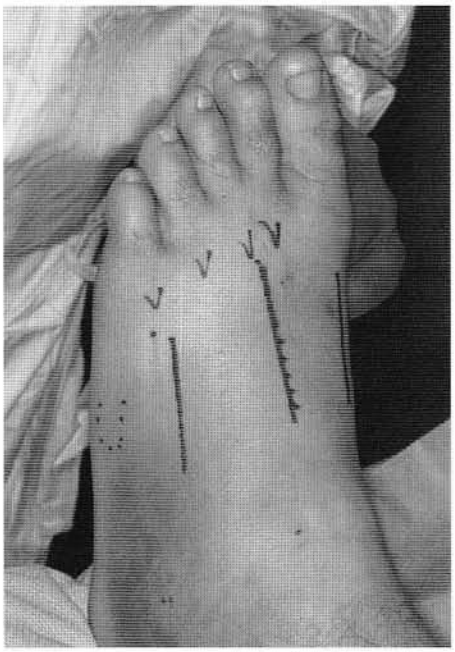

Figure 35. Lateral oblique perspective of the foot showing the planned incisions for the medial, central and lateral column stepwise approach to ORIF.

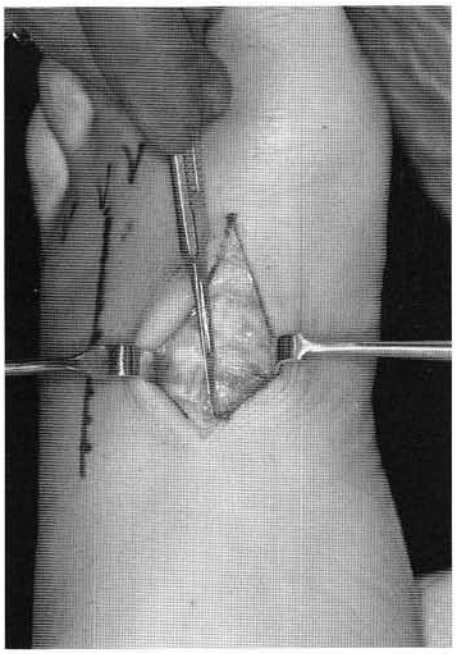

Figure 36. Deep fascial/periosteal incision towards accessing first metatarsal – cuneiform joint subluxation. A stepwise operative reduction medial to lateral reducing each respective Lis Franc articulation is performed.

Figure 37. Intra-operative radiograph demonstrating reduction and provisional fixation of the first metatarsal-cuneiform joint. Attention is then directed to reduce the second metatarsal base via an obliquely directed provisional wire as shown.

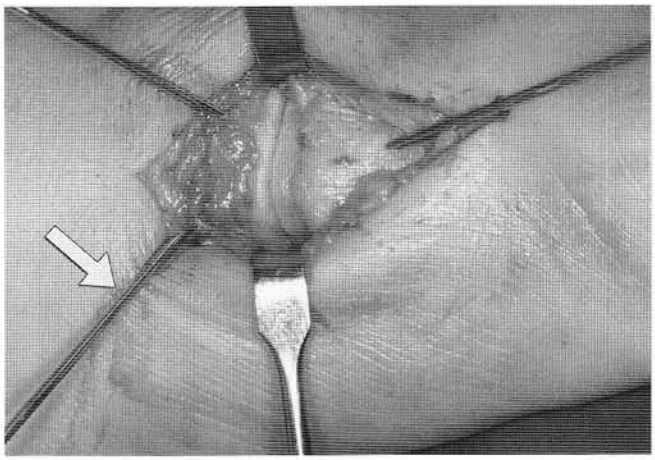

Figure 38. Intra-operative photo demonstrating provisional fixation following reduction of first metatarsal cuneiform joint and obliquely positioned provisional wire to indirectly secure the second metatarsal base and reduce the diastasis.

Figure 39. Indirect reduction is achieved via a medially based, laterally directed provisional fixation wire delivered obliquely from the medial cuneiform to the second metatarsal base. A second direct point of fixation is directed from the base of the second metatarsal to the respective middle cuneiform for stability.

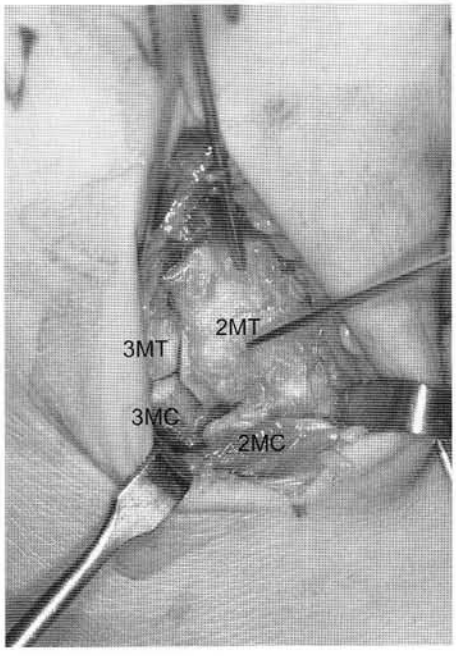

Figure 40. Following provisional fixation of the second metatarsal base, care is taken to reduce the third metatarsal by alignment of third metatarsal base articulation to the lateral cuneiform proximally, and the second metatarsal base medially.

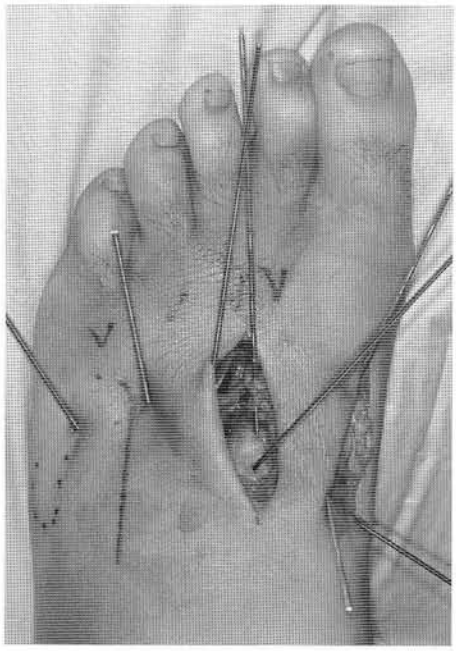

Figure 41. Global perspective of provisional fixation including percutaneous reduction to the fourth and fifth metatarsal-cuboid joint.

Figure 42. Fluoroscopic imaging illustrating a medial to lateral sequential anatomic reduction and provisional fixation.

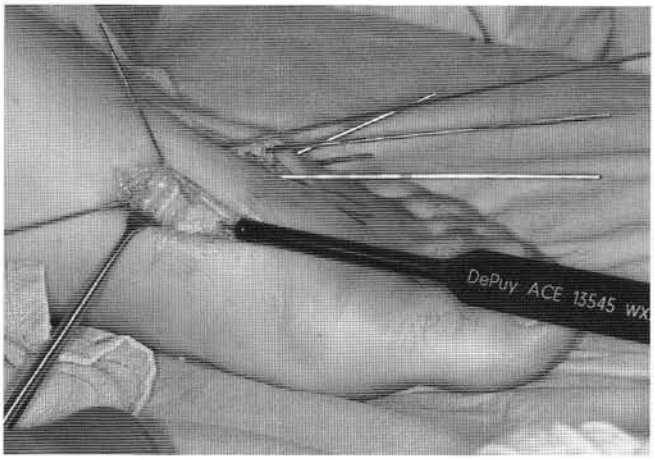

Figure 43. Once provisional fixation is stable and anatomic reduction achieved, conversion of the provisional fixation to permanent fixation achieved in a step-wise medial to lateral direction across the Lis Franc joint.

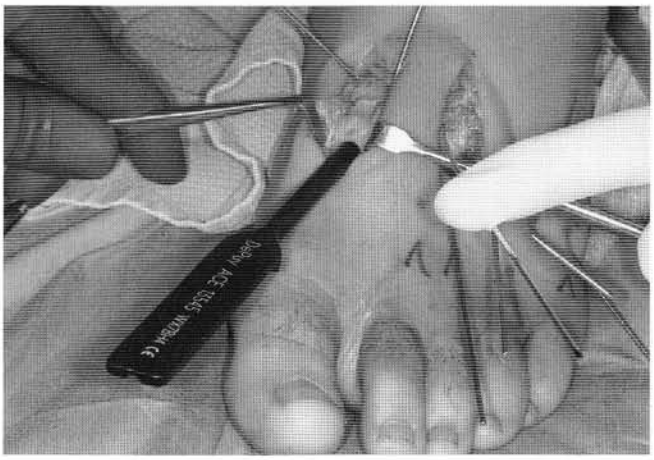

Figure 44. Two points of provisional fixation are maintained to prevent loss of intra-operative anatomic reduction.

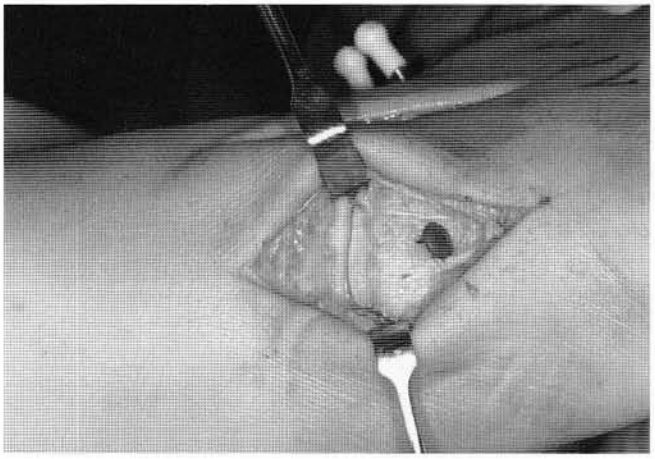

Figure 45. Fully threaded cortical screws are placed to maintain stability. The "positional" screw technique is utilized and final confirmation is obtained.

Figure 46. DP view demonstrates anatomic reduction with a permanent internal fixation construct.

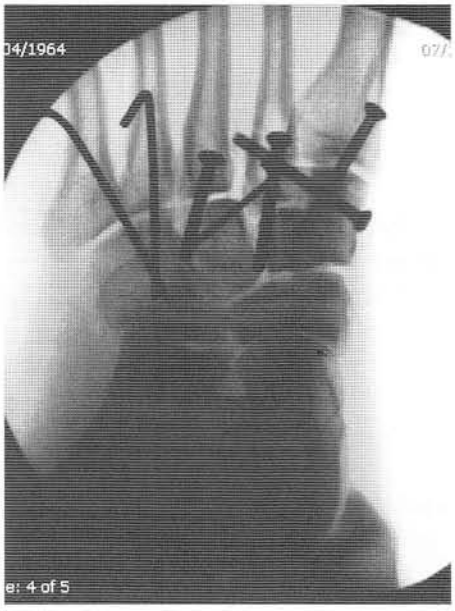

Figure 47. Lateral oblique view demonstrates anatomic reduction and percutaneous stabilization of the fourth and fifth metatarsal cuboid articulation.

Figure 48. Lateral view demonstrates anatomic alignment of the Lis Franc joint in the sagittal plane.

POSTOPERATIVE MANAGEMENT

The postoperative management of tarsometatarsal fracture repair and arthrodesis generally mandates an extended period of immobilization and off-loading (6-8 weeks) prior to return to weight-bearing activity.

Initially, a modified Jones compressive dressing or posterior splint is utilized to maintain the foot in a neutral position, control edema and local and/or regional nerve blocks and long acting local anesthetics (bupivacaine 0.25 % or 0.5 %) is an adjunctive enhancement to postoperative pain control and has known benefit in reducing narcotic usage following foot and ankle surgery.

Care is taken to inspect the surgical site(s) within five to seven days of the tarsometatarsal surgical procedure and continued edema control, serial casting, or application of a CAM type walker boot is provided. Instruction in pin care is rendered in surgical cases utilizing external fixation constructs and percutaneous k-wire techniques throughout the short-term post-operative follow-up. Suture removal is generally recommended between fourteen and twenty-one days. The extremity

may be bathed regularly once the skin is sealed and no evidence of wound complications is noted.

A formal physical therapy protocol may be instituted during the postoperative period. Edema control, passive range of motion exercise and desensitization techniques may serve as an adjunct to pain control, and are recommended to commence early in the recovery period to best serve the objectives of edema and pain control, and functional passive and active range of motion exercise. Supervised gait training and assistance may also add value in the challenged or non-compliant patient demographic. A minimum of six weeks of non-weightbearing is universally employed in all cases requiring open reduction and internal fixation for acute fracture dislocations and arthrodesis involving the Lis Franc joint complex. Internal fixation devices (screws) are recommended to remain for a minimum of three to four months following open reduction of Tarsometatarsal fracture and dislocation to promote ligamentous stability and healing. Adjunctive percutaneous wire fixation may be removed earlier, especially when utilized to stabilize the fourth and fifth metatarsal-cuboid joint. In patients undergoing subtotal or total tarsometatarsal arthrodesis, partial weightbearing with limited heel support may be initiated at postoperative week eight. Serial radiographs are generally obtained at four, eight, twelve, and sixteen weeks postoperatively to evaluate Tarsometatarsal position following open reduction. Similarly, recommendations for serial radiographs are equally important to monitor primary bone healing following Tarsometatarsal (Lis Franc) joint arthrodesis.

At times, internal fixation devices are retained following open reduction and fixation of tarso-metatarsal fracture/dislocations while weightbearing activity is initiated. Arthrodesis of the Lis Franc joint complex in patients with metabolic bone disease including osteoporosis, Charcot neuroarthropathy, and those patients with known or suspected abuse of tobacco products mandate extended periods of protective non-weightbearing, counseling and serial radiographic followup.

COMPLICATIONS

Complications specific to surgical intervention of the tarso-metatarsal (Lis Franc) may be varied and range in severity and prognosis. Appropriate timing of surgical intervention and concerted efforts to reduce soft tissue edema greatly reduce the incidence of wound complications such as dehiscence, cellulitis, and abscess formation and deep space infection in the acute traumatic injury.

Surgical incisions should ideally be planned and placed to avoid the superficial sensory nerves overlying the foot including the medial dorsal cutaneous, superficial peroneal distributions and the sural nerve. Such planning and care will reduce the incidence of complications such as neuropraxia, hypoesthesia, hyperesthesia and neurogenic mediated pain from sensory nerve irritation and fibrosis.

In the context of tarso-metatarsal (Lis Franc) fracture dislocations, attention to precise anatomic reduction and realignment is essential to reduce the sequelae of post-traumatic instability, pain, and arthrosis. Purely ligamentous injuries of the tarso-metatarsal joint complex are known to trend towards poorer outcomes despite anatomical reduction and stabilization. Difficulty with certain shoe wear, pain upon ballistic and recreational athletic activities, and limited ability to maintain active weightbearing may be noted following even anatomic reduction and stabilization. Various orthosis management and shoe modification may be of value in reducing forces across the tarso-metatarsal joint.

Malunion, delayed union and non-union are known complications occurring in the tarsometatatarsal region following arthrodesis of a portion or entire tarso-metatarsal joint complex. Advanced arthritic changes, subchondral sclerosis, and cystic degeneration may require bone grafting and biologic support to optimize successful arthrodesis. Care is taken to ensure anatomic alignment and a functional metatarsal weightbearing parabola. Arthrodesis of the fourth and/or fifth metatarsal cuboid joint carries an increased known risk of delayed or non-union. Avoidance of arthrodesis of the fourth and fifth metatarsal cuboid joint is ideally considered. Resection arthroplasty is currently recommended as a viable alternative to isolated lateral column arthrodesis, owing to the functional demand of the lateral component of the tarso-metatarsal (Lis Franc) joint in closed kinetic chain. Lesser metatarsalgia may be a post-operative finding following either sub-total or total arthrodesis. Treatment may necessitate orthotic and shoe modifications including rocker soles and wedges. A significant potential for revision surgery may occur, especially secondary to the sequelae of non-anatomic reduction of Lis Franc fracture dislocations and complications of non-union and malposition. Attention to precise alignment and joint preparation and position will optimize care to those patients with traumatic and degenerative indications for surgical treatment.

CLINICAL TIPS AND PEARLS

Tarsometatarsal Fracture Dislocation

- Control soft tissue edema towards preservation and maintenance of viable soft tissue envelope over the dorsal midfoot.
- Perform detailed clinical exam of each component of tarso-metatarsal joint complex with radiographic correlation, including CT as appropriate to identify subtle, neglected and occult injury.
- Restore anatomic relationship of medial, central and lateral column articulations of tarso-metatarsal joint complex and intercuneiform stability in a stepwise approach.
- Obtain stable internal fixation and adjunctive percutaneous stabilization as appropriate based upon injury pattern.

Tarsometatarsal Arthrodesis

- Ensure anatomic alignment is achieved/restored via arthrodesis - maintain normal or acceptable metatarsal parabola.
- Augment arthrodesis with bone graft and/or ortho biologics in context of advanced degenerative cystic arthrosis as appropriate.
- Avoid fourth/fifth metatarsal cuboid arthrodesis as possible in recalcitrant endstage arthrosis.
- Consider peroneus brevis lengthening towards anatomic relocation of neglected tarsometatarsal fracture/dislocation and sequelae.
- Evaluate and appropriately manage underlying equinus deformity, especially in patients requiring tarso-metatarsal arthrodesis secondary to Charcot neuroarthropathy.

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