TARSAL COALITIONS: A SURGICAL CLASSIFICATION

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INTRODUCTION

Tarsal coalitions occur when there is absent or restricted motion between two or more tarsal bones. Tarsal coalitions may be asymptomatic or may produce a dramatic, and many times characteristic, symptom complex. This symptom complex may ultimately be associated with a rigid pes valgo planus foot deformity. Secondary tonic muscle spasm, most commonly of the peroneus brevis, may also occur creating the condition of peroneal spastic flatfoot. The diagnosis of a tarsal coalition is made through the identification of this symptom complex and/or associated clinical deformity in combination with appropriate radiographic and other imaging studies. Once identified, both conservative and surgical treatment regimes are available for the management of the symptomatic tarsal coalition. However, in regards to the surgical management of tarsal coalitions, treatment has essentially been confined to either resection of the coalition or fusion of the involved joint complex. Since most reports involve only a small series of patients, significant controversy exists as to the indications and results to be expected from these two diverse surgical approaches. For this reason, the author proposes a new classification system which may be used as a framework for the construction of an appropriate treatment plan. The classification system is not meant to be all inclusive, but considers several important parameters used in the development of any treatment regime - patient age, articular involvement, and extent of secondary arthritic changes.[1]

TRADITIONAL CLASSIFICATIONS

Tarsal coalitions have traditionally been classified in several ways, including: (1) etiologic type; (2) anatomic type; and (3) tissue type.

Classification According to Etiologic Type

Initially, almost all tarsal coalitions were considered to be congenital. It is now certain that there are many different etiologies, and that not all tarsal coalitions are congenital. For this reason, tarsal coalitions can be classified according to their etiology - either congenital or acquired.[2]

Congenital tarsal coalitions remain the most frequently identified and reported, although the exact mechanism of congenital coalition is not known. Pfitzner[3] suggested that congenital tarsal coalitions are formed by the incorporation or fusion of accessory ossicles into two adjacent tarsal bones. For example, an os trigonum is an ossicle which may fuse to the talus and/or calcaneus creating a tarsal coalition[4]. Although this has been shown to be one possible cause of congenital coalition, Harris[5] has disproven it as the sole cause by demonstrating a tarsal coalition in a fetus.

Harris's findings support those of Leboucq[6] who suggested that congenital tarsal coalition results from the failure of differentiation and segmentation of primitive mesenchyme. This theory would attribute congenital coalitions to a heritable defect or to an insult in the first trimester of pregnancy. Subsequently, numerous authors have reported hereditary patterns of tarsal coalitions.[7-14]

A large field study by Leonard[15] has provided the most supportive evidence of Leboucq's theory. Leonard concluded that tarsal coalition was a unifactorial disorder with autosomal dominant inheritance. Thus, currently, Leboucq's theory is the most commonly accepted hypothesis for the etiology of congenital tarsal coalitions.

It is now well known that tarsal coalitions can be acquired. Acquired tarsal coalition can result from arthritis, infection, trauma, neoplasms, or other causes. Acquired coalition will be less common in pediatric and adolescent patients. The causes of acquired tarsal coalition can lead to varying degrees of joint limitation without complete restriction of motion. When all age groups are considered, acquired tarsal coalition is a frequent cause of symptomatic peroneal spastic flatfoot.[16]

Classification According to Anatomic Type

Tarsal coalitions may be classified according to their anatomic constituents. Tachdjian[17] has provided a classification subdividing coalitions into the bones that are abnormally united, or less frequently, as part of a complex malformation (Figure 1). Although only descriptive in nature, Tachdjian's classification suggests the importance of assessing other areas of the foot and the remainder of the body when an apparently local or isolated coalition is identified.

Classification According to Tissue Type

Tarsal coalitions can be grouped according to the tissue type of their union. In this way, a coalition may be classified as a synostosis (osseous union), synchondrosis (cartilaginous union), syndesmosis (fibrous union), or a combination of tissue types. A synostosis may evolve from a synchondrosis or syndesmosis. This has been theorized to occur with age or possibly after trauma to the coalition.[16] A synostosis may also be referred to as a complete coalition since all motion is necessarily absent. An incomplete coalition has varying amounts of interposed cartilaginous or fibrous tissue and may allow motion between the involved bones. The tissue type of the coalition is important and should be noted when attempting to diagnose a coalition.

It is the author's impression that the aforementioned traditional classification systems are primarily descriptive in nature. By combining these classifications, a useful description of a tarsal coalition can be made. For example, a tarsal coalition may be described as a congenital synchondrosis of the middle facet of the talocalcaneal joint. Given this information, one can more accurately understand the tarsal coalition present. However, these traditional classification systems, even when combined, provide only a small amount of information which will be of assistance in developing a successful therapeutic plan. For this reason, a new classification system based upon the patient's osseous maturity, the articular relationship of the bones involved in the

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FIGURE 1

Isolated Anomaly
  Dual between two tarsal bones
    Talocalcaneal
      Middle
        Complete
        Incomplete
        Rudimentary
      Posterior
      Anterior
    Calcaneonavicular
    Talonavicular
    Calcaneocuboid
    Naviculocuneiform
  Multiple - combinations of the above
  Massive - all tarsal bones fused together

Part of a Complex Malformation
  In association with other synostoses
    Carpal coalition
    Symphalangism
  As one of manifestations of a syndrome
    Nievergelt-Pearlman
    Apert's
  In association with major limb anomalies
    Absence of toes or rays
    "Ball-and-socket" ankle joint
    Fibular hemimelia
    Phocomelia
    Proximal focal femoral deficiency

Fig. 1. Classification of tarsal coalitions according to anatomic type. (Revised from Tachdjian MO: The Child's Foot, p. 262, WB Saunders, Philadelphia, 1985.)

coalition, and the secondary changes in surrounding joints is proposed.

ARTICULAR CLASSIFICATION SYSTEM

The author proposes the *Articular Classification System* as a surgical classification system for tarsal coalitions. This articular classification system, when combined with the descriptive parameters already discussed may serve as a basis for dialog and communication about possible surgical treatment. The classification assumes that the most important criteria for determining surgical treatment are the patient's age, the articular involvement or relationship of the bones forming the coalition, and the degree of secondary arthritic changes in joints around the coalition.

Patient Age

The age of a patient is virtually always a factor when the surgical treatment of a tarsal coalition is contemplated. Ideally, in all patients, one would like to be able to resect the tarsal coalition and restore normal or near normal function to the involved joint(s). Practically though, this is frequently not possible. Thus, one must balance the likelihood of success of resection of the coalition against the possible need for additional surgery (i.e., arthrodesing procedures) should this resection procedure fail.

In the younger patient who has not yet achieved osseous maturity (i.e., physeal growth plates are still open), resection would certainly seem to be the treatment of choice for most tarsal coalitions. The remodelling potential of the growing patient is not to be underestimated. For example, it is well documented that the osseously immature patient is much more likely than an adult patient to achieve an asymptomatic recovery with an acceptable return of function after a severe, joint depression calcaneal fracture. Similarly, in the juvenile patient, the increased joint motion achieved with resection of a tarsal coalition, combined with continued osseous growth and remodelling, would hopefully result in a more normal, less painful joint complex in the area of the previous coalition. In this osseously immature patient, major arthrodesing procedures could be performed at a later date (even after osseous maturity has been achieved) should the resection attempt fail.

In adult or osseously mature patients, resection of the tarsal coalition may also be considered, but is more prone to failure. The limited remodelling potential in the adult patient diminishes the probability of recovery to a functional, asymptomatic state. Prior to coalition resection, the patient should certainly be informed of the risk of recurrent or increased joint limitation and symptomatology in the area of the excised tarsal coalition. The patient should further understand that arthrodesis might eventually be necessary to treat the condition and diminish their symptom complex. With this understood, the adult patient with a tarsal coalition can undergo an attempt at resection of their coalition. Arthrodesis of the joints affected by the coalition may be performed at a later date if this resection attempt fails.

As will be discussed, there are other factors to weigh when considering resection of a tarsal coalition. Certain patients will be poor candidates for resection regardless of their osseous maturity. When the potential for subjective and objective recovery following resection of a tarsal coalition is dubious, then arthrodesis should generally be considered as the first surgical alternative.

Thus, as stated earlier, one must balance the probability of the success of resection of the coalition against the conceivable need for additional surgery (i.e., arthrodesing procedures) should this resection procedure fail. With other factors being equal, generally the younger the patient, the more amenable the tarsal coalition is to surgical resection.

Articular Involvement

The articular involvement, or the joints affected by the tarsal coalition, is the most important factor when considering the surgical management of a tarsal coalition. Tarsal coalitions can be divided into those which are extraarticular (i.e., occuring outside normal joint(s)), or intraarticular (i.e., occuring within normal joint(s)) (Figure 2).

Extraarticular tarsal coalitions are those which occur between two or more tarsal bones which do not normally articulate with one another, or outside the joint spaces of two or more tarsal bones which do articulate with one another. Historically, these coalitions have been referred to as "bars" as they "bar" or limit motion between supposedly otherwise normal tarsal structures. The most common example of an

FIGURE 2

Extraarticular Coalitions
    Calcaneonavicular
    Cubonavicular
Intraarticular Coalitions
    Talocalcaneal
      Middle
      Posterior
      Anterior
      Combination
    Talonavicular
    Calcaneocuboid
    Naviculocuneiform

Fig. 2. Division of tarsal coalitions into extraarticular and intraarticular coalitions. Multiple and massive coalitions are usually intraarticular and are frequently associated with secondary arthritic changes. (Adapted from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 63.)

extraarticular tarsal coalition is the calcaneonavicular bar. This coalition occurs between the calcaneus and navicular, two bones between which there is normally no articulating joint. Extraarticular coalitions are generally more responsive to resection as their excision does not destroy or alter the existing tarsal joint(s).

Intraarticular tarsal coalitions are those which occur within the joint spaces of two or more tarsal bones. Traditionally, these coalitions have been referred to as "bridges" as they "bridge" across a joint. Coalition of the middle facet of the talocalcaneal joint is the most frequently occuring example of an intraarticular tarsal coalition. This coalition, whether osseous, cartilaginous, or fibrous, occurs and alters a normal joint relationship. Since the affected joint surfaces in an intraarticular coalition are not normal, resection of an intraarticular tarsal coalition is more prone to failure. For this reason, the intraarticular tarsal coalition is generally less amenable to resection as its excision destroys or alters an already abnormal tarsal joint.

Secondary Arthritic Changes

The presence or absence of arthritic changes in the joints surrounding a tarsal coalition will have a significant impact on the selection of a surgical remedy. These changes often are considered to be secondary to the restricted motion and altered biomechanics created by the tarsal coalition, and are therefore termed secondary arthritic changes. Many of these changes are classically seen with tarsal coalitions. For example, talonavicular joint beaking is a secondary change commonly seen with a middle facet talocalcaneal joint coalition. Narrowing of joint spaces, joint lipping or osteophyte formation, and adaptive changes in osseous structures and joints are all frequent secondary arthritic changes which may be associated with a tarsal coalition.

Obviously, the greater the quantity and severity of the secondary arthritic changes present in conjunction with a tarsal coalition, the more difficult will be the surgical procedure for that coalition. Further, with more secondary arthritic changes, the tarsal area will be less responsive to simple resection of the tarsal coalition. Resection of a tarsal coalition in the presence of significant secondary arthritic changes could result in further biomechanical adjustment being necessary in an already mechanically compensated foot. This generally results in further aggravation of any existing symptom complex. Thus, when significant secondary arthritic changes are associated with a tarsal coalition, an arthrodesis-type procedure is usually considered the procedure of choice.

Proposed Classification System

Based upon the aforementioned parameters, the classification system divides patients based upon osseous age into juvenile (osseous immaturity) and adult (osseous maturity) categories. These categories are then further subdivided into the articular involvement of the coalition - whether extra-articular or intra-articular. Finally, the classification is further subdivided into the presence or absence of significant secondary arthritis or indirect changes within surrounding joints (Figure 3).
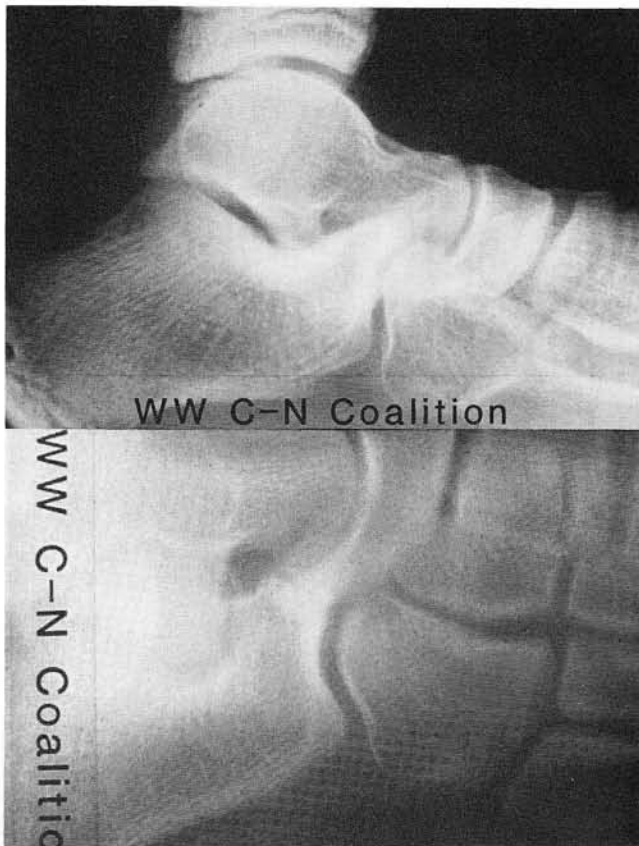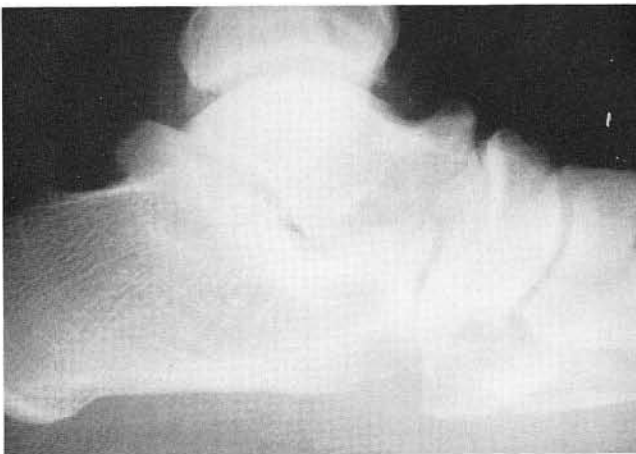
Juvenile - IA

The "Juvenile - IA" coalition or "Juvenile, extraarticular coalition without secondary changes" represents an extraarticular coalition with minimal secondary arthritic changes in an osseously immature individual (i.e., juvenile patient). Traditionally, an extraarticular coalition such as a cal-

FIGURE 3

Juvenile (Osseous Immaturity)
   Type I - Extraarticular coalition
      A - No secondary arthritis
      B - Secondary arthritis
   Type II - Intraarticular coalition
      A - No secondary arthritis
      B - Secondary arthritis
Adult (Osseous Maturity)
   Type I - Extraarticular coalition
      A - No secondary arthritis
      B - Secondary arthritis
   Type II - Intraarticular coalition
      A - No secondary arthritis
      B - Secondary arthritis

Fig. 3. Articular Classification System. (Adapted from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 62.)

Fig. 4. Example of Juvenile - IA coalition. A calcaneonavicular bar in an osseously immature (11-year old) patient. Minimal secondary arthritic changes are noted. (Reprinted with permission from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 63.)

caneonavicular coalition, has been considered more amenable to surgical resection. This is particularly true when no secondary degenerative changes in surrounding joints have occurred. Thus, in the younger patient with an extraarticular coalition and minimal secondary arthritic changes, resection of the coalition is generally the procedure of choice (Figure 4).

If the coalition is a calcaneonavicular bar, the classic interposition arthroplasty procedure, as first described by Badgley,[18] is excision of the coalition with interposition of the extensor digitorum brevis muscle belly into the resultant defect. Many surgeons have reported good success with this procedure.[19-25] The most commonly described postoperative problem has been varying degrees of recurrence of the limited motion associated with the coalition. This was found to be due to fibrous or osseous tissue formation at the site of the original coalition, but generally was not found to be a problem if a generous resection of the bar was initially performed. Despite this, several suggested modifications have been proposed which attempt to limit the formation of fibrous or osseous tissue at the coalition resection site and from the bleeding resected bone ends. These suggestions include the coagulation of the bone ends,[17] the use of bone wax on the bone ends,[26] the interposition of adipose tissue between the bone ends instead of the muscle belly,[17,27] or the insertion of a silicone implant between the bone ends instead of the muscle belly.[28]

In similar fashion, other more uncommon extra-articular coalitions without secondary degenerative changes, such as a cubonavicular coalition, should offer similar hope of favorable results following resection.

Several authors[29,30] have discussed the possibility of performing a varus-producing osteotomy of the calcaneus as a means of treating a tarsal coalition. Dwyer[30] reasoned that the valgus position of the rearfoot, commonly seen with a tarsal coalition, produces an "oblique strain of the ligaments" in the rearfoot and ankle with resultant pain. He advocated an opening wedge calcaneal osteotomy with a bone graft inserted through a lateral approach. Similarly, Cain and Hyman[29] described success in treating coalitions with an analogous procedure. Instead of an opening osteotomy, Cain and Hyman performed a closing osteotomy of the calcaneus through a medial

approach. Neither of these reports suggested resection of the coalition along with the calcaneal osteotomy. Logically, the osteotomy alone would seem of limited benefit as demonstrated by orthotic devices which maintain the heel in a varus position, and yet, afford only minimal relief of subjective symptoms. However in treating the extraarticular coalition, if significant heel valgus is present, a varus-producing calcaneal osteotomy combined with resection of the coalition may be of some benefit.

Juvenile - IB

The "Juvenile - IB" coalition or "Juvenile, extraarticular coalition with secondary changes" represents an extraarticular coalition in an osseously immature individual with significant secondary arthritic changes (Figure 5). Generally, an extraarticular coalition with secondary arthritic changes is less amenable to simple surgical resection. However, in the younger patient it should still be strongly considered with the the potential benefits of resection weighed against the possible need for additional surgery (i.e., arthrodesis) in the future. If resection of the coalition is to be performed, informed consent should include a discussion of the potential future need for arthrodesis. Alternatively, resection of the coalition with a simple exostectomy of any significant spurring may be considered.

As with any coalition, over time significant degenerative changes may occur with an extraar-ticular coalition. In a calcaneonavicular coalition, the talonavicular joint will usually demonstrate the most apparent changes. In the younger patient with mild secondary degenerative changes, extensor digitorum brevis interpositional arthroplasty may again be attempted. However, the patient and parents should be told that a triple arthrodesis may need to be performed in the future. With more significant degenerative changes, triple arthrodesis is the initial procedure of choice. In cases where triple arthrodesis is to be performed, a complete coalition (i.e., synostosis) may be left intact. However, if the coalition is incomplete (i.e., syndesmosis or synchondrosis) or if significant positional abnormalities exist, the coalition should be resected to obtain optimal postoperative position and fusion. In the osseously immature individual, triple arthrodesis is ideally delayed until after tarsal osseous maturity.

Juvenile - IIA

As previously discussed, extraarticular coalitions are generally reasoned to be more amenable to resection, while intraarticular coalitions are traditionally considered an indication for arthodesis. The exception to this premise might be the "Juvenile - IIA" coalition or "Juvenile, intraarticular coalition without secondary changes." This coalition represents an intraarticular coalition which occurs in an osseously immature patient with minimal or no secondary degenerative changes (Figure 6). In certain situations, resection of this

Fig. 5. Example of Juvenile - IB coalition. A calcaneonavicular bar in an osseously immature (14-year old) patient with significant secondary arthritic changes. Note talonavicular joint beaking.
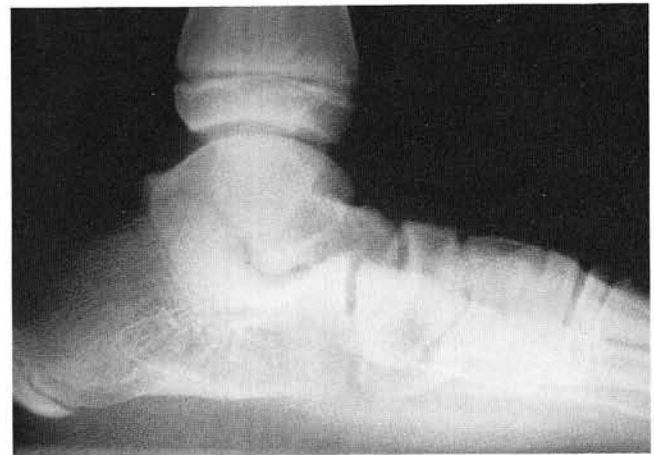

Fig. 6. Example of Juvenile - IIA coalition. A synostosis of the middle facet of the talocalcaneal joint in an osseously immature (14-year old) patient. Note the following classic lateral radiograph findings of such a coalition: (1) loss of subtalar joint clarity; (2) flattening of the lateral talar process; and (3) halo sign. Minimal secondary arthritic changes, such as talonavicular joint beaking, are noted.

type of coalition may allow objective improvement of the motion of the tarsal joints, and a subjective decrease in the patient's symptoms. If the coalition is small and/or incomplete in nature, this coalition may potentially be even more amenable to resection arthroplasty. Since this intraarticular coalition has permanently altered a joint, it should be remembered that future arthrodesis will many times be necessary.

A common example of a "Juvenile - IIA" coalition would be a middle facet coalition of the subtalar joint. Typically, resection of this coalition leaves a defect and an irregular area in one of the articular facets of a major weightbearing joint. Logically then, one would expect resection of such a coalition to result in a limited increase in motion with probable crepitus in the joint space. If the patient has concommitant peroneal muscle spasm, one would anticipate a continuation of the tonic spasm. Thus, the logical postoperative expectation would seem to be limited objective improvement and potentially little subjective improvement in symptoms. However, several authors have described resection of intraarticular coalitions with or without the interposition of autogenous fat grafts, and have reported satisfactory results.[17,19,25,31] Similarly, interposition arthroplasty may be achieved by performing resection of the coalition accompanied by the use of a subtalar joint motion blocking device or arthroereisis to maintain the joint space (Figure 7).[1,32]

Another example where resection might be beneficial, is the posterior facet talocalcaneal coalition secondary to a fractured Stieda's process or os trigonum. If the coalition occurs within the posterior facet of the subtalar joint, it would be an intraarticular coalition. If it occured outside the subtalar joint, it would be considered an extraarticular coalition. In either scenario, surgical resection of the coalition and/or os trigonum may lead to a satisfactory functional result.[4]

In the reports of Dwyer[30] and Cain and Hyman,[29] no distinction was made between extraarticular and intraarticular coalitions. They uniformly felt that varus-producing osteotomies of the calcaneus could afford relief of symptoms in tarsal coalitions without significant secondary arthrosis. Unfortunately, no long-term followup studies have been reported to substantiate their beliefs. A varus-producing osteotomy of the
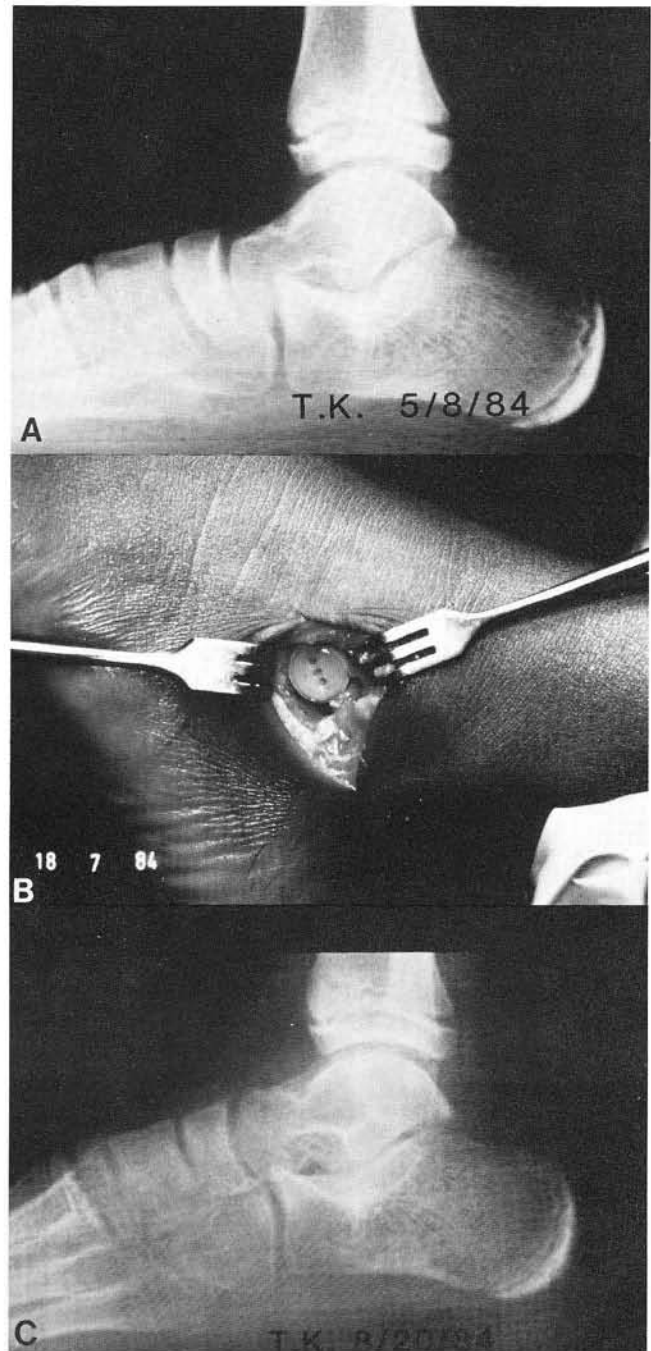
Fig. 7. Juvenile patient (12-year old) with middle facet talocalcaneal coalition and minimal secondary arthritic changes (i.e., Juvenile - IIA coalition). **A** - Preoperative radiograph; **B** - Insertion of arthroereisis into sinus tarsi; **C** - Postoperative radiograph. Note the postoperative decrease in the talar declination angle and improved subtalar joint appearance. (Reprinted with permission from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 73.)

calcaneus may be a useful surgical adjunct if concomitant resection of the coalition is contemplated.

In those cases with significant intraarticular joint involvement or in cases of failed resection, arthrodesis would seem to be the procedure of choice. Since the midtarsal and subtalar joints work in unison, in most instances, triple arthrodesis is preferred over single arthrodesis. With talocalcaneal coalitions involving the middle facet and without secondary arthritic changes, debate continues as to the preferred arthrodesis - isolated subtalar joint arthodesis or triple arthrodesis. The author contends, and a recent report by Mann and Baumgarten[32] suggests, that isolated arthrodesis generally provides a superior functional result. Arguably, triple arthrodesis should be reserved for cases where the coalition, although not associated with secondary degenerative changes, is demonstrating significant structural influence (e.g., profound forefoot varus, rearfoot valgus, or equinus). In such cases, triple arthrodesis would be necessary to obtain a structurally and biomechanically acceptable forefoot to rearfoot relationship.

Juvenile - IIB

The "Juvenile - IIB" coalition or "Juvenile, intraarticular coalition with secondary changes" represents an intraarticular coalition in an osseously immature individual with significant secondary arthritic changes (Figure 8). Such an intraarticular coalition with moderate to severe secondary arthritic changes is optimally treated with a triple arthrodesis after osseous maturity.

Adult - IA

The "Adult - IA" coalition or "Adult, extraarticular coalition without secondary changes" represents an extraarticular coalition in an osseously mature individual with minimal secondary arthritic changes (Figure 9). In the adult patient, one generally considers arthrodesis more strongly than in the child. However, when the coalition is extraarticular and no secondary arthritic involvement is noted, interpositional arthroplasty may be considered. Since the adult patient has more limited remodelling potential, any attempted resection should be approached with caution. The patient should be informed preoperatively that recurrent
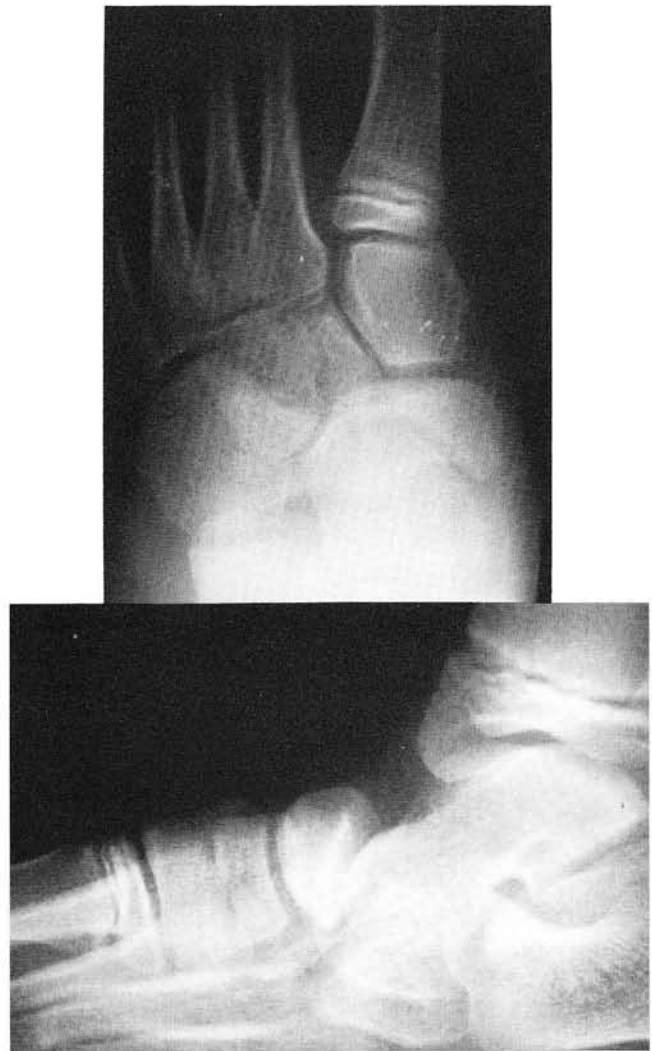
Fig. 8. Example of Juvenile - IIB coalition. A syndesmosis of the middle facet of the talocalcaneal joint in a 13-year old patient. Note rearfoot pathology and secondary changes including a significantly deformed talonavicular joint with severe wedging of the navicular.

or increased symptoms may result following an interpositional arthroplasty, and that an arthrodesing procedure may be necessary in the future to placate the symptom complex. Again, an individualized decision must be made for each patient, weighing the benefits of initial resection with the possible need for a second surgery (i.e., arthrodesis) at a later date against an immediate arthrodesing procedure.

Adult - IB

The "Adult - IB" coalition or "Adult, extraarticular coalition with secondary changes" represents an extraarticular coalition in an adult or osseously

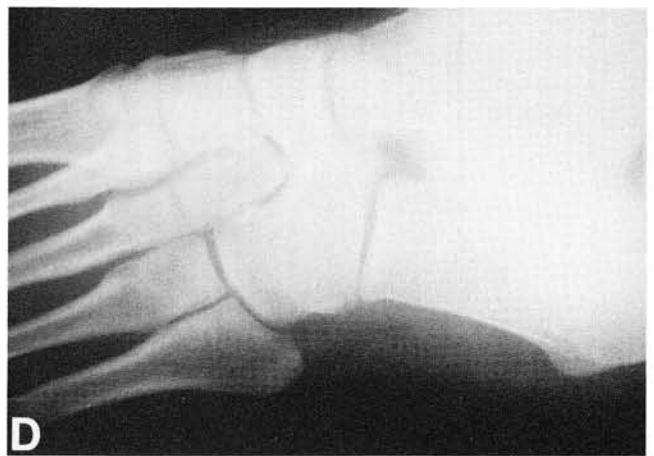Fig. 9A.

Fig. 9B.

Fig. 9C.

Fig. 9D.

Examples of Adult - IA coalitions. A-B - A calcaneonavicular bar with minimal secondary arthritic changes in a 22-year old patient. Note cavovarus attitude of the foot. C-D - A cubonavicular synostosis without significant secondary arthritic changes in an 18-year old patient.

mature individual with significant secondary arthritic changes (Figure 10). When the extraarticular coalition in the adult is associated with moderate to severe secondary degenerative changes, arthrodesis is preferable. In most cases, triple arthrodesis will be indicated. Not withstanding, in rare instances where only a single joint demonstrates significant secondary arthritic changes, resection of the coalition with a simple arthroplasty/exostectomy at the involved joint or a single joint arthrodesis may be viable alternatives.
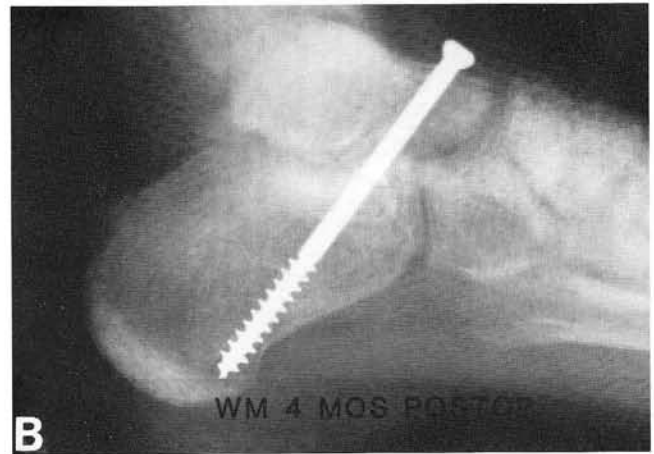
Adult - IIA

The "Adult - IIA" coalition or "Adult, intraarticular coalition without secondary changes" represents an intraarticular coalition in an osseously mature individual without significant secondary arthritic

changes (Figure 11A). Unlike the juvenile patient, resection of an intraarticular coalition should generally not be considered in the adult patient. Due to the very limited potential for recovery to a functional, asymptomatic state following resection, arthrodesis should be viewed as the primary surgical option. Only if the patient is adamant and fully understands the probable future need for arthrodesis, should interpositional arthroplasty be considered.

Isolated arthrodesis of the involved joint may be performed if minimal secondary arthritic changes are noted (Figure 11B). Triple arthrodesis may also be considered, and is certainly preferable if one needs to obtain positional correction in the foot For example, the midtarsal joint resection/position in a triple arthrodesis could be used to derotate the forefoot in relation-
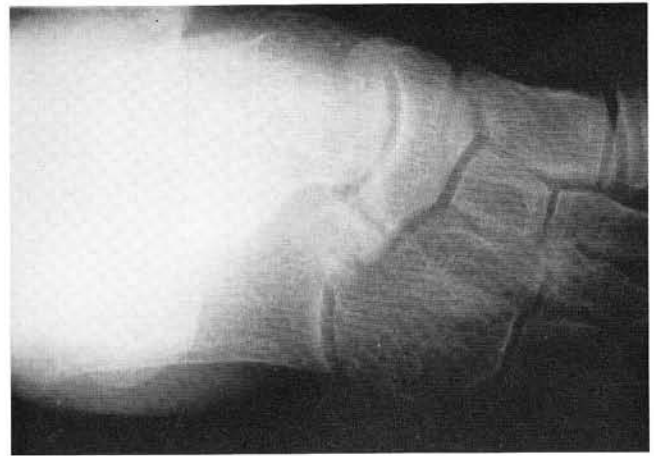
Fig. 10. Example of Adult - IB coalition. A calcaneonavicular bar with large talonavicular exostosis in a 20-year old patient. Patient underwent surgical resection of coalition with exostectomy of talonavicular prominence.
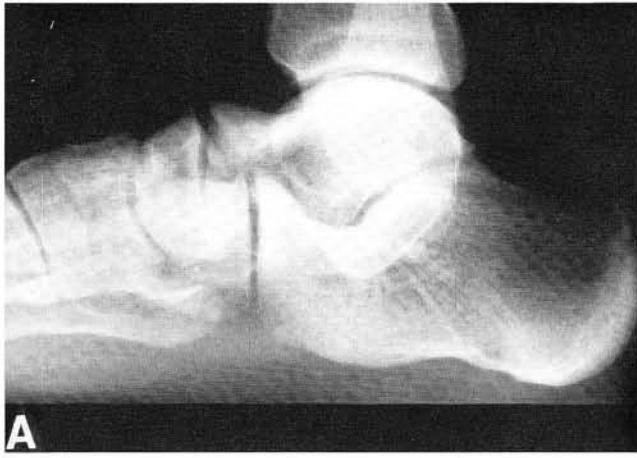

Fig. 11A. Example of Adult - IIA coalition. A - A 19-year old patient with a syndesmosis of the middle facet of the talocalcaneal joint. Note minimal secondary arthritic changes.

Fig. 11B. Example of Adult - IIA coalition. B - Postoperative radiograph of same patient, 4-months following isolated subtalar joint arthrodesis with screw fixation. (Reprinted with permission from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 74.)
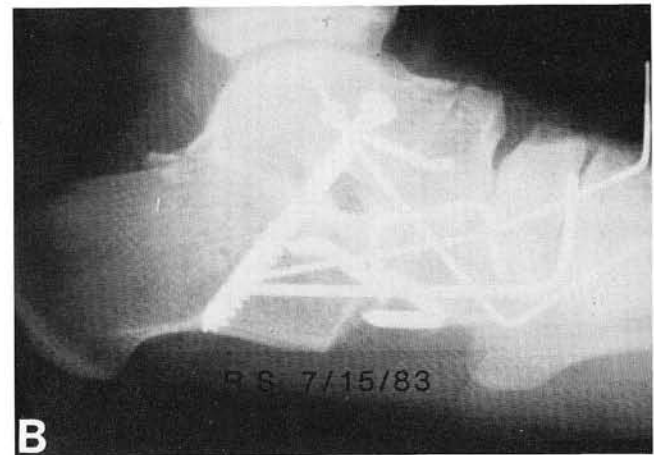

Fig. 12A. A 17-year old patient with a synostosis of the talonavicular joint with minimal secondary arthritic changes (i.e., Adult - IIA coalition). A - Preoperative radiograph. Patient had 20 degrees of forefoot varus deformity.

Fig. 12B. Immediate postoperative radiograph following triple arthrodesis with internal fixation.

Fig. 13A. Example of Adult - IIB coalition. A 17-year old patient with a synostosis of the middle facet of the talocalcaneal joint. Note signficant secondary arthritic changes including both talonavicular and calcaneocuboid joint beaking. A - Preoperative radiograph.
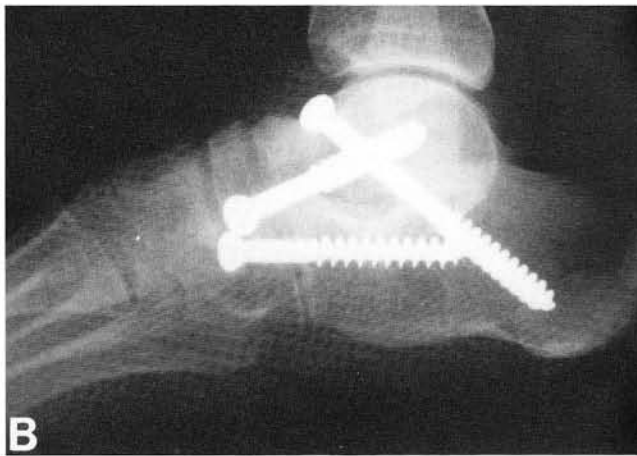
Fig. 13B. Example of Adult - IIB coalition. B - Postoperative radiograph, 3-months following a triple arthrodesis with internal screw fixation.

ship to the rearfoot to correct a significant forefoot varus or supinatus deformity (Figure 12).

Adult - IIB

The "Adult - IIB" coalition or "Adult, intraarticular coalition with secondary changes" represents an intraarticular coalition in an osseously mature individual with significant secondary arthritic changes (Figure 13A). This type of coalition often presents with the most pathologic scenario: a rigid pes valgo planus foot, associated severe degenerative changes, and frequent concommitant peroneal muscle spasm. Therefore, triple arthrodesis is the procedure of choice for the "Adult II - B" coalition (Figure 13B).

FIGURE 14

JUVENILE - IA
  Resection with interposition of EDB muscle
  Resection with interposition of adipose tissue
    Resection with varus-producing calcaneal osteotomy
  Resection with insertion of implant
  Varus-producing calcaneal osteotomy alone
JUVENILE - IB
  Resection with interposition of EDB muscle
  Resection with interposition of adipose tissue
    Resection with varus-producing calcaneal osteotomy
  Resection with insertion of implant
  Varus-producing calcaneal osteotomy alone
  Triple arthrodesis
JUVENILE - IIA
  Resection alone
  Resection with interposition of adipose tissue
  Resection with interposition of arthroereisis
    Resection with varus-producing calcaneal osteotomy
  Varus-producing calcaneal osteotomy alone
  Isolated/single arthrodesis
  Triple arthrodesis
JUVENILE - IIB
  Triple arthrodesis
ADULT - IA
  Resection with interposition of EDB muscle
  Resection with interposition of adipose tissue
    Resection with varus-producing calcaneal osteotomy
  Resection with insertion of implant
  Varus-producing calcaneal osteotomy alone
  Triple arthrodesis
ADULT - IB
  Resection with isolated/single arthrodesis
  Triple arthrodesis
ADULT - IIA
  Isolated/single arthrodesis
  Triple arthrodesis
ADULT - IIB
  Triple arthrodesis

Fig. 14. Possible surgical procedures based on the Articular Classification System. Note that procedures listed in bold type are currently most commonly performed. (Revised from Downey MS: Tarsal coalition: current clinical aspects with introduction of a surgical classification. In McGlamry ED (ed.): Reconstructive Surgery of the Foot and Leg: Update '89. Podiatry Institute Publishing Company, Tucker, Georgia, 1989, p. 75.)

SUMMARY

The author offers the *Articular Classification System* as a format for discussing management options in the treatment of tarsal coalitions. In this sense, this new classification system provides a superior method of grouping tarsal coalitions, and debating the surgical options for any individual patient (Figure 14). It should be remembered that procedural selection will vary from patient to patient, and that recommended surgical procedures are dependent upon the combined goals and desires of both the surgeon and patient in attempting to obtain both subjective and objective improvement. Thus, the classification system cannot be encyclopedic, but considers several important parameters used in the development of any coalition's treatment regime - patient age, articular involvement, and the extent of secondary arthritic changes. It is hoped that based upon this system, recommended procedures and the report of long-term results can be more accurately related.

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RECALCITRANT PLANTAR HEEL PAIN: A VARIANT OF TARSAL TUNNEL SYNDROME

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Plantar calcaneal heel pain is a common malady affecting patients that present to the podiatrist for treatment. This often recognized clinical entity is most typically related to hyperpronation of the hindfoot and midfoot, with associated supinatus of the forefoot. This relationship can create chronic enthesitis affecting the calcaneal attachment of the plantar fascia and the origins of the intrinsic musculature of the plantar vault. This ailment, in most cases, satisfactorily responds to conservative therapy and strong consideration should be given to the possibility of concomitant plantar nerve entrapment (a variant of tarsal tunnel syndrome) in cases proving to be resistant to typical therapeutic measures.[1, 2]

Patients with heel pain related to chronic nerve compression usually describe sharp, often burning pain localized to the plantar-medial aspect of the tuberosity of the calcaneus. The primary symptom seems to most often be exquisite local tenderness localized deep to the proximal (dorsal) portion of the belly of abductor hallucis, although Tinel's sign may be elicited along the distribution of either, or both, of the plantar nerves. Less frequently, paresthesia is elicited proximally over the tarsal tunnel region. It is important to ascertain that the patient is experiencing deep pain, and not superficial symptoms correlating to the skin or immediate subcutaneous tissues. The symptoms are usually aggravated by weightbearing and ambulation, and post-static dyskinesia is often present. In most cases, there are no visible signs of discoloration, edema, or local increase in skin temperature. Electro-diagnostic studies may be indicative of nerve entrapment. Radiographs may or may not display a plantar calcaneal spur.

Nonoperative treatment of this condition requires careful mechanical support and balancing and, if necessary, local infiltration of glucocorticosteroid about the plantar nerves at the level of the porta pedis and deep plantar fascia. In general, this form of therapy should be administered for about three months.

Operative intervention should only be undertaken in those cases where symptoms cause significant disability despite appropriate conservative therapy. The mainstay of surgical intervention involves accurate external neurolysis of the medial and lateral plantar nerves as they traverse the porta pedis and enter the plantar vault, in conjunction with release of the deep fascia and partial plantar fasciectomy, and remodeling of the plantar calcaneal spur.

External neurolysis requires sectioning the flexor retinaculum and opening the tarsal tunnel to allow identification of the posterior tibial nerve and its branches. The bifurcation into medial and lateral plantar nerves most commonly occurs proximal to the tip of the medial malleolus,[3] and