Fracture of the Proximal Fifth Metatarsal

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The diagnosis, pathomechanics, time from injury to treatment, and optimal treatment of proximal fifth metatarsal fractures are topics of great debate. Use of the term "Jones fracture" to describe all such injuries in the orthopaedic literature and among treating physicians has added to the confusion, resulting in negative consequences for prognosis and appropriate treatment recommendations. Improved patient outcomes are dependent on correct classification of the fracture, appropriate treatment selection, and proper technique.

Knowledge of anatomy is vital in distinguishing the fracture types. The base of the fifth metatarsal has three anatomic fracture zones: zone 1, tuberosity; zone 2, metaphyseal-diaphyseal junction (Jones); and zone 3, diaphyseal stress. Identifying the correct zone is important because the healing characteristics and treatment are different for fractures occurring in each[1-3] (Figure 1).

The radiographic appearance of proximal fifth metatarsal fracture is classified into three types under the Torg classification: type I, fracture on the lateral aspect of the tuberosity, extending proximally into the metatarsocuboid joint (Figure 2, A); type II, Jones fracture, beginning laterally in the distal part of the tuberosity and extending obliquely and proximally into the medial cortex at the fourth and fifth metatarsal base articulation (Figure 2, B); and type III, fracture distal to the fourth and fifth metatarsal base articulation (Figure 2, C).[4] The type I tuberosity fracture is the most common.

The mechanism of injury can be correlated to fracture type. Type I fracture (ie, tuberosity) is caused by forces exerted on the peroneus brevis tendon or the lateral band of the plantar fascia with inversion of the foot. Type II (ie, Jones) fracture is caused by an indirect large adduction force applied to the forefoot with the ankle in plantar flexion.[5] The ligaments at the base of the fourth and fifth metatarsals are resistant to displacement, and type II fracture occurs in the direction of the joint between the fourth and fifth metatarsals. Type III fracture (ie, diaphyseal stress), which occurs distal to the metaphyseal-diaphyseal juncture, is caused by overuse or overload. This type of injury may be acute or chronic.

In a description of 21 fractures of the fifth metatarsal base, Carp[6] was one of the first to note a tendency toward delayed union and the first to surmise that a poor blood supply was the cause. Smith et al[7] and Shereff et al[8] described the blood supply to the proximal fifth metatarsal. Perfusion occurs through metaphyseal arteries that enter at the base. A nutrient artery enters at the proximal diaphysis and tracks proximally across the so-called watershed area at the metaphyseal-diaphyseal junction. This watershed area creates an avascular zone, which can increase the risk of delayed union or nonunion (Figure 3).

Indications and Contraindications

In nonathletes, 6 to 8 weeks of non–weight-bearing cast immobilization

The video that accompanies this article is "Fracture of the Proximal Fifth Metatarsal," available on the *Orthopaedic Knowledge Online* Website, at http://www5.aaos.org/oko/jaaos/surgical.cfm

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J Am Acad Orthop Surg 2009;17: 458-464

is sufficient to manage acute, nondisplaced Jones fracture or acute metaphyseal or diaphyseal fracture (ie, Torg type I) (Table 1). Radiographically, healing occurs in a medial-to-lateral direction at the fracture site. Provided that the healing process is progressing satisfactorily, callus formation at the fracture site without intramedullary sclerosis should be evident by 6 to 8 weeks. For fractures that demonstrate little or no callus formation radiographically at 6 to 8 weeks, pulsed electromagnetic field therapy is reported to be an effective alternative to surgery for the management of delayed union and nonunion of the proximal fifth metatarsal.[9]

Kavanaugh et al[10] and DeLee et al[11] reported a high rate of delayed union or nonunion in athletes treated nonsurgically. Kavanaugh et al[10] also found a prodrome of pain in 9 of 22 patients and raised the question of "stress fracture." In addition, these authors further studied 11 of the patients and found that the injury resulted secondary to vertical and mediolateral forces responsible for fracture, not ankle inversion. Screw fixation has been recommended in athletes with acute fracture and in nonathletes with delayed union.[1,10-14] Prolonged healing has been noted in athletes who were treated nonsurgically.[2,15,16]

Torg[14] classified diaphyseal fracture into three subtypes based on the age of the fracture (Table 1). He noted that patients who showed radiographic signs of delayed union or nonunion were less likely to heal with nonsurgical treatment (Figure 4). The criteria for stress fracture established by DeLee et al[11] are pain (prodrome) before the onset of acute fracture, radiographic evidence of stress phenomenon, and no prior treatment.

Clapper et al[16] reported a 100%

Figure 1

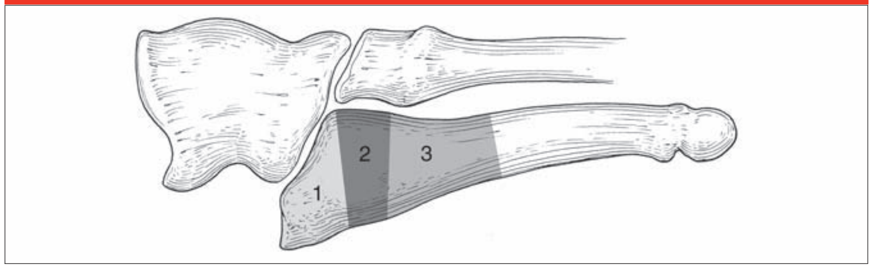
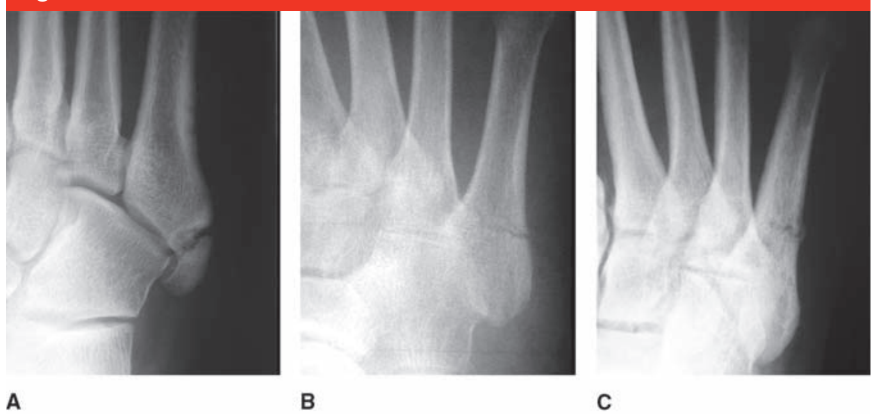


Illustration demonstrating the three types of proximal fifth metatarsal fracture by zone: 1, tuberosity avulsion; 2, metaphyseal-diaphyseal junction (Jones); and 3, diaphyseal stress. (Adapted with permission from Lawrence SJ, Botte MJ: Jones' fractures and related fractures of the proximal fifth metatarsal. *Foot Ankle* 1993;14:358-365.)

Figure 2



Torg classification of proximal fifth metatarsal fracture. **A,** Oblique radiograph of the proximal fifth metatarsal demonstrating a type I (ie, avulsion) fracture extending into the metatarsocuboid joint. **B,** AP radiograph of an acute type II metaphyseal-diaphyseal (ie, Jones) fracture. **C,** AP radiograph of an acute type III (ie, diaphyseal) fracture that extends into zone 3, distal to the vascular watershed of the metaphyseal-diaphyseal region.

Figure 3

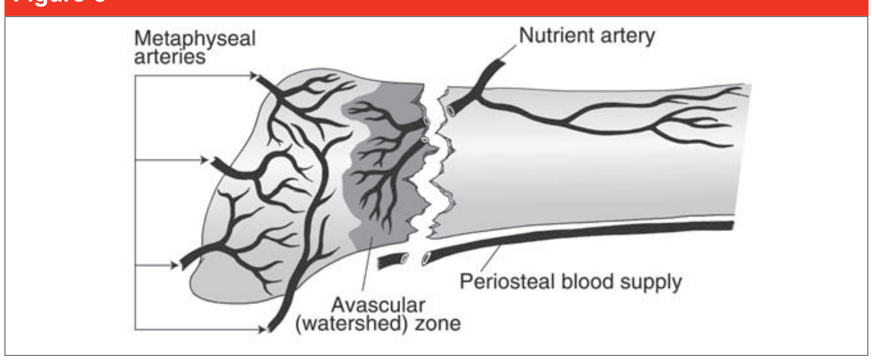


Illustration of the vascular supply to the proximal fifth metatarsal demonstrating the avascular, or watershed, zone in the metaphyseal-diaphyseal region. (Adapted from Dameron TB Jr: Fractures of the proximal fifth metatarsal: Selecting the best treatment option. *J Am Acad Orthop Surg* 1995;3:110-114.)

Table 1

Torg Classification of Proximal Fifth Metatarsal Fracture by Radiographic Appearance[4]

Type	Age of Fracture	Characteristics
I	Acute	Narrow fracture line, no intramedullary sclerosis
II	Delayed union	Widened fracture line with intramedullary sclerosis
III	Nonunion	Medullary canal obliterated

Figure 4

Oblique radiograph of a Torg type II proximal fifth metatarsal fracture with a widened lateral fracture gap and early intramedullary sclerosis, indicating delayed union. The intramedullary canal is narrow.

union rate in seven patients who received surgical treatment for Jones fracture. Average healing time following surgery was 12.1 weeks, compared with 21.2 weeks for the 18 patients who were treated with casting alone. These authors contended that surgical intervention is highly effective and low in risk and that it results in better patient satisfaction than does casting. Quill[2] concluded that intramedullary screw fixation should be considered in all Jones fractures, including in the nonathlete.

The literature supports early surgical treatment of acute Jones fracture in the high-performance athlete,[2,10,11,16] in the informed patient who prefers surgery to the risk of nonunion with nonsurgical treatment,[2,13,16,17] and in the patient with a diaphyseal stress fracture with radiographic evidence of delayed union or nonunion.[11,14] Surgery is contraindicated in the patient with vascular compromise or local infection, as well as in the patient who is medically unstable and for whom general or spinal anesthesia is inappropriate. Diabetes is not necessarily a contraindication to surgery. Yue and Marcus[18] reported success with open reduction and internal fixation of Jones fracture with bone grafting in patients with diabetes. They also noted that delayed open reduction and internal fixation with bone grafting after a trial of casting does not limit healing potential in these patients.

Surgical Technique

Treatment may consist of intramedullary screw fixation with reaming of the canal, with or without bone graft, with compression at the fracture site; corticocancellous inlay bone grafting; or a combination of the two. DeLee et al[11] first described percutaneous screw fixation for Torg type II and III fractures and Jones fractures, and Nunley[19] updated and refined the technique.

Surgery usually is performed on an outpatient basis using ankle-block anesthesia. General anesthesia is admin-

Figure 5

Intraoperative photograph showing proper positioning of patient and fluoroscopic equipment to ensure access to the three standard radiographic views (ie, AP, oblique, lateral) of the foot necessary for proper screw placement in the patient with proximal fifth metatarsal fracture.

istered when draping of the leg with a thigh tourniquet is desired. The patient is placed in a semilateral decubitus position on a beanbag or on a large hip bolster when adequate internal rotation of the hip can be obtained. The foot is placed over the fluoroscopy machine, and the surgeon should confirm that true AP, lateral, and oblique views of the fifth metatarsal can be obtained (Figure 5).

A Kirschner wire is placed over the top of the fifth metatarsal to estimate the axial alignment of the shaft under fluoroscopy. A line is drawn with a surgical pen along the Kirschner wire just proximal to the shaft to indicate proper placement of the incision (Figure 6) (**video 0:12**).

Surgical Approach

A 2-cm incision is made proximal to the intersection of the line drawn with the surgical pen along the Kirschner wire and the base of the fifth metatarsal. The sural nerve usually is encountered directly under the skin incision; great care must be taken to protect this nerve during screw insertion. The peroneus brevis tendon usually is not encountered because this tendon generally lies superior to the insertion site (**video 0:25**). However, the surgeon may encounter the lateral band of the plantar fascia.

Guidewire Insertion

After the soft tissues are spread, a guidewire is inserted in the high and inside position at the base of the fifth metatarsal (Figure 7). The guide pin is advanced under fluoroscopy in two planes from proximal to distal (Figure 8, A). The fifth metatarsal is a curved bone, and passing a straight screw down this bone will result in a gap at the fracture site. Thus, the guidewire should not be placed past the curvature of the fifth metatarsal. Once the guide pin has passed the fracture site, it is introduced to the isthmus and is not advanced any farther (**video 0:52**).

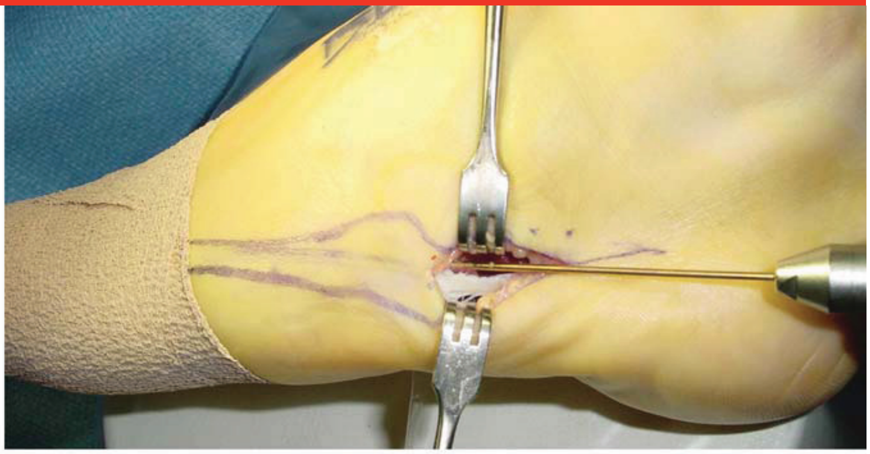
With continued protection of the soft tissues, the cannulated drill is placed over the guidewire (Figure 8, B). In general, a 3.2- or 3.5-mm cannulated drill bit is used to begin, and it is common to advance to a 5-mm bit for larger canals (**video 1:29**). The size of the fifth

Figure 6

Intraoperative photograph demonstrating alignment of the Kirschner wire over the fifth metatarsal. Under fluoroscopy, the wire is placed from the oblique view. (This patient is different from the patient shown in the video.)

Figure 7

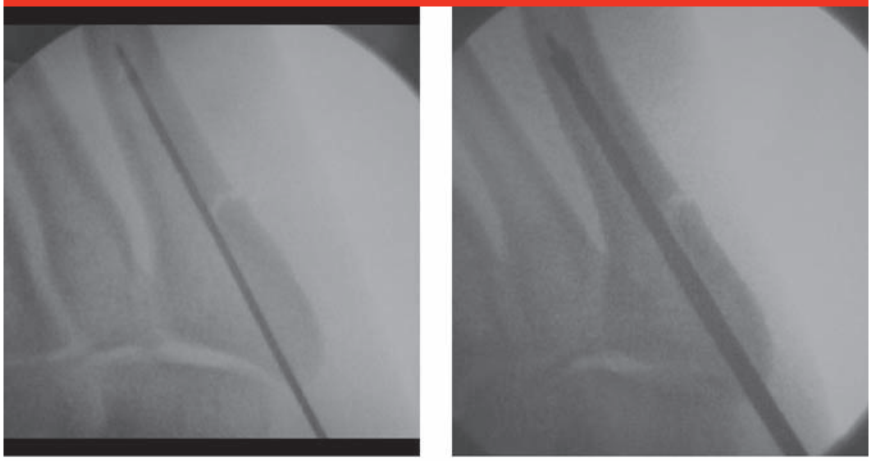
A



B

A, A model with a black dot indicating the correct entry point for the guidewire on the styloid process of the fifth metatarsal. **B,** Intraoperative photograph demonstrating a guidewire inserted into the base of the fifth metatarsal. (This patient is different from the patient shown in the video.)

Figure 8



A B

A, Intraoperative fluoroscopic image demonstrating advancement of the guidewire into the intramedullary canal up to but not beyond the curvature of a proximal fifth metatarsal fracture. **B,** Also under fluoroscopy, a cannulated drill bit is advanced over the guidewire to open the canal for the appropriately sized screw.

Figure 9

Oblique radiograph demonstrating fracture of the fifth metatarsal shaft resulting from placement of too large and too long a screw into the intramedullary canal during attempted fixation of a Jones fracture.

metatarsal intramedullary canal varies considerably by individual; thus, the surgeon will need to determine which size screw will provide a snug fit in the endosteum with adequate bite of the threads to give sufficient compression at the fracture site. A cannulated screw ≥5.5 mm, or most often a 6.5-mm solid cancellous or 7.0-mm cannulated screw, is necessary for stabilization of proximal fifth metatarsal fracture. When a solid screw is chosen, a depth gauge is used to determine optimal screw length.

Screw Insertion and Biomechanical Considerations

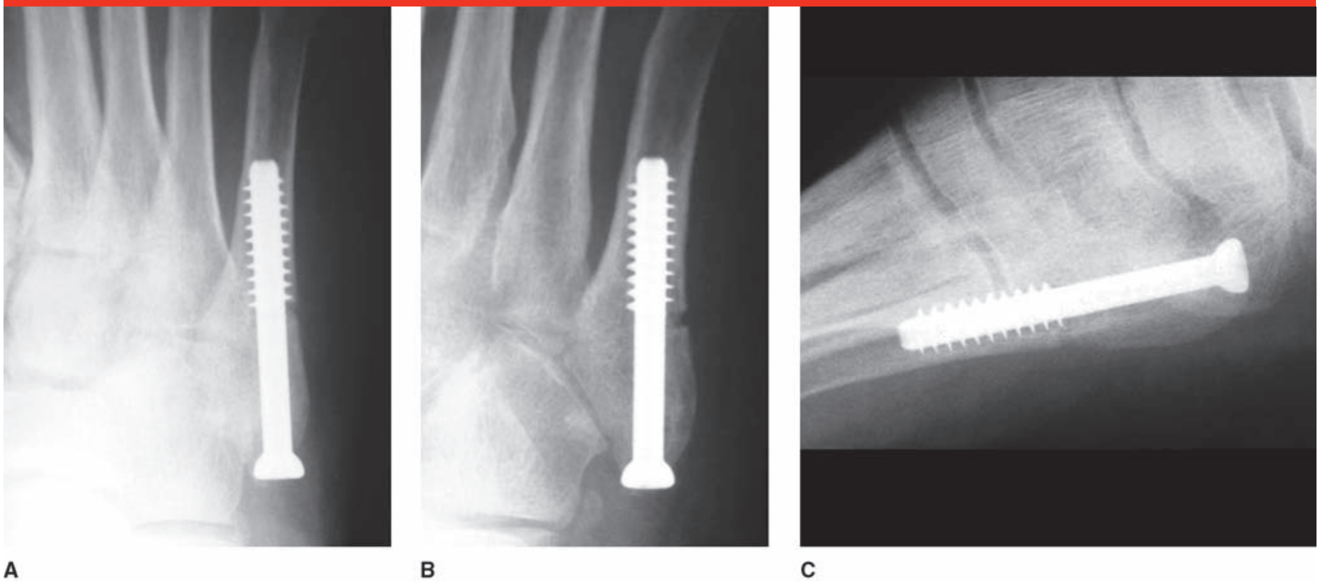
Once the canal has been enlarged to accept the 4.5- or 5.0-mm cannulated drill bit, the guide pin and drill can be withdrawn if a solid screw is to be used. At this point, it is easy to find the entry point on the tuberosity. The tap corresponding to the selected screw is placed into the medullary canal not only to cut a channel for the threads but also to serve as a sound to ensure adequate endosteal bite (**video 2:04**). Attempting to force a large screw into a smaller canal can cause diaphyseal fracture (Figure 9).

It is important for all threads of the screw to pass the fracture site but not to extend down the intramedullary canal past 50% to 60% of the length of the fifth metatarsal. Placing the screw past that point may straighten the bone and produce fracture gap, increasing the risk of delayed union or nonunion.

Once the tapping is completed, a countersink may be used to finish the bone preparation, if necessary, and a screw of the proper length is inserted. As the screwdriver is turned, the surgeon should see the distal portion of the fifth metatarsal and the toe turn. This movement indicates excellent capture of the endosteal bone distally and serves as a caution against overtightening. Fluoroscopic evaluation of the fracture in three planes is done to ensure proper screw position and compression at the fracture site (Figure 10) (**video 2:24**). The skin is closed with two or three interrupted nylon sutures.

A wide screw may be better than a narrow one. The screw diameter should be large enough to fill the canal and obtain adequate endosteal bite with the threads. For most skeletally mature patients, the screw used should be ≥4.5 mm.[20] Kelly et al[21] showed that the fifth metatarsal can accommodate a 6.5-mm screw and that this size affords greater pullout strength than do smaller-diameter screws. A too-large screw may cause fracture and increases the risk of stress shielding across the fracture site. The screw must be long enough that threads cross the fracture site. However, a too-long screw may be detrimental because a straight screw passing down curved bone may gap the fracture. Selection of a cannulated versus a solid screw is based on strength characteristics. Solid screws are less likely to break, but it is not clear whether this difference is significant.[22]

Figure 10



A, Anteroposterior radiograph of a correctly positioned 7.0-mm cannulated screw used for fixation of a Jones fracture. **B,** Oblique view demonstrating proper endosteal thread purchase. **C,** Lateral view demonstrating proper screw placement in the fifth metatarsal shaft.

Pearls

- The incision should be made proximal to the fifth metatarsal base between the peroneus brevis and longus tendons.
- The guidewire should be started in a high and inside position at the base of the fifth metatarsal.
- The selected screw size must allow adequate endosteal bite of the screw threads.
- The screw threads must cross the fracture for compression to occur at the fracture site.
- The screw should not be excessively long (ie, do not straighten the fifth metatarsal).

Pitfalls

- An improper screw angle may cause gapping at the fracture site.
- A screw that is too short will not compress the fracture because the threads will not completely cross the fracture site.
- A screw that is too long placed in curved bone may cause gapping at the fracture site.
- A screw that is too large in diameter may cause further fracture, cortical compromise, and/or stress shielding.

Postoperative Care

Following intramedullary screw fixation for acute Jones fracture, the patient is placed in a splint or cast for 2 weeks, advancing to a CAM walker with or without a molded orthosis for 2 more weeks. AP, lateral, and oblique radiographic views are obtained at the initial postoperative visit to confirm fracture alignment and obtain a baseline for comparison with follow-up images. At 4 weeks, the patient is allowed to begin weight bearing as tolerated with a molded orthotic device in a stiff-soled shoe to decrease stress at the fracture site. Radiographs are repeated at 6 weeks. When callus is seen at the fracture site, the athlete may begin light jogging using a molded orthotic device in a modified training shoe with a stiff sole. At 8 weeks, the patient may return to sport if symptoms allow. For diaphyseal stress fracture, the normal course is non–weight bearing for 6 weeks, followed by progressive weight bearing over the next 4 to 6 weeks.

Complications

The four most common complications following surgery to repair the proximal fifth metatarsal are delayed union or nonunion, refracture, prominent screw head, and sural nerve injury. Delayed union and nonunion have been correlated with use of screws <4.5 mm.[23] Undersized inlay grafts and incomplete reaming of the sclerotic canal have also been correlated with failure, and early return to vigorous activity likely plays a role in delayed union and nonunion.[24] Refracture after surgical treatment of a Jones fracture can occur after healing and screw removal; thus, it is recommended that the screw be left in until the end of the patient's athletic career.[13] The recommended management for fracture following screw removal consists of rereaming and fixation with a larger screw.[24] Pain from a prominent screw head after fixation can be managed with shoe modifications.[11] Awareness that the dorsolateral branch of the sural nerve is within 2 to 3 mm of the eventual position of the screw head can help avoid injury to the nerve during screw insertion.[25]

Summary

Acute fracture and nonunion of the proximal fifth metatarsal are difficult injuries to manage. The ability to distinguish the three distinct fracture patterns (ie, tuberosity, Jones, diaphyseal stress) is important because each has its own mechanism of injury, location, treatment options, and prognosis for healing. Tuberosity fractures, true acute Jones fractures, and Torg type I diaphyseal stress fractures have a high rate of union with nonsurgical management. However, primary surgical intervention with an intramedullary screw and/or inlay corticocancellous bone graft is the preferred treatment for acute Jones fracture in the athlete, delayed union or nonunion of Jones fracture in the nonathlete and athlete, and Torg type II and III fracture.[14]

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 19-21 are level III studies. References 1-3, 5-10, 13-15, 17, 22-24, and 34 are level IV reports, and references 4, 16, and 18 are level V expert opinion.

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