

Percutaneous Zadek Osteotomy for Insertional Achilles Tendinopathy



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KEYWORDS

- Zadek osteotomy • Minimally invasive surgery • Percutaneous
- Insertional Achilles tendinopathy • Haglund's deformity

KEY POINTS

- The percutaneous dorsal closing wedge calcaneal (Zadek) osteotomy is a safe and effective surgical treatment of patients with insertional Achilles tendinopathy with or without Haglund's deformity. When performed percutaneously, complications can be minimized.
- Similar improvement in patient-reported outcomes has been reported with the percutaneous Zadek osteotomy (ZO) and the gold standard open midline Achilles tendon splitting approach.
- Significantly fewer complications, namely wound complications, have been reported with the percutaneous ZO in comparison to the open midline Achilles tendon splitting approach.
- The mechanical advantage that is offered to patients who undergo the ZO has been of significant interest in recent literature.
- As there are currently very few contraindications for the percutaneous ZO, it may soon be considered a first-line surgical management option for patients with insertional Achilles tendinopathy with or without Haglund's deformity.

INTRODUCTION

It has been estimated that 6% of the population will experience Achilles heel pain throughout their life, 33% of which will have insertional Achilles tendinopathy (IAT). Historically, the open midline Achilles tendon splitting approach has been considered the gold standard intervention for IAT with or without Haglund's deformity. Meanwhile,

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Abbreviations	
CAM	controlled ankle motion
FFI	Functional Foot Index
IAT	insertional Achilles tendinopathy
MIS	minimally invasive surgery
VAS	Visual Analogue Scale
ZO	Zadek osteotomy

minimally invasive surgery (MIS) of the foot and ankle has gained momentum in the United States with the development of MIS techniques. In comparison to open procedures, MIS has been associated with reduced complications and a faster recovery.^{1–11} For IAT specifically, there are many MIS procedures that have demonstrated great success. In their contemporary review, Hall and colleagues highlighted the spectrum of disease that is Haglund’s syndrome, and the multitude of endoscopic and percutaneous approaches to the patient with Haglund’s syndrome.⁴ While many procedures may benefit a particular subset of patients, they propose that one MIS procedure holds the potential to serve as a novel, first line surgical management strategy for the majority of patients with IAT, with or without Haglund’s deformity: the percutaneous Zadek osteotomy (ZO).⁴ The percutaneous ZO has been repetitively demonstrated as a safe and effective treatment of patients with IAT with or without Haglund’s deformity, with minimal complications and a high rate of patient satisfaction.^{1–3,6,12–14}

HISTORY

The dorsal closing wedge calcaneal osteotomy was first described in 1939 by Dr Isadore Zadek as an alternative procedure for Achillotendinitis or Achillobursitis (now IAT). This calcaneal ZO was introduced as an open technique that allowed for surgical correction of insertional Achilles pathology, without direct operation on the pathologic tendon.^{15–17} Since its introduction, this procedure has proved to be very successful in relieving the symptoms of patients with IAT.¹⁶ However, as this was described as an open procedure, it involved a large lateral incision. As with many open foot and ankle surgeries about the hindfoot, the open ZO was associated with many wound, infection, and nerve complications, limiting its adoption.^{17–20}

In 1965, the ZO was reintroduced by Keck and Kelly as a mechanism for treating patients with Haglund’s deformity.²¹ Of note, the term “Haglund’s syndrome” had not yet been coined at this time, though the epidemiologic connection between IAT and Haglund’s deformity was frequently observed. Keck and Kelly noted this connection and modified the Zadek procedure slightly to include resection of a Haglund’s deformity. With this modification, they reached a new patient population of interest and managed to popularize this technique. Despite the same profile of associated complications, many studies since this time have boasted the effectiveness of the ZO.^{15,17,18,20,22–29} A systematic review of more recent literature reported a complication rate of 10.2% with the open ZO.⁶ With the increasing popularity of MIS, the ZO has again resurfaced, this time as a percutaneous procedure.³⁰

BACKGROUND

Conventional approaches to IAT begin with nonoperative modalities for every patient. Patients are first prescribed treatment to include eccentric loading physical therapy, shoe wear modifications, activity modifications, pulsed ultrasound therapy,

platelet-rich plasma injections, shockwave therapy, etc. However, the failure rate associated with nonoperative management has been quoted as high as 40%; patients who fall into this category after 3 to 6 months are potential candidates for surgical intervention.³¹ The traditional, open Achilles tendon splitting procedure for IAT includes tendon debridement and Haglund's deformity resection through a large posterior midline incision. Following Achilles tenolysis and debridement, the Haglund's deformity is excised, and the tendon is reattached. While this procedure is considered an effective approach to IAT correction, the complication profile associated with this procedure includes impaired wound healing, sural nerve injury, wound tenderness, residual Achilles insertional pain, shoe wear irritation, infection, pain, prolonged recovery time, and skin hypersensitivity.³²⁻³⁴

Over 75 years ago, Dr Isadore Zadek described the dorsal closing wedge calcaneal osteotomy with the intention of modifying the vector of the Achilles insertion without mandatory detachment and reattachment of the tendon. When this procedure was originally introduced, there was no consideration of a potential Haglund's deformity. Nevertheless, by removing the dorsal-based wedge from the calcaneus, the insertion point of the Achilles (and posteriosuperior calcaneal tuberosity) is moved to a more anterior and superior position. This modification simultaneously allows for indirect decompression of the Achilles tendinous insertion about the calcaneus, and a functionally lengthened gastrocnemius complex. Furthermore, the ZO modification relieves much of the pathological strain to the tendon, permitting symptomatic relief of IAT and Haglund's deformity.^{16,18} As the Achilles remains untouched during the ZO correction, a patient's recovery is dependent solely on bone-to-bone healing rather than tendon-to-bone healing. By eliminating any direct operation to the pathologic soft tissues about the hindfoot, a patient's recovery time is reduced significantly.^{3,14}

Numerous studies have reiterated the effectiveness and safety of ZO.^{17,18,20,22} Zang and colleagues demonstrated improved Visual Analogue Scale (VAS) and AOFAS scores and no complications at an average of 3.1 years following ZO.³⁵ Similarly, Ge and colleagues demonstrated a significant improvement in AOFAS and VISA-A scores at only 3 months following ZO; scores continued to improve across a mean 86.5 months follow-up.¹⁷ López-Capdevila et al demonstrated 100% patients satisfaction and improvement in VAS and AOFAS scores at a mean 18.3 months follow-up of ZO for treatment of IAT.¹⁸ Georgiannaos and colleagues observed improvement in AOFAS and VISA-A scores, and a mean of 21 weeks return to sport in 52 athletes treated with ZO for IAT at a minimum 3 year follow-up.¹⁹

Few studies have directly compared the outcomes of the open ZO to those of the gold standard, open midline tendon splitting resection. Recently, in their systematic review and meta-analysis, Karaismailoglu and colleagues allowed for such comparisons.³⁶ This meta-analysis of 15 studies ($N = 396$) demonstrated similar post-operative improvement in AOFAS scores following ZO and the open midline splitting procedure. Interestingly, while both cohorts underwent open procedures about the hindfoot, a significantly higher incidence of wound complications was observed following the open midline tendon splitting approach.³⁶ These findings were echoed in the recent retrospective analysis presented by Hall and colleagues.³⁷ The authors similarly found no difference in patient-reported outcomes scores following the open midline Achilles tendon splitting approach and percutaneous ZO; a significant reduction in wound complications ($P < .001$) was observed with the percutaneous osteotomy.³⁷

With the advancement of modern techniques in minimally invasive foot and ankle surgery, the ZO can now be performed as a percutaneous surgery.^{1,17,18,20,22,38} The

systematic review by Bakaes and colleagues reported on 625 procedures across 17 studies at a minimum 12-month follow-up. Both open ZO and percutaneous ZO demonstrated significant improvement in patient-reported outcome metrics, yet the open cohort had a mean complication rate of 10.2%, while the percutaneous cohort had a mean complication rate of only 5.8%.⁶ As a result of the improved outcomes with the percutaneous ZO technique, it has gained significant momentum in the literature over the past decade; many have suggested this percutaneous intervention may evolve to become first line treatment option for patients presenting with persistent IAT.^{3,14}

Current literature has continued to support the use of percutaneous ZO for IAT, demonstrating significant improvement in patient-reported outcome measures with a very low rate of complications (**Tables 1** and **2**).^{1–4,6,12–14,30} The retrospective study by Choi and Suh directly compared the percutaneous ZO and the open Haglund's resection.¹ Percutaneous ZO and open Haglund's resection showed statistically significant improvement in VAS and VISA-A scores; however, the ZO cohort allowed for much faster recovery. At 6 months follow-up, the percutaneous ZO cohort had patient outcome scores that were significantly improved from those of the open cohort.¹ A large retrospective study by Hall and colleagues reported a very low complication rate (3.8%) in their review of over 100 patients at a minimum of 2 year follow-up duration.² They observed a 98.1% satisfaction rate with only 3.8% complications. Further, they observed a significant ($P < .001$) improvement in VAS and Functional Foot Index (FFI) scores at final post-operative follow-up.²

There has been significant interest in efforts to better define the advantage offered with the percutaneous ZO. The quadrant system technique described by Kaplan and colleagues offers a cut guide that surgeons can utilize to more reproducibly resect their dorsal wedge (**Fig. 1**).³⁰ In their large ($N = 104$) retrospective study, Hall and colleagues identified a statistically significant learning curve associated with the percutaneous ZO.¹³ However, this learning curve was rather brief (cases 1–14) and only significant in relation to procedure time. There was no statistically significant difference in complications and/or patient-reported outcome measurements (**Fig. 2**).¹³

A recent publication by Nunes and colleagues described changes in the foot and ankle mechanics following ZO by using a virtual, 3D simulation model.³⁹ The authors found significant alterations in hindfoot alignment, exclusively in the sagittal plane. A significant decrease was observed in calcaneal length (79–73 mm), Fowler-Philips angle (57° – 43°), calcaneal pitch angle (24° – 20°), and sagittal talocalcaneal angle (55° – 47°) ($P < .001$). No difference was observed in axial talocalcaneal angle or hindfoot moment arm.³⁹

In a small cadaveric study, Bellas and colleagues observed changes in retrocalcaneal pressure, Achilles strain, and calcaneal structure with the ZO.⁴⁰ With the removal of a 10 mm dorsal wedge, a mean 9.9 mm anterior translation of the Haglund's deformity, and 3.4 mm anterior translation of the Achilles tendon was accomplished. Simultaneously, a 44% reduction in retrocalcaneal pressure was observed, in addition to a significant increase in X/Y ratio. The strain about the anterior Achilles fibers was increased by 20% ($P = .484$) while the strain about the posterior Achilles fibers was decreased by 39% ($P = .088$).⁴⁰

In addition to the aforementioned studies, the prospective study by Friesenbichler and colleagues analyzed the objective strength and function following ZO.²⁹ While their study was rather small and evaluated post-operative changes following open ZO, data revealed an improvement in gait dynamics without disturbance in gait kinematics or kinetics. They reported a significant pre-operative deficit in plantarflexion strength in the affected limb (7%–10%) that was recovered in the majority of their patients post-operatively.²⁹

Table 1
Percutaneous (MIS) and Open Zadek Osteotomy Literature review

Author	Zadek Osteotomy Type	Country	Level of Evidence	Participants, <i>n</i>	Mean Age, <i>y</i>	Feet, <i>n</i>	Women, <i>n</i>	Follow-Up, <i>mo</i>
Choi & Suh, ¹ 2022	MIS	South Korea	III	10	37.4	11	6	20.3
deMeireles et al, ¹⁴ 2022	MIS	United States	IV	32	56.1	32	NR	16.1
Hall et al, ² 2024	MIS	United States	III	104	51.8	104	67	41.2
Nordio et al, ³ 2020	MIS	Italy	III	26	57	26	14	12
Cengiz & Karaoglu, ²⁵ 2022	Open	Turkey	III	20	45.8	20	14	72
Ge et al, ¹⁷ 2020	Open	China	III	12	32.8	12	3	86.5
Georgiannos et al, ²² 2016	Open	Greece	IV	52	32.5	64	30	Range 36–60
López-Capdevila et al, ¹⁸ 2020	Open	Spain	IV	18	49	18	11	18.3
Maffulli et al, ²³ 2020	Open	Italy	IV	28	54.7	28	15	Range 24–30
Tourne et al, ⁴³ 2022	Open	France	III	50	54	50	15	84
Maffulli et al, ²⁴ 2021	Open	Ireland	II	25	53.5	25	14	Range 24–28
Tourne et al, ⁵³ 2022	Open	France	II	22	48.5	22	9	12
Zheng et al, ²⁰ 2020	Open	China	III	19	48.6	19	NR	16.3

A review of recent literature describing outcomes and complications following ZO.

Table 2 Outcomes Following Percutaneous (MIS) or Open Zadek Osteotomy							
Author	Zadek Osteotomy Type	Daofas	DVAS	DVISA-A	Complication (Total)	Complication (Rate)	Satisfaction Rate
Choi & Suh, ¹ 2022	MIS	NR	5.3 ^a	51.9 ^a	1	9.1%	NR
deMeireles et al, ¹⁴ 2022	MIS	NR	NR	NR	1	3.1%	NR
Hall et al, ² 2024	MIS	NR	7.3 ^a	NR	4	3.8%	98.1%
Nordio et al, ³ 2020	MIS	57 ^a	8 ^a	NR	2	7.7%	92%
Cengiz & Karaoglu, ²⁵ 2022	Open	32.6 ^a	4.5 ^a	NR	0	0%	NR
Ge et al, ¹⁷ 2020	Open	46.2 ^a	NR	61.1	1	8.3%	NR
Georgiannos et al, ²² 2016	Open	36.2 ^a	NR	24.3 ^a	8	12.5%	NR
López-Capdevila et al, ¹⁸ 2020	Open	45.0 ^a	6.1 ^a	50.7 ^a	3	16.7%	100%
Maffulli et al, ²³ 2020	Open	NR	NR	NR	3	10.7%	NR
Maffulli et al, ²⁴ 2021	Open	NR	35.5 ^a	51 ^a	3	12%	NR
Tourne et al, ⁴³ 2022	Open	38.4 ^a	NR	24.9 ^a	3	6%	NR
Tourne et al, ⁵³ 2022	Open	32.0 ^a	NR	NR	0	0%	NR
Zheng et al, ²⁰ 2020	Open	33.2 ^a	5.4 ^a	NR	1	5.3%	95%

Post-operative results demonstrated the following percutaneous (MIS) or open ZO.

^a P<.05 reported, indicating statistical significance.

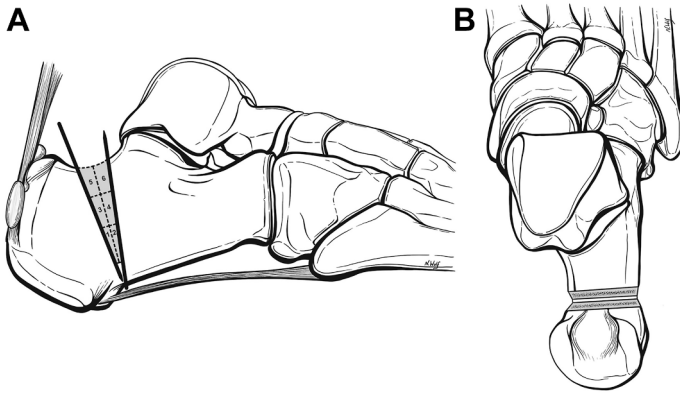


Fig. 1. (A and B) Surgical technique and quadrant cut guide, as previously described by Kaplan et al.³⁰ (Kaplan, J. R. M. et al., (2023). Percutaneous Zadek osteotomy for insertional achilles tendinopathy and Haglund deformity: a technique tip. *Foot & Ankle International*, 44(9), 931–935. <https://doi.org/10.1177/10711007231181124>.)

While there are numerous examples in the literature that demonstrate safe and effective treatment of IAT with the percutaneous ZO at short and midterm follow-up, limited long-term data exist. As a community, there is much for us to learn regarding the advantages of the ZO. Future prospective, multi-centered studies, including randomized controlled trials, will be necessary to answer our remaining questions over the next decade.

INDICATIONS AND CONTRAINDICATIONS

Currently, the indications for surgical intervention with percutaneous ZO are quite broad, while contraindications have yet to be solidified. Indications for surgical management of IAT with or without Haglund's deformity include patients who have persistent symptoms that fail to improve with conservative management. A trial of

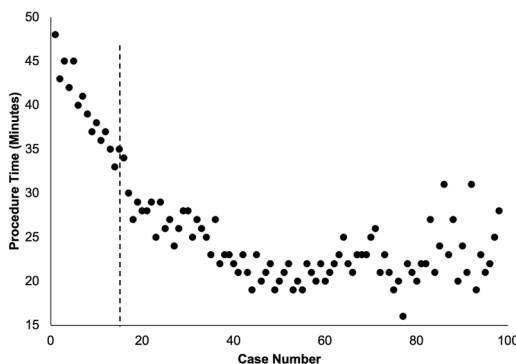


Fig. 2. Learning curve in terms of OR time versus surgeon experience ($P < .05$); no difference in patient-reported outcome scores observed, as previously described by Hall and colleagues.¹³ Dotted line indicates resolution of this learning curve at approximately case #14. (Kaplan, J. R. M. et al., (2023). Percutaneous Zadek osteotomy for insertional achilles tendinopathy and Haglund deformity: a technique tip. *Foot & Ankle International*, 44(9), 931–935. <https://doi.org/10.1177/10711007231181124>.)

conservative treatment is to involve eccentric loading therapy, shoe wear modification, immobilization, activity modification, and anti-inflammatories therapy over 3 to 6 months. Indications for ZO reported in the literature include patients with moderate Achilles degeneration, a posterior calcaneal prominence greater than 5 mm, a spur ossification 7 to 15 mm, and an X/Y ratio less than 2.5.⁴¹

Meanwhile, for the percutaneous ZO, such criteria have not been defined. Various radiographic parameters have been proposed to offer guidance on patient selection for ZO; however, literature currently lacks robust evidence to support any specific criterion.⁴² For example, previous studies have proposed measurements such as Chauveaux-Liet angle ($>12^\circ$), X/Y ratio (<2.5), increased calcaneal pitch angle ($>30^\circ$) on standard radiographs to identify appropriate patients for MIS ZO.^{41–43} Still, very few studies report patient outcomes following ZO and/or the open Haglund's resection with respect to these radiographic parameters. Literature has instead demonstrated improvement in patient-reported outcomes following percutaneous ZO, regardless of any pre-operative radiographic findings, with minimal complications.

A recent retrospective analysis by Hall and colleagues sought to evaluate changes in patient-reported outcomes in patients with an X/Y ratio less than 2.5 and those with X/Y greater than 2.5 following the percutaneous ZO.⁴⁴ Their analysis demonstrated no difference in post-operative patient-reported pain or mobility scores between the 2 cohorts at a minimum of 12 months follow-up.⁴⁴ Despite hypotheses by Tourné and colleagues, no data exist to suggest an X/Y < 2.5 is a reproducible method of predicting success with ZO. Based on current evidence, it appears no radiographic parameters do not correlate with success following percutaneous ZO; patients with IAT do very well following ZO regardless of any radiographic criteria.

It has been proposed previously that patients with extensive degeneration and/or calcification may be better suited with an open approach where debridement of the Achilles tendon may be accomplished. Accordingly, MRI has often been used to grade IAT and guide surgical management. The retrospective study by Baumbach and colleagues attempted to correlate patient-reported outcomes following the open midline Achilles tendon splitting procedure for IAT, and various pre-operative radiographic criteria. They graded 88 patients with IAT using 15 separate radiograph/MRI parameters.^{45,46} Baumbach and colleagues reported no correlation between patient-reported outcomes and MRI parameters such as tendon degeneration, partial tendon rupture, retrocalcaneal bursitis, posterosuperior calcaneal prominence, or superficial calcaneal bursitis.

The short report by Hall and colleagues demonstrated similar findings when comparing the severity of IAT on MRI and patient outcomes following percutaneous ZO.⁴⁷ IAT was graded on pre-operative MRI as previously described by Nicholson and colleagues.⁴⁸ They found improvement in PROMIS scores within each cohort, no difference in the change in PROMIS scores between cohorts. Even patients with Grade III (severe) Achilles tendinopathy did well following percutaneous ZO, with few complications and significant improvement in patient-reported outcomes.⁴⁷ As neither Baumbach and colleagues nor Hall and colleagues were able to report any statistical association between pre-operative MRI findings and post-operative outcomes, MRI findings may not be predictive of surgical outcomes for patients with IAT. Further, both studies suggest MRI may not be a necessary component of pre-operative evaluation in this population.

Currently, the authors recommend a percutaneous ZO on any patient presenting with IAT, with or without a Haglund's deformity, who has failed greater than 3 months of nonoperative management. The authors believe that any patient who is a reasonable candidate for an open Haglund's midline Achilles tendon splitting approach is

similarly a candidate for percutaneous ZO. Nevertheless, a criterion for Zadek patient selection has yet to be defined reliably; therefore, more research is needed in this area.

SURGICAL TECHNIQUE

The percutaneous ZO accomplishes excision of the same, dorsal-based wedge once described by Zadek, but with a 3×30 mm (10 cm) Shannon burr, through a very small (5 mm) incision.³⁰ This MIS hindfoot osteotomy can be accomplished under a lower extremity nerve block (popliteal/adductor canal or saphenous) in conjunction with sedation. A tourniquet is not recommended as to avoid bone thermal necrosis. Patients are positioned in the lateral decubitus position with their operative leg held off the end of the bed, resting on the mini-C-arm. A 10 mm dorsal closing wedge on the lateral calcaneus is approximated with wire under lateral fluoroscopy (Figs. 3 and 4).

A “safe zone” over the calcaneal tuberosity is identified and marked on the patient to avoid important neurovascular structures about the lateral hindfoot.⁴⁹ A 5 mm lateral

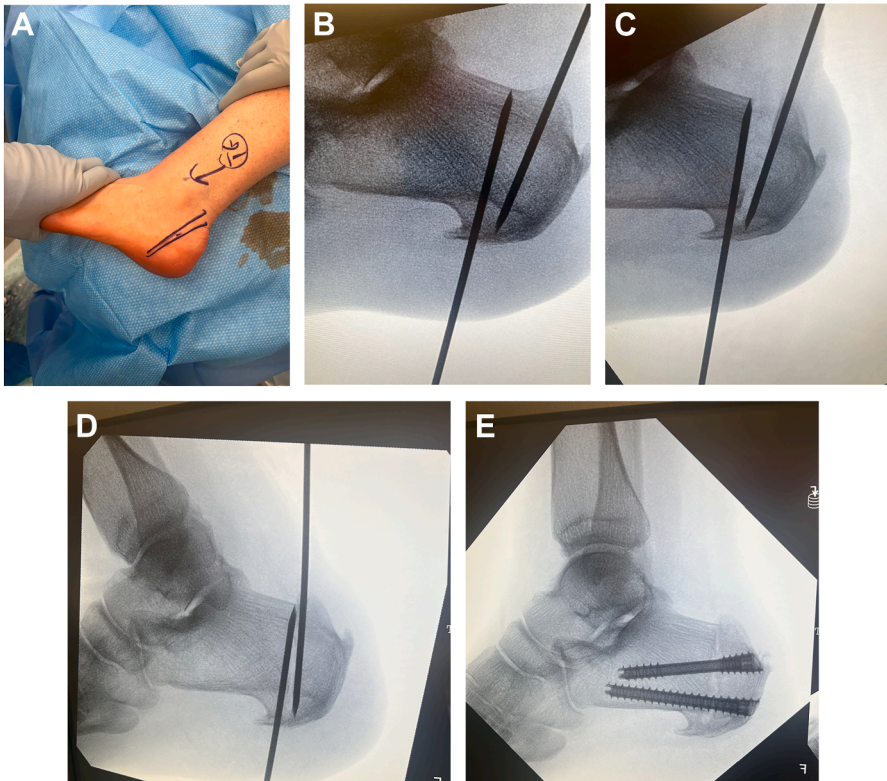


Fig. 3. (A–E) Clinical and fluoroscopic visualization of K-wire placement; fluoroscopic visualization of final screw placement for percutaneous ZO, as described by Kaplan and colleagues.³⁰ (Kaplan, J. R. M. et al., (2023). Percutaneous Zadek osteotomy for insertional achilles tendinopathy and Haglund deformity: a technique tip. *Foot & Ankle International*, 44(9), 931–935. <https://doi.org/10.1177/10711007231181124>). Abbreviation: ZO, Zadek osteotomy.



Fig. 4. Zadek dorsal closing wedge osteotomy marked out on lateral weight-bearing radiograph.

incision is made at the apex of the ZO, approximately 5 to 8 mm at or just posterior to the origin of the plantar fascia at the calcaneal tuberosity. After a blunt hemostat is used to spread down to bone, a 3 mm × 30 mm Shannon burr with a 4:1 reducer set at 6000 rpm can be advanced into the lateral calcaneus. Prior to burring, burr position at the apex of the osteotomy is confirmed on lateral fluoroscopy of the calcaneus. The wedge is marked out on the skin and centered at the posterosuperior calcaneal bony prominence, to remove this area as a source of mechanical irritation on the Achilles tendon. Copious refrigerated (37°F) normal saline via bulb syringe is applied at the operative site throughout burring; we recommend pausing the Shannon burr every 3 to 4 seconds to allow for cooling.⁵⁰

Once the first limb of the osteotomy is complete, the Shannon burr is used to shave a dorsal 10 mm wedge following the Kaplan cut guide.³⁰ Alternatively, a second limb of the osteotomy can be performed and then the central remaining bone wedge is removed using a pituitary rongeur. The osteotomy is then reduced with maximal ankle dorsiflexion. Two guidewires are next placed across the osteotomy from the posterior calcaneal tuberosity into the subchondral bone at the posterior facet, followed by two 7.0 mm headless compression screws (**Fig. 5**). Of note, the ankle is to be kept in maximal dorsiflexion throughout this time. Implant position should be confirmed on lateral and Harris axial fluoroscopic views of the calcaneus. After sufficient irrigation, incisions can be closed with 3-0 nylon sutures. A post-operative soft dressing is recommended along with a short, controlled ankle motion (CAM) boot or Trilam splint based on surgeon preference. The patient is non-weight-bearing for 2 weeks post-operatively.

At a patient's 2 week visit, sutures are removed and a weightbearing lateral radiograph of the foot is obtained. Patient is made weightbearing as tolerated in the



Fig. 5. Pre-operative and post-operative lateral weight-bearing radiographs demonstrating anatomic changes to the hindfoot following percutaneous ZO. ZO, Zadek osteotomy.

CAM boot. Patients start physical therapy at 3 weeks post-operatively for gait training, range of motion exercises, plantar fascia exercises, and Achilles strengthening. Patients should be counseled that they cannot drive for 6 weeks after right foot surgery. At the 6 week follow-up visit, patients can be transitioned into regular, supportive sneakers as tolerated. Patients can return to driving and low-impact activity such as biking, swimming, and elliptical at this time. Patients should be counseled that some heel soreness is expected to persist through weeks 6 to 12 after surgery. Return to high impact activities is allowed at 12 weeks post-operatively, as tolerated.

COMPLICATIONS

The percutaneous ZO is often selected over the more traditional open Haglund's resection for its accelerated recovery period and reduction in complication rate. Multiple authors have reported minimal complications following the percutaneous ZO at mid-term follow-up durations.^{2,3,14} Most recent studies have reported as few as 3.8% complications, even greater than 2 years post-operation.² In comparison, the gold standard, open Haglund's resection, has been associated with a complication rate upwards of 50% and a revision rate of 45.5%.⁵ For example, in the retrospective study by Hall and colleagues, a complication rate of 40.0% was reported among patients who underwent the open midline Achilles tendon splitting approach for IAT; over one-third of such complications were due to wound dehiscence.³⁷ While the open Haglund's resection is a highly vetted and successful surgery for patients with IAT, a large cohort of patients might experience wound dehiscence, infection, or nerve issues following this procedure.

Like any intervention, complications may occur after the percutaneous ZO. Of the reported 3% to 6% of patients who will experience a complication, most have included non-union, painful hardware, or altered hindfoot alignment.^{28,36} Post-operative chronic plantar fasciitis may also occur when the apex of the ZO is anterior to the plantar fascia origin, though this tends to resolve with conservative management modalities. In a retrospective analysis, Choi and Suh reported only one complication (non-union) following the percutaneous ZO, as did deMeireles and colleagues; similarly, Nordio and colleagues reported one case of non-union and one case of painful hardware.^{1,3,14} In the systematic review by Bakaes and colleagues, a mean 5.8% complication rate was observed among studies that reported on the percutaneous ZO, including 1.4% painful hardware and 4.4% nonunion.⁶ These non-unions were often due to fixation with 1 screw and no protection of the plantar hinge. Therefore, the author of this article recommend use of 2 screws, one screw to compress the osteotomy, and the other one utilized to protect the plantar hinge to minimize this risk. In the largest and most recent retrospective review by Hall and colleagues, a complication rate of only 3.8% was reported; 1.9% painful hardware, less than 1.0% non-union, and less than 1.0% partial plantar fascia rupture that occurred 7 months post-operatively. As these are rather infrequent findings, the percutaneous ZO allows for a significant reduction in the complication rate in comparison to other interventions for IAT.^{5,6}

FUTURE CONSIDERATIONS

While current literature has demonstrated the percutaneous ZO to be safe and effective, there is still much that we do not know about this MIS. Major areas of interest for further study will primarily seek to answer the following questions:

1. How can we better optimize (and standardize) the percutaneous ZO technique?

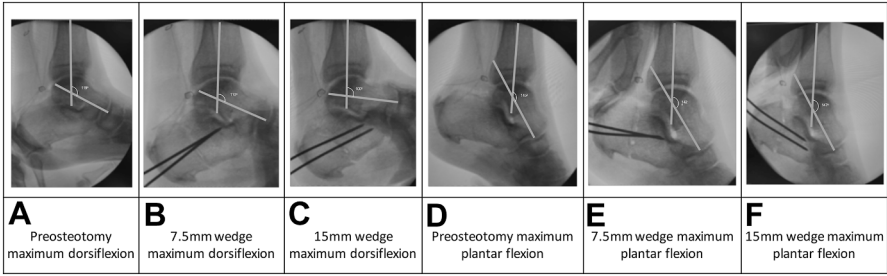


Fig. 6. (A–F) Maximum dorsiflexion and plantarflexion observed in cadaveric models with removal of a 7.5 mm or 15 mm wedge, as previously described by Kaplan and colleagues.¹⁷ (Ge, Z., Ma, L., Tang, H. et al. Comparison of dorsal closing wedge calcaneal osteotomy versus posterosuperior prominence resection for the treatment of Haglund syndrome. *J Orthop Surg Res* 15, 168 (2020). <https://doi.org/10.1186/s13018-020-01687-6>.)

2. Which patients should be offered a percutaneous ZO versus other surgical treatments for IAT?

In order to optimize the percutaneous ZO technique, further investigation is required to better define the biomechanical improvement that percutaneous ZO provides. For example, cadaveric studies suggest a dorsal wedge greater than 7.5 mm is preferred to increase patients’ post-operative range of motion and a 10 mm wedge has demonstrated some objective improvement in the posterior strain to the Achilles, however no statistically significant improvement has been reported or correlated with patient outcomes.^{12,40} As no further specification has been described regarding wedge size, this may be one specific area worthy of future investigation (**Fig. 6**).

Investigations into the histologic and inflammatory profile associated with IAT also remains limited.⁵¹ Further, there are little to no data available to describe the post-operative changes to the Achilles following ZO and/or other interventions for IAT. As the ZO allows for relief of symptoms without direct operation on the Achilles, it is plausible these changes differ from other procedures. These investigations would allow insight into how the ZO alters the pathology of the Achilles tendon, and how those changes correlate to a patients’ symptomatology. As there are no established criteria for identifying which patients would experience the largest benefit from ZO in comparison to other interventions for IAT,^{45,47} these investigations may also better define the clinical indications for ZO versus other interventions for IAT.

SUMMARY

The percutaneous ZO allows for treatment of IAT with or without a Haglund’s deformity, without directly operating on the Achilles tendon. This procedure can be performed percutaneously, reducing wound complications and recovery time. The cut guide described by Kaplan and colleagues offers surgeons a comprehensive technique to follow when first incorporating this technique into their practice.³⁰ Though a learning curve has been observed, it was only significant with respect to procedure time.¹³ The literature continues to support a significant improvement in patient-reported outcomes and low complication rate following percutaneous ZO; however, there are still many unanswered questions surrounding this procedure. Future investigations into the biomechanical advantage of ZO may better define a treatment pathway for patients who should undergo percutaneous ZO versus other interventions

for IAT. The authors believe that future studies will continue to support the paradigm shift of percutaneous ZO as a potential first-line surgical intervention for IAT.

CLINICS CARE POINTS

- In patients with IAT, the percutaneous ZO has demonstrated significant improvement in patient-reported outcome measures such as PROMIS, FFI, and VAS scores.^{2,3,44,47}
- The percutaneous ZO has been associated with a learning curve regarding operation time that resolves around case 14; no change in patient outcomes was detected.¹³
- Based on evidence from recent cadaver studies, removal of a dorsal-based wedge of greater than 7.5 mm is recommended to maximize post-operative function.¹²
- Recent literature has demonstrated a 3.8% rate of complications following percutaneous ZO. Comparably, the open midline Achilles tendon approach has demonstrated up to a 50% rate of complications in the literature.^{2,31}
- Percutaneous ZO has demonstrated success in treating patients with IAT of Grade 1 to 3 tendinopathy on pre-operative MRI.⁵²

DISCLOSURES

T.A. Gonzalez: Consultant for Treace Medical Concepts Inc, Surgical Fusion Technologies, Stryker, Enovis, Exactech, Surgebright; Royalties: Surgical Fusion Technologies, Treace Medical Concepts, Vilex. S.H. Kiriluk: Nothing to disclose. O.N. Schipper: Consultant for Treace Medical Concepts Inc, SFI, Enovis, Exactech; Royalties: Treace Medical Concepts Inc, SFI, Enovis.

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