



Implant Surgery for Hammertoe Correction

Part 3

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The search for an optimal surgical method to correct hammertoe deformity has been ongoing for several decades. The traditional surgical approach has been utilizing K-wires for PIP joint fixation in some manner such as fixating all three phalanges when performing an end-to-end arthrodesis of the PIP joint in plantarflexed position, the Selig technique in which the K-wire was bent distally and a bandage was applied to the toe at the level of MTP joint in a plantarflexed position, and the double K-wire technique described in the article of the October 2026 edition of *The Surgical Technologist*. However, there are issues regarding the use of K-wires of which the ends are external to the toe including being pulled out accidentally, protrusion increases the risk of postoperative surgical site infection (SSI), the wires may have to be removed prior to the bone completely healing such as in the instance of a SSI, and K-wires can migrate or are unstable leading to nonunion and malalignment of the bone.

To resolve these issues, several types of implants have been developed and marketed by various companies to improve the surgical treatment of hammertoe deformity.

- Arthrex Dynanite® - A cannulated, threaded implant made of *nitinol*. The barbs on the implant are extended by introducing a K-wire which keep the implant fixated. Cannulation provides the surgeon with the ability to cross the MTP joint with the K-wire if necessary. The implants are available in 12 mm, 14 mm, and 16 mm sizes.
- Gamedica Opti-Toe® - A cannulated two-piece implant made of titanium.
- Zimmer Biomet markets the Nextra® hammertoe correction system that is a two-piece implant with a locking mechanism. Specialized reamers are used to facilitate positioning the implant.
 - Paragon 28 (division of Zimmer Biomet) HammerTube® - A single piece made of *PEEK* that is coated with titanium on the distal and proximal ends of the implant. The center of the implant is left uncoated to allow it to be cut at the joint space to facilitate removal.

The focus of this article will be on the Stryker™ Smart Toe II Intra-

LEARNING OBJECTIVES

- ▲ Discuss the surgical steps of the box joint arthrodesis for correcting hammertoe deformity
- ▲ Explain the various aspects of the Smart Toe II Implant including indication for use, contraindications, and advantages
- ▲ List the steps of the Smart Toe II Implant surgical procedure
- ▲ Summarize the background of PEEK medical implants
- ▲ Identify the indications for use, contraindications, and potential adverse effects of the Vector Hammertoe Implant
- ▲ Review the steps of the Vector Hammertoe Implant surgical procedure

KEYWORDS

box joint arthrodesis, K-wire, metatarsal phalangeal (MTP) joint, middle phalanx, PEEK, proximal interphalangeal joint, proximal phalanx

DEFINITIONS

Hydroxyapatite: Naturally occurring calcium phosphate mineral that is chemically similar to human bone. When applied to a surgical implant it actively promotes bone growth and attachment.

Nitinol: Metal alloy made of nickel and titanium that is used for medical devices such as catheters, heart valves, orthopedic implants, and stents.

Polyetheretherketone: High-performance thermoplastic (plastic polymer material that becomes moldable and pliable at elevated temperatures and solidifies upon cooling) that is an alternative to titanium alloys.¹ It was produced in 1978 in a United Kingdom laboratory.¹ Its initial application in surgical implants was intervertebral fusion cages beginning in 1990.

ABBREVIATIONS

HA: hydroxyapatite

K-wire: Kirschner wire

PEEK: polyetheretherketone

PIP joint: proximal interphalangeal joint

medullary Implant® and the NVision™ Vector Hammer-toe Implant®. Initially, there is a brief discussion of the box joint arthrodesis procedure that does not involve the use of K-wires.

BOX JOINT ARTHRODESIS OF THE PIP JOINT TO CORRECT HAMMERTOE DEFORMITY

Bernbach and Bernbach first described the box joint arthrodesis procedure in an article published in 1985.² The concept was drawn from the tongue and groove technique used in cabinet making. The original procedure utilized a 2.2 mm x 8 mm cancellous screw. Miller et al, typically use a 2.0 mm headless screw that is placed in all three phalanges, distal to proximal, and the following is a description of the procedure.²

1. Using a #15 knife blade, a linear elliptical incision is made over the dorsum of the toe that extends over the proximal phalanx to the distal interphalangeal joint.
2. The ellipse of the skin incision is removed, and the surgeon dissects down to the extensor tendon.
3. The tendon and dorsal capsule is transected at the level of the PIP joint.
4. The tendon ends are dissected free from the base of the middle phalanx and proximal to the metaphyseal and diaphyseal connection of the proximal phalanx.
5. The collateral ligaments located on the lateral and medial sides of the PIP joint are transected to expose the joint.
6. Using a sagittal saw, the surgeon resects the articular surface of the head of the proximal phalanx. (Figure 1)



Figure 1
With proper exposure of the proximal phalanx head, sagittal saw is then used in the coronal plane for the first cut.

7. A transverse incision is made in the proximal phalanx slightly proximal to the PIP joint. (Figure 2)



Figure 2
Resection of the dorsal aspect of the head of the proximal phalanx is finished transversely.

8. A second incision is then made from inferior to superior in the transverse plane to join the first incision, thus leaving a dorsal cortical shelf intact. The surgeon will preserve the cartilage at the base of the middle phalanx to minimize shortening. (Figure 3)



Figure 3
Once the cut is complete the fragment is removed to display proper bony contouring for acceptance of the middle phalangeal portion.

9. A 3-4 mm incision is made into the base of the middle phalanx that bisects the height of the phalanx. (Figure 4)



Figure 4
Resection of the plantar base of the middle phalanx.

10. The next incision is made dorsal to plantar to join the middle phalanx incision that creates the plantar cortical shelf. The osseous box joint has now been made.
11. The surgeon inserts a K-wire to achieve temporary fixation. (Figure 5)



Figure 5
Guidewire is then placed for temporary fixation.

12. A 2.0 mm headless cannulated screw is inserted slightly dorsal proximal to distal plantar to prevent the bone from fracturing dorsally.² (Figure 6)

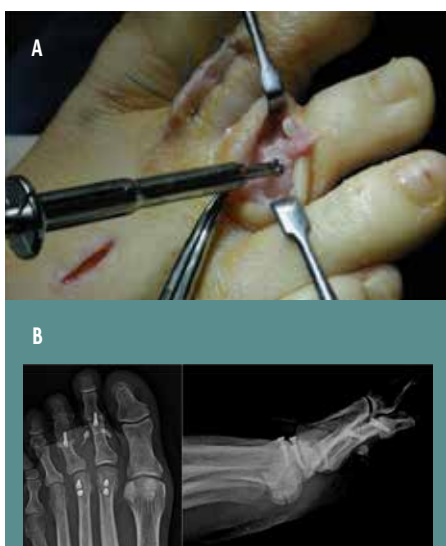


Figure 6
Cannulated screw inserted: (A) 2.0 mm headless cannulated screw is then inserted, (B) immediate postoperative AP and lateral view radiograph of the final correction of the 2nd and 3rd digits with associated osteotomies to metatarsal 2 and 3.

In Miller's et al study, the box arthrodesis had a low complication rate of 5.8%.² Additionally, the procedure had a success rate of 95.35%, combined with a low rate of revision at 4.65%.² The two main disadvantages of the procedure are the delicate bone cuts that must be precisely made and the cost of using a screw for fixation as opposed to a K-wire.

STRYKER SMART TOE II INTRAMEDULLARY IMPLANT

The Smart Toe II implant is made of nitinol, an alloy of 50% nickel and 50% titanium. It is activated by body temperature to adjust to the shape of the toe's anatomy. (Figure 7) The implant is provided within a sterile package and must be stored at 0° C (32° F) or colder for a minimum of two hours prior to implantation to maintain its contracted, long, narrow shape. The implant must not be removed from the freezer until the surgeon is ready to place the implant. The implant should never be re-sterilized because the heat will alter its biomechanics that can result in failure of the implant once placed. Patient education includes communicating that the implant can be damaged or broken because of vigorous activity or trauma to the digit. Additionally, the patient should be made aware that the implant has a finite expected service life.

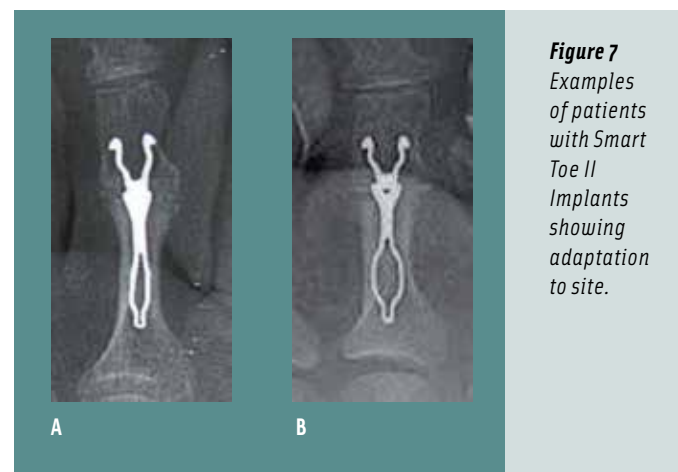


Figure 7
Examples of patients with Smart Toe II Implants showing adaptation to site.

The implant is contraindicated for use on patients who are allergic to the components of the implant as well as patients with a nickel sensitivity. The implant should not be used in conjunction with other implants that have a different metal alloy. Only the Smart Toe II Implant instruments should be used to place the implant.

The following are the steps of the implant procedure. A surgeon may wish to use the positioning rod which is also addressed.

1. Prior to making the skin incision, the surgeon selects the correct size of implant based upon pre-operative X-rays and the sizing guide provided in the specialty instrument tray. (Figure 8)



Figure 8 Color code and sizing guide pad

2. Using a #15 knife blade, the surgeon will make a linear incision to expose the interphalangeal joint of the proximal and middle phalanges. (Figure 9)



Figure 9 Linear skin incision

3. The head of the proximal phalanx is resected approximately 2-3 mm. (Figure 10)
 - a. To prepare the site for inserting the implant, the surgeon will use a 2 mm drill bit, drilling down the center of the proximal phalanx until the cutting flutes are not seen. If the surgeon considers the canal too narrow for inserting the implant, the drill bit will be used to remove additional bone to enlarge the canal.
 - b. **Technique note for the CST:** Have the middle phalanx short broach ready in case the surgeon determines the cortical bone is dense and needs to use the broach to better prepare the canal in the bone. The broach will be manually inserted to avoid fracturing the bone.



Figure 10 Head of the proximal phalanx is resected.

4. Using the stop drill bit, the surgeon creates the canal in the middle phalanx.
 - a. The surgeon will then use the surfacing reamer to manually remove the cartilage. (Figure 11)

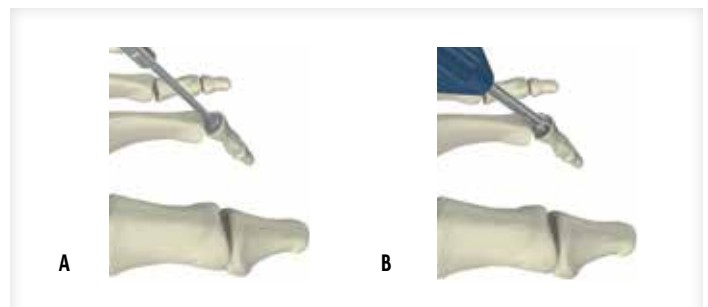


Figure 11 Middle phalanx preparation: (A) Creating canal in middle phalanx, (B) manually removing cartilage.

5. Next, the size 15 short broach that is indicated by a yellow dot is inserted up to the stop.
 - a. The next size, 16, 19, and 20, is inserted up to the laser mark.
 - b. Lastly, size 21 and 22 is inserted up to the stop.
 - c. **Technique notes for the CST:** The CST should have the broaches lined up in the correct order of use and verbalize to the surgeon the size of the broach when passing it. If the surgeon determines that manually using a broach is insufficient, have a small mallet ready for use for the surgeon to gently tap on the broach. (Figure 12)

Figure 12 Middle phalanx preparation continued: (A & B) Middle phalanx short broach with yellow dot inserted, (C) size 16, 19, & 20 broach, (D) size 21 & 22 broach



A

6. The implant holding forceps must be used to remove the Smart Toe II from the packaging insert. (Figure 13)
 - a. While holding the implant with the forceps, the surgeon inserts the long end of the implant into the canal of the proximal phalanx until the forceps touch the proximal phalanx. At this point, the surgeon **must not** remove the forceps.
 - b. **Use of the Positioning Rod:** The implant is slightly inserted into the canal so as the hole in the implant is still visible. The positioning rod is inserted, while the implant continues to be held with the forceps. The implant is inserted the rest of the way with the positioning rod and forceps still in place.

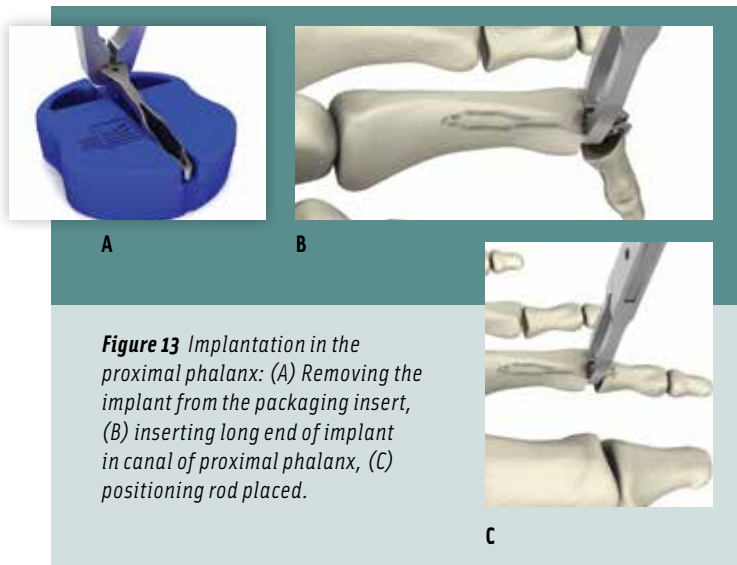


Figure 13 Implantation in the proximal phalanx: (A) Removing the implant from the packaging insert, (B) inserting long end of implant in canal of proximal phalanx, (C) positioning rod placed.

7. While still holding the implant in place, the middle phalanx is partially reduced over the distal portion of the implant placing it within the canal. (Figure 14)
 - a. The surgeon now removes the forceps and manually completes the reduction.
 - b. The surgeon should hold the reduction in place for approximately one minute. This allows the heat of the body to warm the implant that activates the memory metal. The width of the implant expands, locking it in place against the walls of the canal. Additionally, the

- implant contracts along its length to pull the ends of the bones together to facilitate fusion.
- c. **Use of the Positioning Rod:** The middle phalanx is partially reduced with the positioning rod and forceps still in place. Once partially reduced, the forceps are removed, but not the positioning rod. When the phalanx is fully reduced, the positioning rod is removed, and the surgeon compresses the two phalanges for approximately one minute.
- d. **Technique note for the CST:** Have a sterile basin filled with warm sterile water, 37° C (98.6 ° F) to 40° C (104° F), available if the surgeon wishes to soak the toe to facilitate speeding up the metal memory process.³

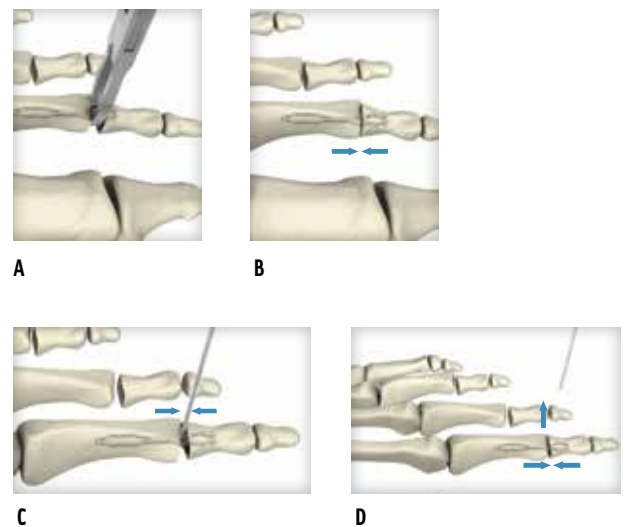
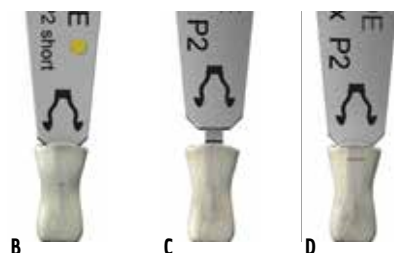


Figure 14 Implantation in the middle phalanx: (A) Partial reduction, (B) complete reduction, (C) phalanx partially reduced with positioning rod in place, (D) positioning rod removed and compression of the phalanx completed.

After the incision is closed, a sterile dressing is applied that is not too tight. The patient will be encouraged to place some weight on the foot later the same day of surgery. The bones will fuse within the next several weeks.



"The implant expands to lock against the walls of the canal, then contracts along its length to pull the bone ends together and facilitate fusion."

NVISION™ BIOMEDICAL TECHNOLOGIES VECTOR® HAMMERTOE IMPLANT

The Vector Hammertoe Implant is manufactured of PEEK-Optima® HA Enhanced with the HA combined into the PEEK and not just used as a coating. The implant consists of one piece where the distal portion is screwed into the bone, and the proximal portion is manually inserted. (Figure 15)

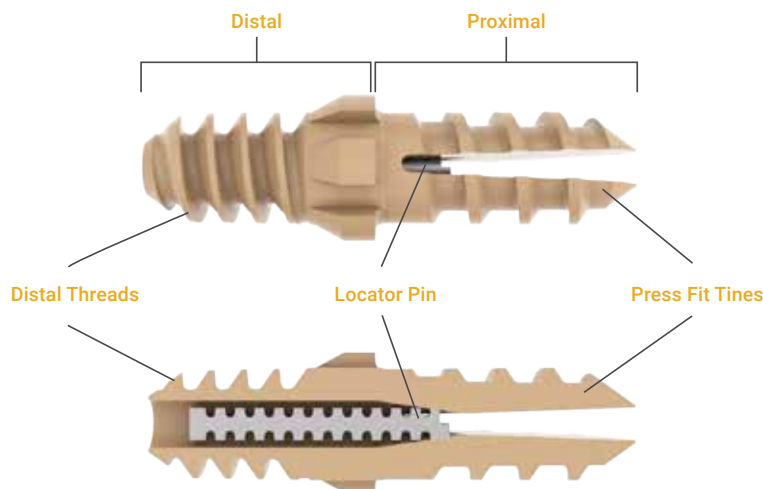


Figure 15 Diagrams of the implant

Contraindications and precautions are typical of most implants.

- The implants should never be re-sterilized.
- The K-wires are intended for single use only.
- Only the Vector specialty instruments should be used to place the implant.
- Implant should not be placed if the patient has an active or suspected infection.
- The implant should not be used in conjunction with other implants that have a different metal alloy.
- Implanting an implant of the incorrect size, particularly if it is too small, can lead to implant fracture.
- Patient has been identified as having an inadequate quality or quantity of bone that would not allow stabilization of the bone while healing.
- The patient should be educated as to the potential adverse effects of the procedure including the migration or subluxation of the implant that can result in limiting the range of motion of the digit.⁴

The following are the steps of the implant procedure, including insertion of a non-cannulated and cannulated implant.

1. Using a #15 knife blade, the surgeon makes a linear skin incision over the dorsal aspect of the PIP joint.
2. A transverse capsulotomy is completed as well as releasing soft tissue as necessary to expose the PIP joint.
3. Depending on surgeon's preference, a sagittal saw or bone cutter will be used to make the transverse resection of the head of the proximal phalanx. (Figure 16)



Figure 16
Resection of the proximal phalanx.

4. The cartilage at the base of the middle phalanx is resected while avoiding the removal of bone to avoid shortening the digit. (Figure 17)



Figure 17
Cartilage resected from base of middle phalanx

5. Using the implant sizer, the surgeon determines the correct size of implant. (Figure 18)
 - a. The implant sizer is radiopaque and therefore can be used with fluoroscopy.



Figure 18
Determining the size of needed implant using implant sizer.

6. The following are the steps for preparing the middle phalanx. The steps are the same for both the non-cannulated and cannulated implant when inserting the K-wire, except a double K-wire is used for the cannulated implant.
 - a. The K-wire is inserted into the middle phalanx in antegrade fashion down the center of the bone and exits at the distal end of the toe. (Figure 19 A)
 - b. The K-wire is left extending 1-2 mm from the base of the middle phalanx and the blunt end of the K-wire is used to make a slight indentation in the proximal phalanx as the reference point for drilling. (Figure 19 B)
 - c. The cannulated drill bit with the correct sized diameter is slid over the K-wire and hand drilled to the last laser line. (Figure 19 C, D)
 - d. The CST then hands the correct size of tap that is placed over the K-wire and advanced until the stop is flush with the joint surface. (Figure 19 E, F)

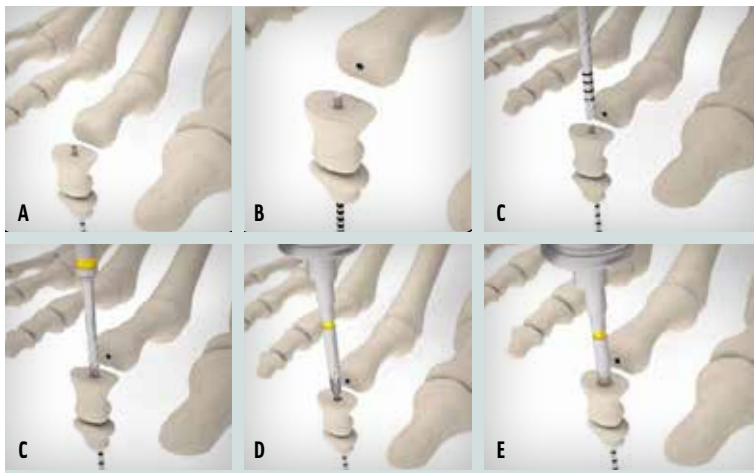


Figure 19 Middle phalanx preparation: (A) K-wire inserted antegrade into the middle phalanx, (B) Central axis of the proximal phalanx indented with blunt end of K-wire, (C) Cannulated drill placed over the K-wire, (D) K-wire is hand drilled to the laser line, (E) Tap is placed over the K-wire, (F) Tap is advanced until the shoulder is flush with bone surface.

7. The following is the step for preparing the proximal phalanx.
 - a. Using the indentation previously made in the bone as a guide, a hand drill is used to drill the hole in the proximal phalanx to the last laser mark. (Figure 20 A & B)
8. The following are the steps for inserting the implant in the middle phalanx.
 - a. Non-cannulated: The K-wire will be slowly pulled distally until the blunt end is flush with the bottom of the distal pilot hole. (Figure 21 A & B)
 - b. Cannulated: The K-wire will be slowly pulled distally until the proximal end of the K-wire is 3-5 mm sub-flush. (Figure 22 A & B)
 - c. This step is the same for both the non-cannulated and cannulated implant. The inserter is used to thread the distal portion of the implant into the middle phalanx until the shoulder of the inserter is 0.5 mm subflush with the surface of the bone. (Figure 23 A – C)



Figure 20 Proximal phalanx preparation: (A & B) Using a hand drill, the proximal phalanx is drilled to the last laser mark.

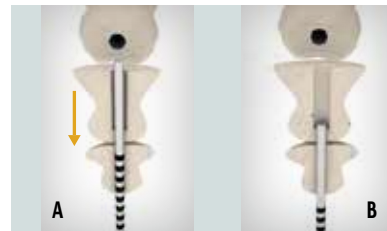


Figure 21 Non-cannulated: (A & B) K-wire is pulled distally until the blunt end is flush with bottom of the distal pilot hole.

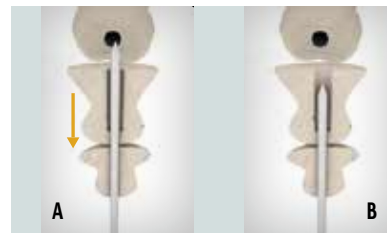
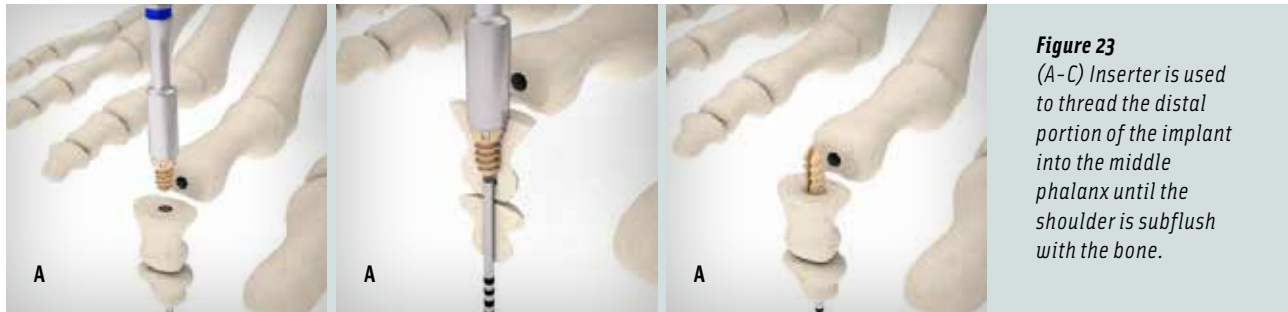
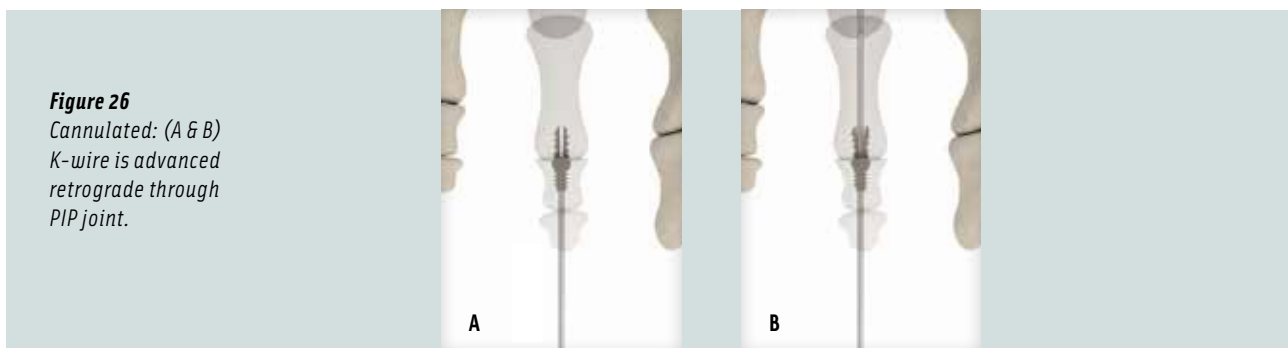
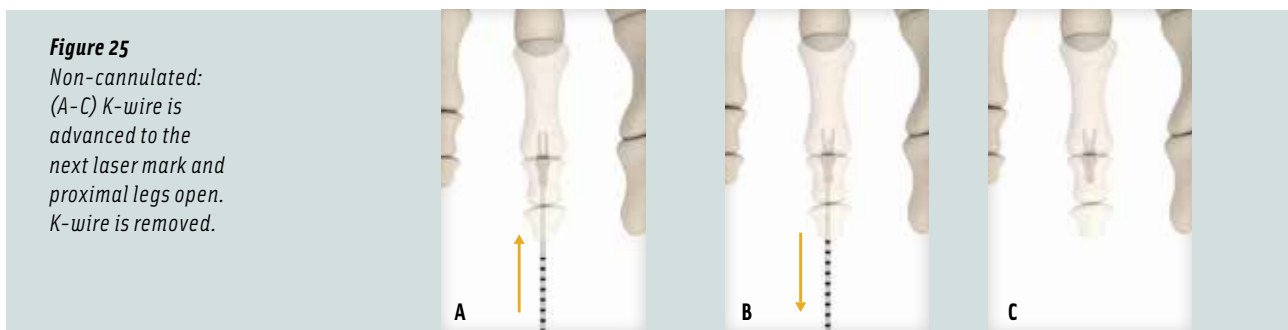


Figure 22 Cannulated: (A & B) K-wire is pulled distally until the proximal end of the K-wire is subflush.

"The surgeon's choice depends on the patient's anatomy and pathology, as well as the system or procedure with which the surgeon is most familiar."



9. The following are the steps for inserting the implant in the proximal phalanx.
 - a. The implant is placed into the pre-drilled canal of the proximal phalanx. (Figure 24 A & B)
 - b. Non-cannulated: The K-wire is inserted to the next laser mark to push the locator pins proximally that causes the proximal legs of the implant to open. The K-wire is then removed. (Figure 25 A-C)
 - c. Cannulated: The K-wire is advanced retrograde through the PIP joint and stopped by the surgeon at their preferred location.⁴ (Figure 26 A & B)



"The patient may place some weight on the foot later the same day of surgery, with the bones fusing over the next several weeks."

CONCLUSION

There are multiple types of systems commercially available for correcting hammertoe deformity. Each has its own advantages and disadvantages, with one of the primary disadvantages being cost as compared to using K-wires. It is obviously the decision of the surgeon as to what they feel is best to be used according to the anatomy and pathology of the patient as well as the system or procedure of which they are most familiar.

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1. Which of the following materials promotes bone grown and attachment when used in the manufacturing process of a metal implant?
 - a. Nitinol
 - b. Titanium alloy
 - c. Hydroxyapatite
 - d. Polyetheretherketone
2. What millimeter size of screw is used during a box joint arthrodesis?
 - a. .5
 - b. 1.0
 - c. 1.5
 - d. 2.0
3. What instrument is used to resect the articular surface of the head of the proximal phalanx during a box joint arthrodesis?
 - a. Bone cutter
 - b. Sagittal saw
 - c. Rongeur
 - d. Rasp
4. What degrees centigrade must the Smart Toe II implant be stored?
 - a. 0
 - b. 12
 - c. 20
 - d. 32
5. What millimeter size of drill bit is used to prepare the Smart Toe II implant insertion site of the proximal phalanx?
 - a. 1.0
 - b. 1.5
 - c. 2.0
 - d. 2.5
6. What instrument must not be removed from the Smart Toe II implant once the long end of the implant is within the proximal phalanx?
 - a. K-wire
 - b. Broach
 - c. Rod
 - d. Forceps
7. How many minutes should the CST time the surgeon when the Smart Toe II implant is in place and the reduction has been completed?
 - a. 1
 - b. 3
 - c. 5
 - d. 7
8. What should the CST have available to accelerate the metal memory process of the Smart Toe II implant once the reduction has been completed?
 - a. Cold towels
 - b. Ace bandage
 - c. Warm saline
 - d. Overhead heater
9. The Vector hammertoe implant sizer can be used with fluoroscopy.
 - a. True
 - b. False
10. How is the small indentation made in the proximal phalanx during the Vector procedure?
 - a. Tap
 - b. K-wire
 - c. Drill bit
 - d. Locator pin

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