



## Clinical Principles of Intraosseous Vascular Access

ARROW® EZ-IO® Intraosseous Vascular Access System



2014-2780

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Key concepts covered in this presentation include:

- Indications and Contraindications
- Basic bone anatomy
- Site selection/identification
- Needle set selection
- Insertion technique
- Infusing medications and fluids
- Care of the patient
- Assessment/documentation
- Removing the catheter
- Care of the driver
- Clinical support resources

## Indications

The ARROW® EZ-IO® Intraosseous Vascular Access System is indicated for adult and pediatric patients any time vascular access is difficult to obtain in emergent, urgent or medically necessary situations for 24 hours

Adults	Pediatrics
<ul style="list-style-type: none"> <li>• Proximal humerus</li> <li>• Proximal tibia</li> <li>• Distal tibia</li> </ul>	<ul style="list-style-type: none"> <li>• Distal femur</li> <li>• Proximal humerus</li> <li>• Proximal tibia</li> <li>• Distal tibia</li> </ul>



## Contraindications

- Fracture of target bone
- Infection at area of insertion
- Inability to identify landmarks
- IO or attempted IO access in target bone within previous 48 hours
- Prosthesis or orthopedic procedure near insertion site

The ARROW® EZ-IO® Intraosseous Vascular Access System is designed to be a safe, effective solution for fast vascular access when you're facing difficult vascular access (DVA) challenges in emergent, urgent or medically necessary situations for adult and pediatric patients for 24 hours.

The system provides vascular access to the central circulation within seconds for the delivery of medications, intravenous (IV) fluids and blood products providing peripheral access with central performance.

There are few contraindications to IO access, and they are all relevant to site selection:

- Trauma/Fracture (in the targeted bone) - If there is a fracture (or suspected fracture) in the bone in which the needle set is to be placed, an alternate site must be chosen. When IO access is placed in a fractured bone, fluid may extravasate into the surrounding tissue through the fracture. This can lead to complications including compartment syndrome. If a tibial fracture is suspected, both the proximal and distal sites are contraindicated as they share a common pathway inside the bone. However, if the patient has a fractured femur and an intact tibia, the tibial sites could be considered – circulation from the lower leg should be assessed to determine the appropriateness for IO vascular access.
- IO or attempted IO access in the target bone within the past 48 hours: Healing from intraosseous insertion generally takes approximately 48 hours and is required before another IO catheter can be safely placed in the same bone. Within 48 hours fibrin formation and clotting are sufficient to prevent infiltration/extravasation through the previous IO access hole. If IO access was attempted in the bone, the same consideration applies. Complete healing, to the point where the hole can no longer be detected by Xray usually takes several days or weeks.
- Prosthesis or previous orthopedic procedures near insertion site: If the patient has a surgical scar over a joint; assume there is a titanium appliance within the joint – and do not attempt IO access at that site. Select a different insertion site and assess that site for use.

- Infection at the insertion site; do not insert the needle set through infected or inflamed tissue.
- Inability to locate landmarks (e.g. due to excessive tissue): Inability to locate insertion site landmarks for any reason (including excess adipose tissues) is a contraindication - select an alternate insertion site where landmarks are identifiable.

- Emergent, urgent or medically necessary situations
  - Immediate need for medications or fluids
  - Prevention of delays to vascular access during critical situations
  - Difficult Vascular Access (DVA)
  - Vein preservation



- ✓ Safe: <1% serious complication rate
- ✓ Fast: Vascular access in seconds
- ✓ Efficient: 97% first-attempt success rate
- ✓ Versatile: Can be placed by any qualified healthcare provider
- ✓ Convenient: Requires no additional equipment or resources

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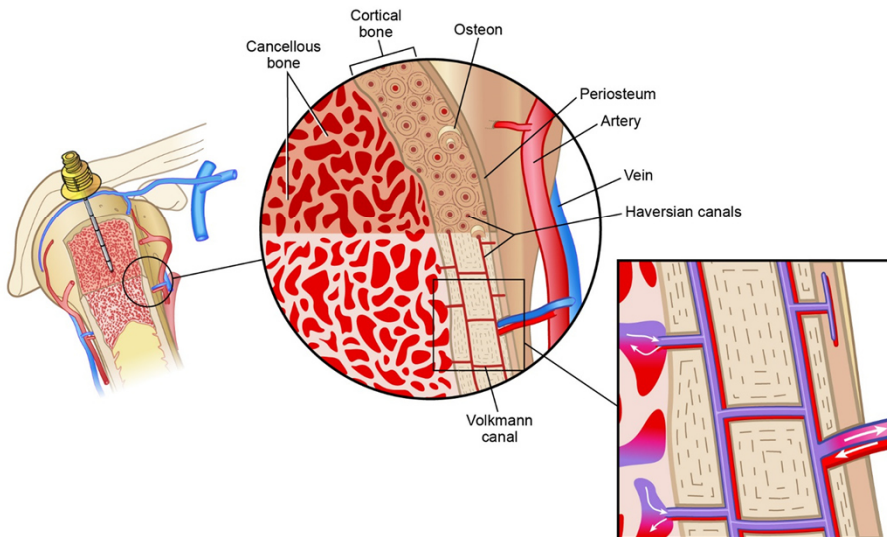
The ARROW® EZ-IO® Vascular Access System is safe, fast and easy, and can be used in any situation where vascular access is challenging. Research shows a serious complication rate of < 1% and clinicians have a 97% insertion success rate.

Placement of peripheral IV catheters for vascular access is common; however, in certain circumstances successful cannulation can be difficult and may require multiple attempts. Vascular access fails during emergency situations up to 40% of the time.

Consider emergencies like hemodynamic instability and respiratory compromise. Outcomes in cardiac or respiratory arrest depend on immediate access. The patient that needs rapid sequence induction/intubation (RSI) may not have time to wait for other forms of vascular access. Patients with DVA may be in need of immediate medications or fluids: shock/trauma, sepsis, stroke, dysrhythmia/chest pain/myocardial infarction (MI), burns, status, epilepticus/seizures, diabetic ketoacidosis (DKA), end-stage renal disease (ESRD), head injury, anaphylaxis, congestive heart failure (CHF), sickle cell crisis/anemia and many other conditions are time sensitive requiring vascular access.

Any patient may present with difficult vascular access (DVA). With the ARROW® EZ-IO® Vascular Access System, vascular access is no longer a problem.

## Highly vascular, non-collapsible access



Rapid flush to  
displace marrow

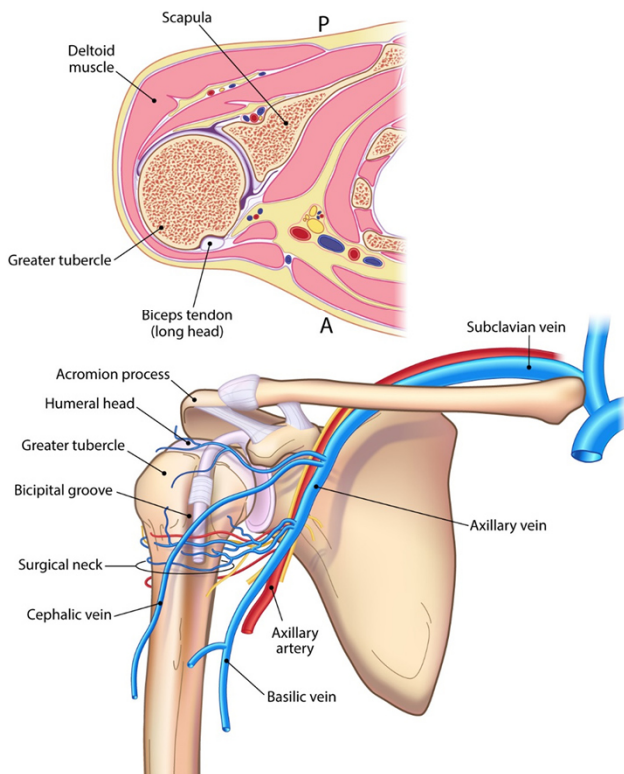
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IO catheters are usually placed in the proximal and distal ends (epiphyses) of long bones due to the thinner cortex and abundance of cancellous (spongy) bone at these sites. Within the medullary space lies a vast system of blood vessels through which blood and fluid pass into the central circulation. The bone acts as a large, non-collapsible vein. Fluid or medication instilled into the intraosseous space gains access to the central circulation within just a few seconds.

The needle set is powered by the driver through bone that is usually 3mm thick or less; accurate identification of the insertion site is important to ensure you are not attempting access through thicker bone. The specially designed cutting IO needle set and powered driver enables clinician control of the insertion with proven tactile feedback. This is integral to success with newborns, infants and young children who may have thinner, softer bones. The ARROW® EZ-IO® Vascular Access System provides rapid, smooth entry into the bone's medullary cavity, creating a conduit to the central circulation.

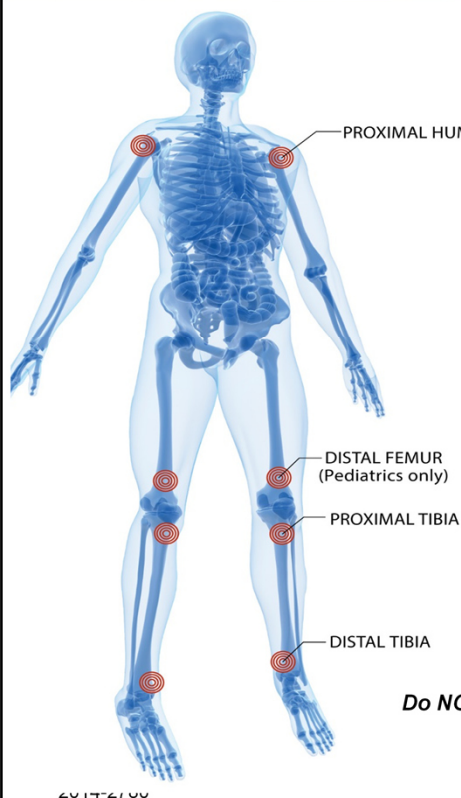
Within the micro-vasculature inside the medullary space lies a hyper-coagulable fibrin mesh as well as red and yellow marrow. The IO space is like a honeycomb of bone. The fibrin mesh and bone marrow is a thick substance and poses more resistance to infusion than blood. To achieve optimal fluid volume and drug delivery times, as well as less pressure for infusions, a rapid flush is necessary to displace the thick bone marrow.



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A common misperception is that it takes a long time for fluids, medications, or blood infused into the intraosseous space to reach the central circulation, when in fact medications and fluids instilled into the intraosseous space gain access to the central circulation within seconds. A preclinical study measuring peak serum concentrations found that epinephrine infused via the IO humeral site has the identical peak serum concentration as central line administration.

This video of real-time fluoroscopy in a human subject demonstrates how quickly IV contrast infused into the medullary space is disseminated into the central circulation. Watch how quickly the dye reaches the right atrium when instilled via the proximal humerus, again demonstrating direct correlation between the subclavian and proximal humerus for infusion of fluids. The distance to the right atrium from the humerus is short; medication and fluid will reach the heart in less than 3 seconds. Typical fluid volume to expect from the proximal humerus site is 5L/hr under pressure. From the tibia to the heart there is more distance to travel, and typical fluid volumes of 1L/hr are achieved under pressure.



- Flow rates average 5L/hr
- 3 seconds to heart with medication/fluids
- Lower insertion & infusion pain
- Less medication required for pain management
- No reported compartment syndrome due to IO access placement

High success rates in pediatric patients

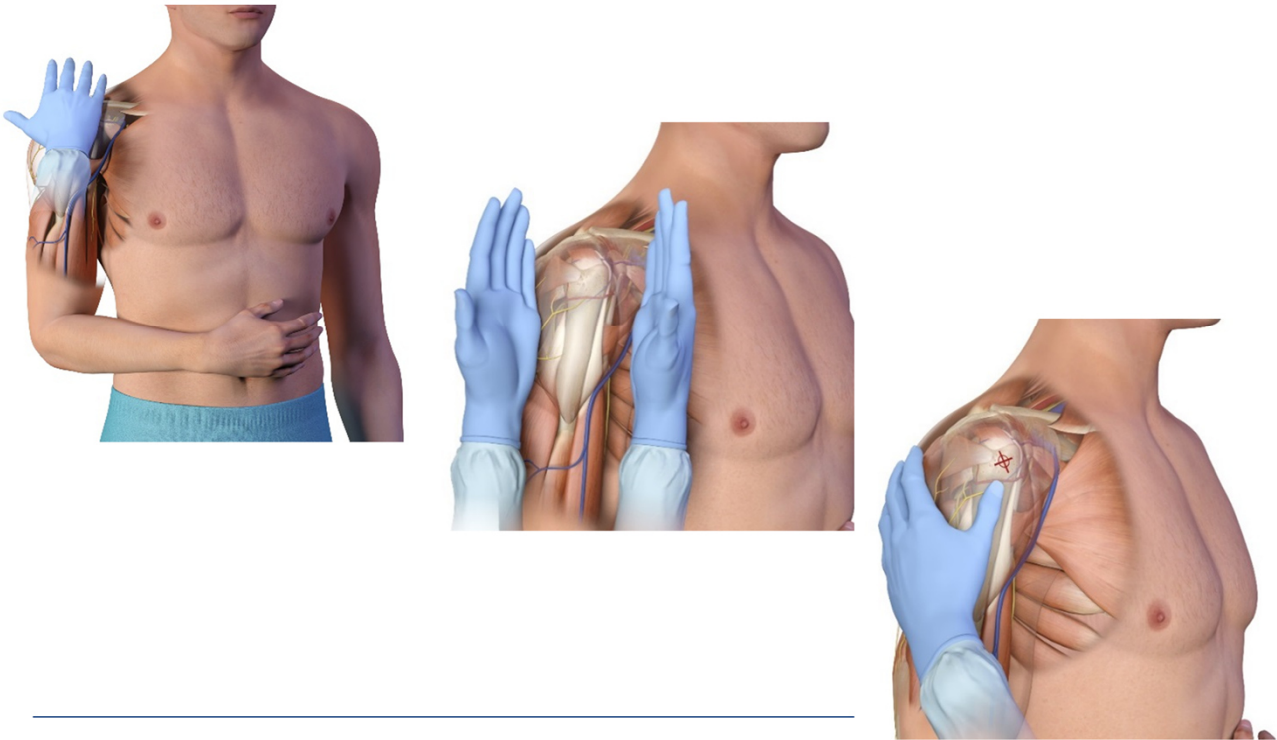
**Do NOT use the powered ARROW® EZ-IO® Vascular Access System in the sternum!**

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The ARROW® EZ-IO® Vascular Access System is indicated for adult insertion in 6 sites: the right and left proximal humerus, the right and left proximal tibia, and the right and left distal tibia. Indications for pediatric insertion include 8 sites: the right and left distal femur, the right and left proximal humerus, the right and left proximal tibia and the right and left distal tibia. *The powered ARROW® EZ-IO® Vascular Access System includes the driver and needle sets and is not intended for placement in the sternum.*

Site selection is based on several factors including patient size, anatomy, presenting condition, ability to locate anatomical landmarks, clinical judgment and experience. Many studies support the proximal humerus as a successful or even superior IO route for flow rates, drug delivery, and management of infusion pain. The proximity of the humerus to the heart ensures rapid infusion of medications into the central circulation. 5L/hr average flow rates can be achieved using the humeral site. Medications and fluids reach the right atrium in just 3 seconds. Research reports insertion into the proximal humerus results in lower insertion and infusion pain than the tibia and requires less medication for pain management.<sup>5</sup> As of July 2014, there has been no reported compartment syndrome due to IO access placement at the proximal humerus.

The distal femur insertion site in pediatrics is supported in the medical literature as a viable site with success rates of 98-100%.



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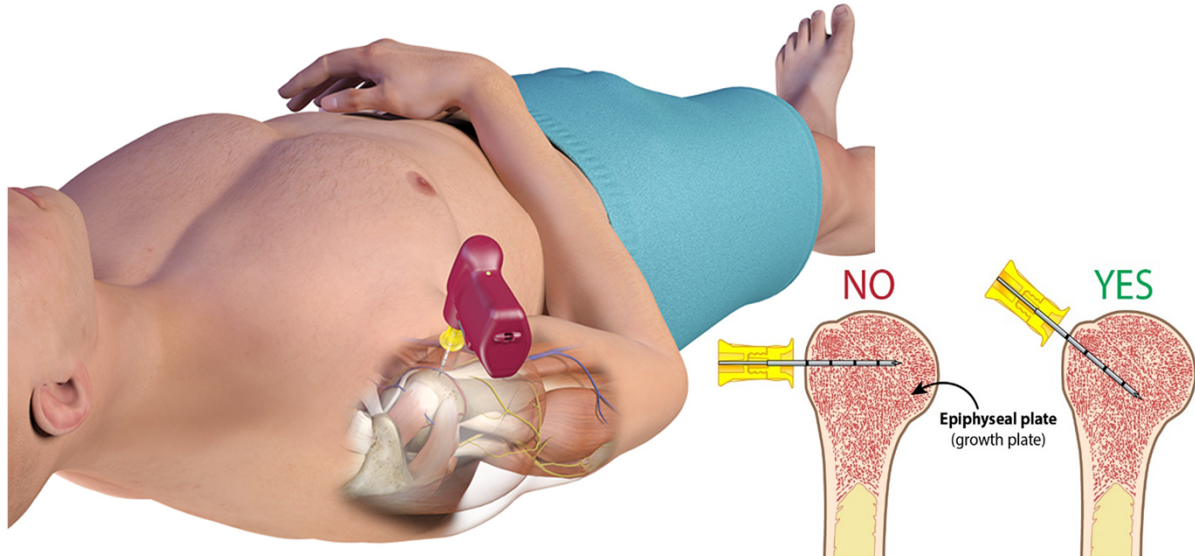
Let's watch this demonstration of correct identification of the proximal humerus site.

### **Proximal Humerus Insertion Site Identification**

1. Place the patient's hand over the abdomen (elbow adducted and humerus internally rotated)
2. Place your palm on the patient's shoulder anteriorly  
The area that feels like a "ball" under your palm is the general target area  
You should be able to feel this ball, even on obese patients, by pushing deeply
3. Place the ulnar aspect of your hand vertically over the axilla and the ulnar aspect of your other hand along the midline of the upper arm laterally
4. Place your thumbs together over the arm  
This identifies the vertical line of insertion on the proximal humerus
5. Palpate deeply up the humerus to the surgical neck  
This may feel like a golf ball on a tee – the spot where the "ball" meets the "tee" is the surgical neck  
The insertion site is 1 to 2 cm above the surgical neck, on the most prominent aspect of the greater tubercle



Humerus: Insert needle set at a 45° angle to the anterior plane and posteromedial



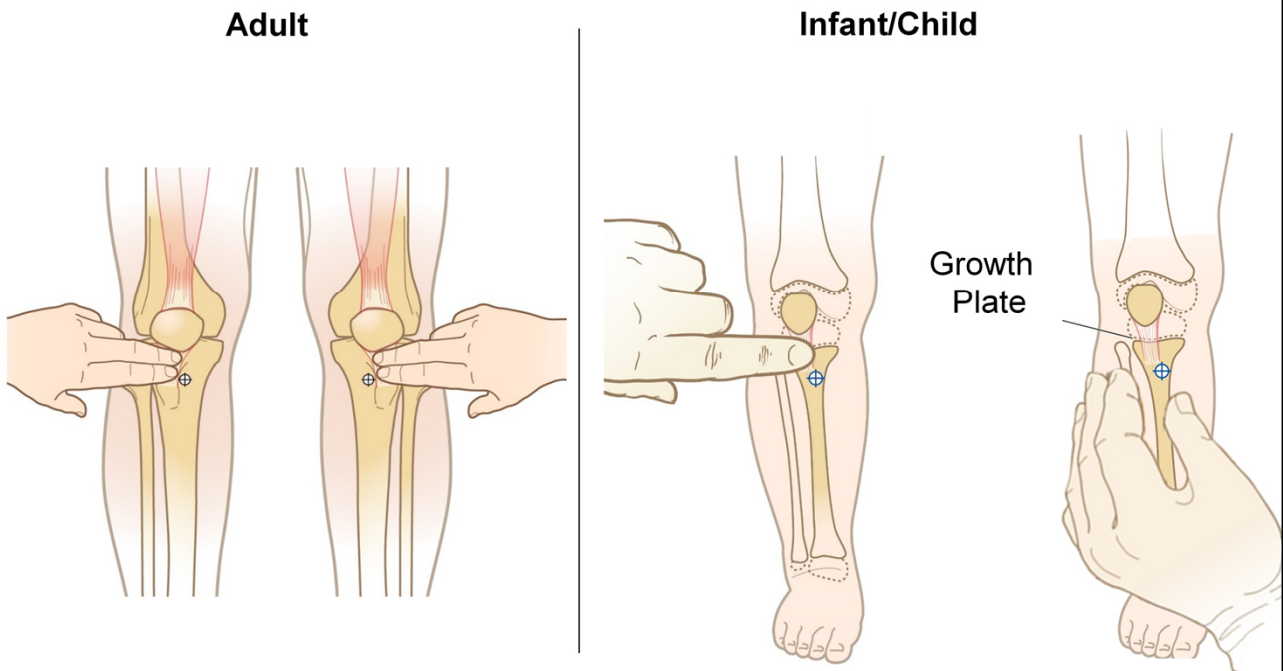
Tibia and Femur: Insert needle set at a 90° angle to the bone

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Insertion angle is important to ensure placement that will provide optimal vascular access. For the proximal humerus insertion, aim the needle set tip at a 45-degree angle to the anterior plane and posteromedial.

For tibia and femur access, aim the needle set tip at a 90-degree angle to the bone.



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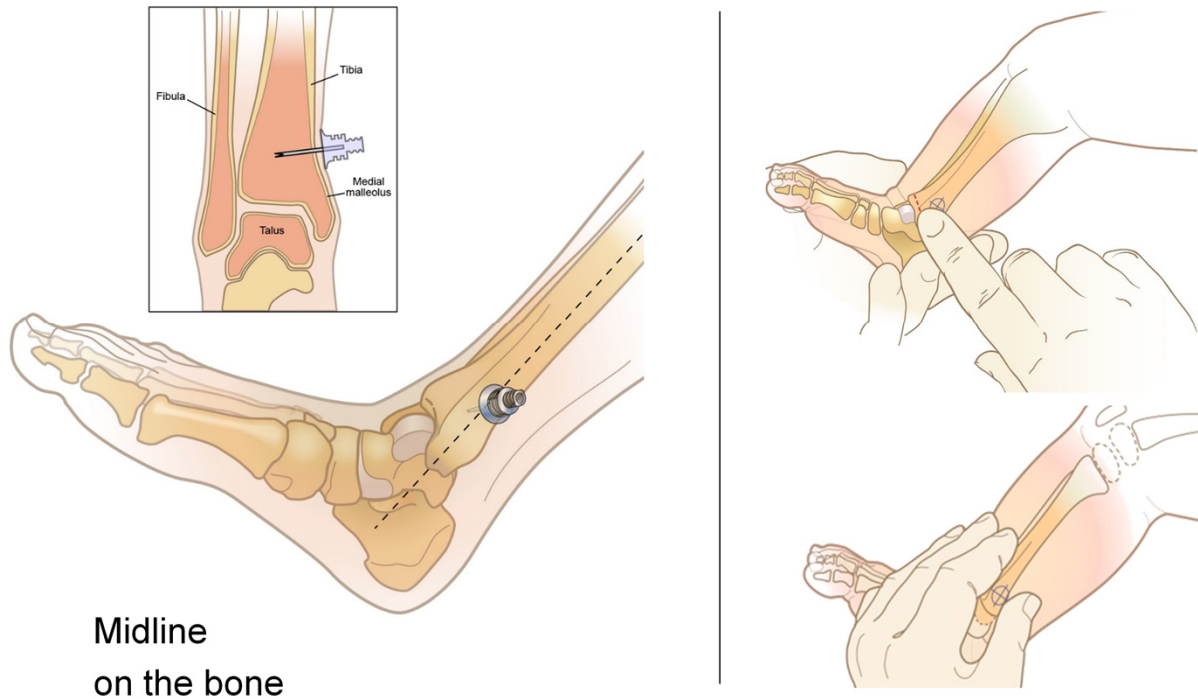
**Proximal Tibia Insertion Site Identification – Adult**

Extend the leg. Insertion site is approximately 2 cm **medial** to the tibial tuberosity, or approximately 3 cm below the patella and approximately 2 cm **medial**, along the flat aspect of the tibia.

**Proximal Tibia Insertion Site Identification – Infant/Child**

Extend the leg. Pinch the tibia between your fingers to identify the medial and lateral borders of the tibia.

Insertion site is approximately 1 cm **medial** to the tibial tuberosity, or just below the patella (approximately 1 cm or one finger width) and slightly **medial** (approximately 1 cm), along the flat aspect of the tibia.



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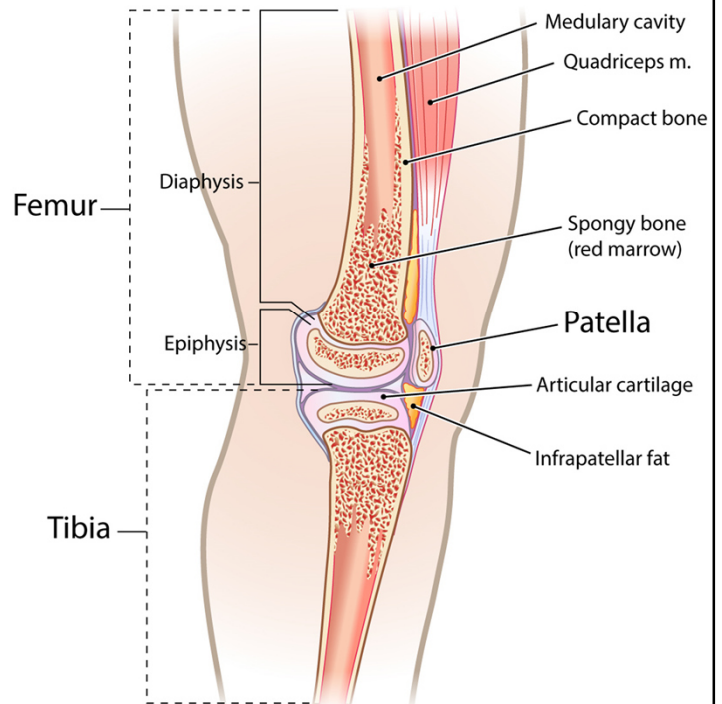
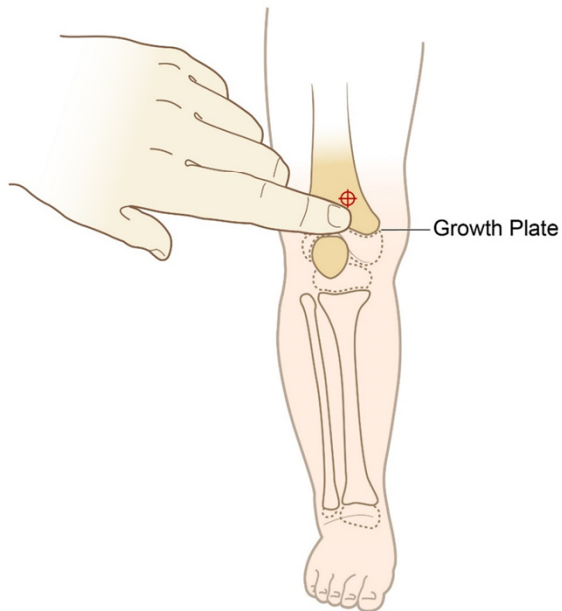
### **Distal Tibia Insertion Site Identification - Adult**

Insertion site is located approximately 3 cm proximal to the most prominent aspect of the medial malleolus. Palpate the anterior and posterior borders of the tibia to assure that your insertion site is on the flat center aspect of the bone.

### **Distal Tibia Insertion Site Identification – Infant/Child**

Insertion site is located approximately 1-2 cm proximal to the most prominent aspect of the medial malleolus. Palpate the anterior and posterior borders of the tibia to assure that your insertion site is on the flat center aspect of the bone.

- Secure the leg out-stretched
- Ensure the knee does not bend



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### Distal Femur Insertion Site Identification - Infant/Child

Secure the leg out-stretched to ensure the knee does not bend. Identify the patella by palpation.

The insertion site is just proximal to the patella (maximum 1 cm) and approximately 1-2 cm **medial** to midline.

- Clinical judgment should be used to determine appropriate needle set selection based on patient weight, anatomy and tissue depth overlying the insertion site



15 mm  
15 gauge  
Indicated for patients  
weighing 3-39 kg



25 mm  
15 gauge  
Indicated for  
patients weighing  
3 kg or over



45 mm  
15 gauge  
Indicated for patients  
weighing 40 kg or over,  
excessive tissue depth

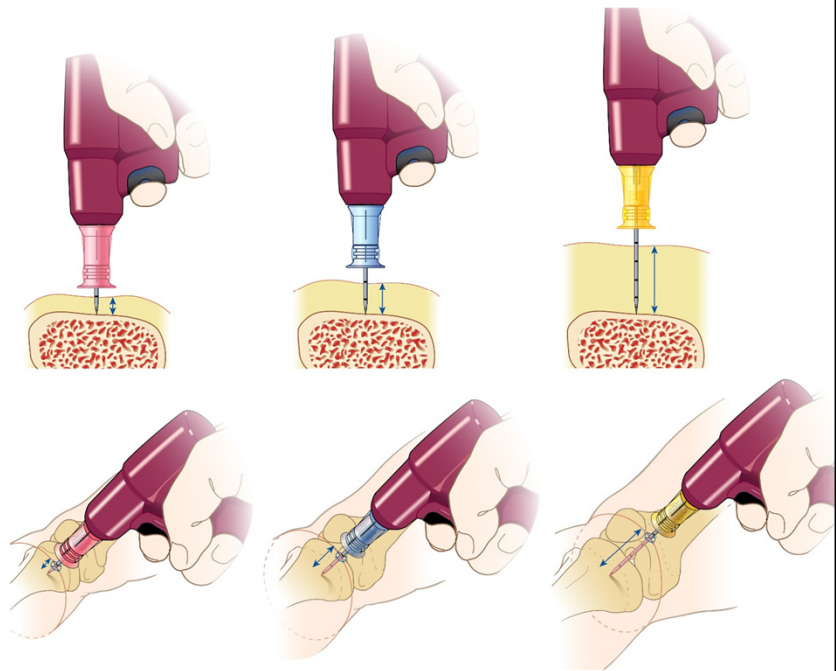
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The single use sterile needle sets are 15 gauge, 304 stainless steel available in 3 lengths:  
15 mm (pink hub) indicated for patients weighing 3-39 kg  
25 mm (blue hub) indicated for patients weighing 3 kg or over  
45 mm (yellow hub) indicated for patients weighing 40 kg or over and/or  
excessive tissue depth

The needle sets do not have “adult” or “pediatric” sizes. Each needle set is US FDA-cleared with weight range guidelines. Clinical judgment should be used to determine appropriate needle set selection based on patient weight, anatomy and tissue depth (skin, adipose and muscle thickness) overlying the insertion site.

For example, a small geriatric female may require a shorter length needle set; an obese child may require a longer needle set. In adults, the 45 mm needle set should be considered for the proximal humerus site in most patients weighing >40 kgs, to accommodate for any inadvertent movement of the extremity after insertion.

- Estimate tissue depth
- Confirm with 5 mm mark visible above the skin



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To facilitate selection of the correct length needle set, tissue depth over the insertion site should be assessed prior to selection of the needle set. Press your thumb or finger over the insertion site to estimate the depth of soft tissue.

The catheter is marked with a black line 5mm from the hub. If the needle set is inserted through the soft tissue and does not reach the bone or the 5mm mark is not visible above the skin with the tip of the needle set touching the bone, the needle set is too short. A longer needle set or alternate site should be chosen prior to penetration of the bone cortex. Using a needle set that is too short will increase the risk of catheter dislodgement leading to infiltration/extravasation, creating a hole in the bone unnecessarily and rendering the site unusable for future IO access for a minimum of 48 hours.

Clinical experience with the device will ultimately present a more rapid approach to needle set selection, but the 5 mm mark assists the clinician with establishing which needle set is appropriate for the patient.

There is often concern expressed by clinicians when selecting a needle set that is long enough to enter the medullary space in infants and small children. With any insertion site or needle set length, clinicians learn to stop by releasing the trigger when they feel the loss of resistance as the needle set enters the medullary space. A bench study, with models designed to mimic bone density, has demonstrated the ease of identifying this “stopping point” for IO access insertion through tactile feedback.

- Prep site
- Prepare supplies
  - Open EZ-Stabilizer® Dressing
  - Prime the EZ-Connect® Extension Set
  - Attach Needle Set to Driver



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Use a clean, no-touch technique for this procedure: sterile equipment, decontaminated hands, non-sterile gloves, and avoidance of gloved hands or non-sterile surfaces contacting exposed sterile equipment or site that must remain uncontaminated to maintain asepsis. If using the distal femur site in pediatrics, secure the leg outstretched. Prep the site by using antiseptic solution of your choice.

Open the appropriate needle pack and remove the EZ-Connect® Extension Set.\* Always prime the extension set with fluid before attaching to the catheter hub. The EZ-Connect® Extension Set primes with approximately 1.0 mL. The extension set has a luer lock that will twist onto the catheter hub.

- If the patient is unresponsive to pain, attach a saline flush to the extension set and prime the tubing with saline, leaving the syringe and remaining saline attached to the extension set.
- If the patient is responsive to pain, consider priming the extension set with 2% epinephrine and preservative-free intravenous lidocaine without for anesthesia prior to initial saline flush.

Open the EZ-Stabilizer® Dressing – the dressing is made with a strong medical adhesive tape that is simple to apply to secure the catheter. It is designed for the 15 mm, 25 mm and 45 mm needle sets.

Hold the driver in your dominant hand and attach the needle set by aligning the magnetized needle set hub to the driver.

Remove the safety cap from the needle set using standard sharps precautions. Stabilize the extremity.

\*The EZ-Connect® Extension Set uses the Robertsite® needleless connector; the connector valve satisfies all CDC requirements for needleless intravascular systems.

Note: The EZ-Connect® Extension Set should NOT be used for high pressure infusion/power injection.

- Stabilize hub and remove driver
- Remove stylet
- Apply EZ-Stabilizer® Dressing
- Firmly attach primed EZ-Connect® Extension Set
- Place wrist band



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To complete the insertion:

Continue to hold the hub while twisting the stylet off the hub with counter clockwise rotations

The catheter should feel firmly seated in the bone (1<sup>st</sup> confirmation of placement)

Place the stylet in a sharps container; always dispose of all sharps and biohazard materials using standard biohazard practices and disposal containers. If using the NeedleVISE® 1 port sharps block, place on stable surface and use a one-handed technique.

Place the EZ-Stabilizer® Dressing over the hub

Attach a primed EZ-Connect® Extension Set to the hub, firmly secure by twisting clockwise

Pull the tabs off the dressing to expose the adhesive, apply to the skin

Aspirate for blood/bone marrow (2<sup>nd</sup> confirmation of placement)

Ensure clamp on extension set is open. Inability to withdraw/aspirate blood from the catheter hub does not mean the insertion was unsuccessful. Consider attempting to aspirate after the flush. Site placement can also be confirmed by ability to administer pressurized fluids, and noting the pharmacologic effects of medication administration after flow is established.

For IO access in the proximal humerus, secure the arm in place across the abdomen

*Due to the mobile nature and design of the humeral joint, arm movement and contraction of the deltoid muscle (e.g. simple abduction, rotation, or extension of the arm) can dislodge the IO catheter.*

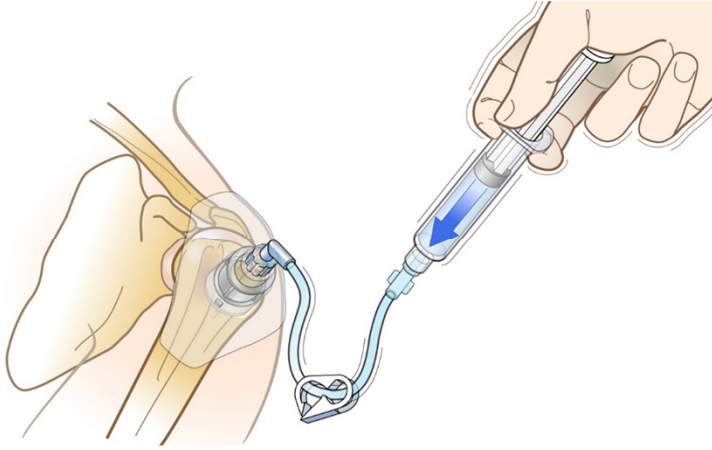
*Raising the arm horizontally above the plane of the torso will often impinge the IO catheter against the acromion and dislodge or bend the catheter. The arm should also be stabilized to limit movement.*

For IO access in the distal femur (pediatrics), the leg should remain immobilized until the IO catheter is removed.

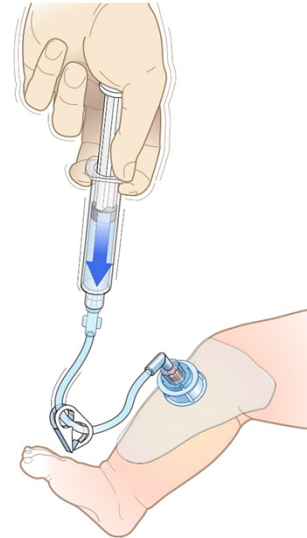
Be sure to apply the wrist band, which includes a place to indicate the date and time of placement



Adults: 5-10 mL



Infants &amp; Children: 2-5 mL



Consider for blood typing and other commonly ordered labs

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**Flush**

It is essential to perform a rapid normal saline (NS) syringe flush into the IO space before attempting to infuse fluids through the catheter. A rapid syringe flush of 5-10 mL normal saline in adults and 2-5 mL normal saline in infants and children helps clear the marrow and fibrin from the medullary space, allowing for effective infusion rates. IO access may be compromised if the line is not used for prolonged periods. IO lines can often be opened successfully by an additional syringe flush. As with an IV infusion, an IO line should be assessed for patency and flushed before and after infusion. It is important to avoid extreme pressure for the flush, which may increase the risk of infiltration/extravasation.

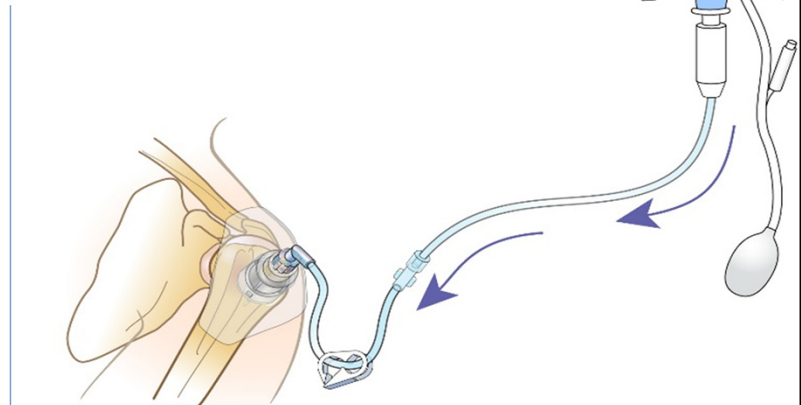
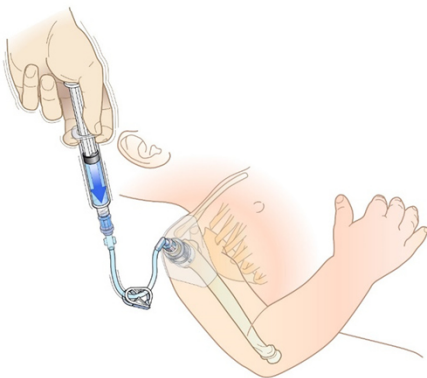
**Labs**

Based on preclinical and clinical evidence comparing IO and venous or arterial sources a number of common laboratory values correlate well; other values show clinical similarity without statistically significant correlation, therefore caution should be exercised with their interpretation. Certain point of care analyzers have been studied with acceptable results. Check with your laboratory for IO specimen processing capabilities. For more information regarding IO specimen lab analysis, refer to the publication *Science and Fundamentals of Intraosseous Vascular Access*, available at: [www.teleflex.com/ezioeducation](http://www.teleflex.com/ezioeducation)

The following recommendations have been developed based on research done by Teleflex Incorporated (Vidacare LLC); study data was based on IO blood specimens obtained prior to any infusions or flush:

- Connect a syringe directly to the catheter hub.
- The first 2 mL of IO blood aspirate may be discarded or considered for point of care testing.
- Samples must be identified as IO blood.

- For optimal flow infuse with pressure
- Administer medications in same dose, rate and concentration as given via peripheral IV



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### Infusions

As with other vascular access lines, IO access flow rates will vary among patients and anatomical sites. Generally, the proximal humerus allows higher flow rates than tibial sites. Adequate flow rates are dependent on performing a rapid flush (syringe bolus) prior to IO infusion and infusing fluids and medications under pressure (e.g. infusion pressure pump or pressure bag). Gravity alone will rarely generate adequate flow rates.

Pressure is the rate-limiting factor in achieving adequate flow rates in IO infusions; the higher the pressure, the greater the flow rate. Many infusion pumps (including rapid infusers such as the Level 1®) are designed to administer large amounts of fluid very rapidly, but often work by measuring volume rather than infusion pressure. If adequate IO flow rates cannot be achieved with an infusion pump, a pressure bag should be considered.

### Medications

Virtually any medication that can be given via a peripheral IV can be given via the IO route using the same dose, rate and concentration. Verify placement/patency prior to all infusions. Use caution when infusing hypertonic solutions, chemotherapeutic agents, or vesicant drugs. Follow medication administration with a flush.

Prime extension set with 2% lidocaine (IV lidocaine)

Slowly infuse initial dose over 120 seconds

Allow lidocaine to dwell in IO space 60 seconds

Flush with normal saline

Slowly infuse 1/2 of initial dose over 60 seconds

Observe cautions/contraindications for lidocaine, confirm dose per institution **Teleflex**  
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For patients able to perceive pain, there can be significant discomfort associated with the initial flush as well as infusion. Pressure changes occur within the bone as a result of infusion of medications and fluids, and if not properly anesthetized, pain associated with IO infusion under pressure is often severe. Anesthetizing the IO space prior to the initial flush should be considered for any patient who is conscious/alert to pain. If time constraints do not permit anesthetization prior to the initial flush, pain management should be considered as soon as time permits, and as needed throughout the course of IO infusion.

**Recommended anesthetic for adult patients responsive to pain:**

Observe recommended cautions/contraindications to using 2% preservative and epinephrine free lidocaine (intravenous lidocaine)

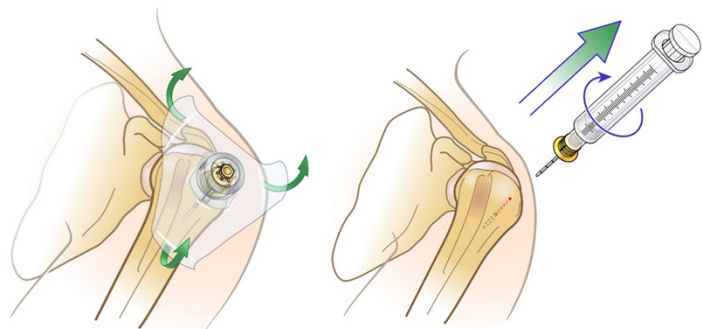
Confirm lidocaine dose per institutional protocol

1. Prime extension set with lidocaine *Note that the priming volume of the EZ-Connect® Extension Set is approximately 1.0 mL*
2. Slowly infuse lidocaine 40 mg IO over 120 seconds THEN allow lidocaine to dwell in IO space 60 seconds
3. Flush with 5-10 mL of normal saline
4. Slowly administer an additional 20 mg of lidocaine IO over 60 seconds AND repeat PRN

Consider systemic pain control for patients not responding to IO lidocaine

For additional information, please visit [www.eziocomfort.com](http://www.eziocomfort.com)

- Assess frequently to ensure:
  - Wrist band is on patient
  - No evidence of complications
    - Catheter is intact/patent
    - No evidence of infiltration/extravasation
  - Dressing & connections are secure
  - Repeat flush as needed
  - Need for initial or additional lidocaine
- Removal



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Care and maintenance of the IO catheter is similar to other venous access routes. Ensure the site is intact and catheter is securely in place, connections are secure and dressing is clean, dry & intact.

Confirm catheter patency/placement prior to and throughout medication and fluid administration.

Repeat a rapid normal saline flush as needed

Monitor frequently for evidence of complications.

Infiltration/extravasation is the most common complication associated with IO insertion, and can lead to serious complications such as compartment syndrome and necrosis. The catheter insertion site and posterior compartments (depending on insertion site) should be monitored frequently for any signs of infiltration/extravasation, localized inflammation, limb perfusion or dislodgement. As with any line, manipulation and patient transport are critical times for ensuring patency remains intact.

Assess patient comfort and manage infusion related pain.

Consider adding an IO documentation template to your computer charting.

The catheter may remain in place up to 24 hours and is not MRI compatible.

- Clean per your institution's protocol or Instructions for Use
  - Check to ensure nothing has attached to the magnetic tip
- Inspect driver and return to case or replace trigger guard
- Do NOT submerge or autoclave driver!



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Drivers are sealed and not intended to be opened. Batteries are not replaceable.

The driver is manufactured using a non-porous, fluid-resistant, medical-grade plastic covering; however, it is not fluid-proof. For cleaning purposes, the driver should *never be submerged* in any cleaning solution. Follow the driver's Instructions for Use when cleaning. Check to ensure that nothing has attached to the magnetic tip. If NOT storing driver in case, the trigger guard may be placed to secure the trigger from accidental discharge/battery waste. The red battery indicator light will illuminate when approximately 10% of battery life remains.

If your clinical environment requires sterilization, the driver can be sterilized using the STERRAD® 100S, NX Standard cycle, and 100NX Standard cycle.

Refer to the Instructions For Use (IFU) for more detailed information.