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Techniques and Procedures

Ring Removal: A Comprehensive Review of Techniques

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□ **Abstract—Background: Entrapped rings can be dangerous, leading to increased pressure and damage to soft tissue, nerves, and vasculature. In order to properly care for these injuries, it is important for emergency medicine clinicians to be aware of the different approaches to remove entrapped rings. Methods: We searched PubMed to determine the different techniques and supporting literature for ring removal. Discussion: There are a number of approaches that can be used to remove an entrapped ring. Clinicians should first consider the role of lubricants to reduce surface tension. Specific removal techniques include compression-based methods, traction-based techniques, rotation-based approaches, and the use of ring-cutting devices. There are unique advantages and limitations of each technique that are important to consider. Conclusions: Emergency medicine clinicians need to be familiar with several different approaches to ring removal. This article summarizes the key techniques, variations on these techniques, advantages, and disadvantages for each approach. © 2022 Published by Elsevier Inc.**

□ **Keywords—Ring removal; Caterpillar technique; String; Compression; Ring cutter**

Introduction

Patients commonly present to the emergency department (ED) for entrapped rings, which they are unable to remove from their digits. Ring entrapment can decrease venous and lymphatic drainage, leading to edema and pain. If the ring is not removed swiftly, the edema will worsen, which can cause injuries to the tissue, vasculature, and nerves. When evaluating patients with ring entrapment, it is important to ascertain how long the ring has been entrapped and what materials the ring is made from (as this can impact the selection of ring-cutting devices). On physical examination, the clinician should evaluate for signs of distal ischemia, which can include white or blue discoloration, mottling, delayed or absent capillary refill, and pain out of proportion. In cases associated with trauma, an x-ray should also be considered to evaluate for an underlying fracture or dislocation, particularly when significant edema and bruising are present.

Entrapped ring removal is a common procedure performed in the ED. However, there are a number of different techniques, and each has unique benefits and limitations that are critical for the emergency medicine clinician to be aware of. This article seeks to summarize the existing data regarding ring removal techniques for the practicing clinician.

Methods

We searched PubMed for articles using a combination of the keywords "ring" and "removal," as well as individual targeted searches of each of the identified techniques. The search was conducted from the database inception to November 27, 2021. There were no language restrictions. Studies were selected for inclusion on the basis of the perceived relevance as determined by the authors, with an emphasis on identifying all major ring removal techniques

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and variations. When available, systematic reviews and meta-analyses were preferentially selected. These were followed sequentially by randomized controlled trials, prospective studies, retrospective studies, case reports, and other narrative reviews when alternate data were not available. A total of 45 articles were selected for inclusion in this narrative review.

Discussion

Role of Lubricants

Surface tension can pose a significant issue with ring removal. The role of lubricants in ring removal has been described for decades as an adjunctive component of multiple techniques to reduce friction between the ring and involved digit (1). An array of lubrication materials is often readily available in EDs, including petroleum jelly, soap, and surgical lubricant, the latter of which is also sterile and bacteriostatic (2,3).

Another approach that has been well-known to jewelers (but is less commonly used in the hospital setting) is Windex®. This is often readily available via environmental services personnel and has a unique advantage over other agents due to the inclusion of several ingredients with surfactant properties (e.g., 2-hexoxyethanol, lauryl dimethyl amine oxide, and sodium dodecylbenzene sulfonate) (4). These surfactants help to surround and remove dirt particles and residue on both the surface of the ring and skin to reduce friction more than traditional lubricants. Although there are no published studies comparing the use of Windex® with other lubricants, the authors have successfully used this in cases refractory to traditional techniques in over a dozen instances with no treatment failures or complications.

Although lubricants can reduce surface tension and facilitate removal, they can also make it more difficult to maintain a grip on the ring. Therefore, we recommend using a permeable material with a strong grip (e.g., gauze) to help hold traction on the ring (Figure 1) (5). Surgical gloves may also be considered to provide enhanced traction compared with traditional latex gloves.

Figure 1. Use of gauze to facilitate removal of the ring after application of lubricant.

Compression-Based Methods

The compression-based method involves reducing distal swelling via several methods and may be combined with other techniques that follow. For this technique, the clinician will wrap an elastic object over the distal finger in order to reduce the swelling and facilitate removal. Advantages of this technique are that it can remove the ring without damaging it and can be performed easily with minimal supplies (Table 1) (6). However, the initial compression can be painful and may require analgesia.

Table 1. Compression Technique (6).

Step	Description
Step 1	Wrap a long piece of 1-inch-wide elastic tape around the finger in a distal-to-proximal direction. Consider using several layers to enhance the compressive force.
Step 2	Elevate the patient's hand above the shoulder and wrap with ice pack
Step 3	Wait 10–15 min
Step 4	Unwrap the finger and attempt removal.
Step 5	Repeat steps 1–4 as needed

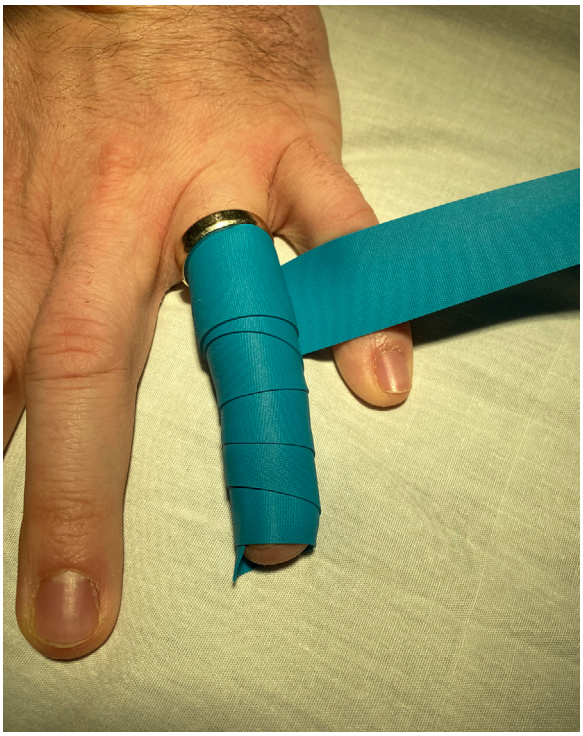

Figure 2. Compression technique using a rubber tourniquet wrapped around the finger.

Several variations to this technique are described in the literature. A rubber tourniquet (typically used for peripheral intravenous line placement) can be used instead of the elastic band, wrapped distal to proximal, and then clamped to itself with a hemostat so the clinician does not have to hold it in place (Figure 2). This technique was reported to be successful in more than 250 cases with only one failure, which was due in part to an enlarged arthritic proximal interphalangeal joint in an older adult patient (7). Other variations have included the use of a Penrose drain and an elastic bandage, two Penrose drains with one wrapped tightly from the tip of the finger proximally and a second wrapped from the proximal interphalangeal joint to the ring, or a self-adhesive bandage (8–10). Another modification describes placing a blood pressure cuff on the patient's forearm and inflating it to 250 mm Hg after removal of the elastic compression device in order to prevent blood from refilling the finger (6). Although these modifications have mostly been limited to case reports and small case series, all have reported successful removal without complications.

Traction-Based Techniques

Caterpillar technique

The caterpillar technique was first described by St. Laurent in 2006 (11). This technique emphasizes using a structured, stepwise approach to axial traction rather than merely pulling the ring distally. This allows the clinician to slowly walk the ring off the finger by alternating areas of pressure and contact (Figure 3, Table 2).

In the original description, St. Laurent reported that this had been highly successful during a 10-year period, but did not provide any specific numbers or data (11). To our knowledge, there have been no other studies evaluating the success of this specific technique. Advantages of this approach are that it is easy to perform and does not require any equipment or supplies. In addition, this approach can be combined with other techniques to facilitate removal. A disadvantage of this technique is that it can be challenging to perform with very edematous fingers.

String pull method

The string pull method was first described by Mizrahi and Lunski in 1986, and was subsequently described by several other authors (12–17). This technique is proposed to work primarily by stabilizing the ring with the strings to reduce backwards and lateral translocation during the removal attempt (Figure 4, Table 3).

Table 2. Caterpillar Technique (11).

Step	Description
Step 1	Apply lubricant to the entire ring and finger.
Step 2	Push the ring in a dorsal direction.
Step 3	While maintaining the upward pressure, swing the top portion of the ring distally.
Step 4	Release the pressure while keeping the top portion of the ring angled distally.
Step 5	Push the ring in a palmar direction.
Step 6	While maintaining downward pressure, swing the bottom portion of the ring distally.
Step 7	Repeat steps 2–6 until the ring is removed.

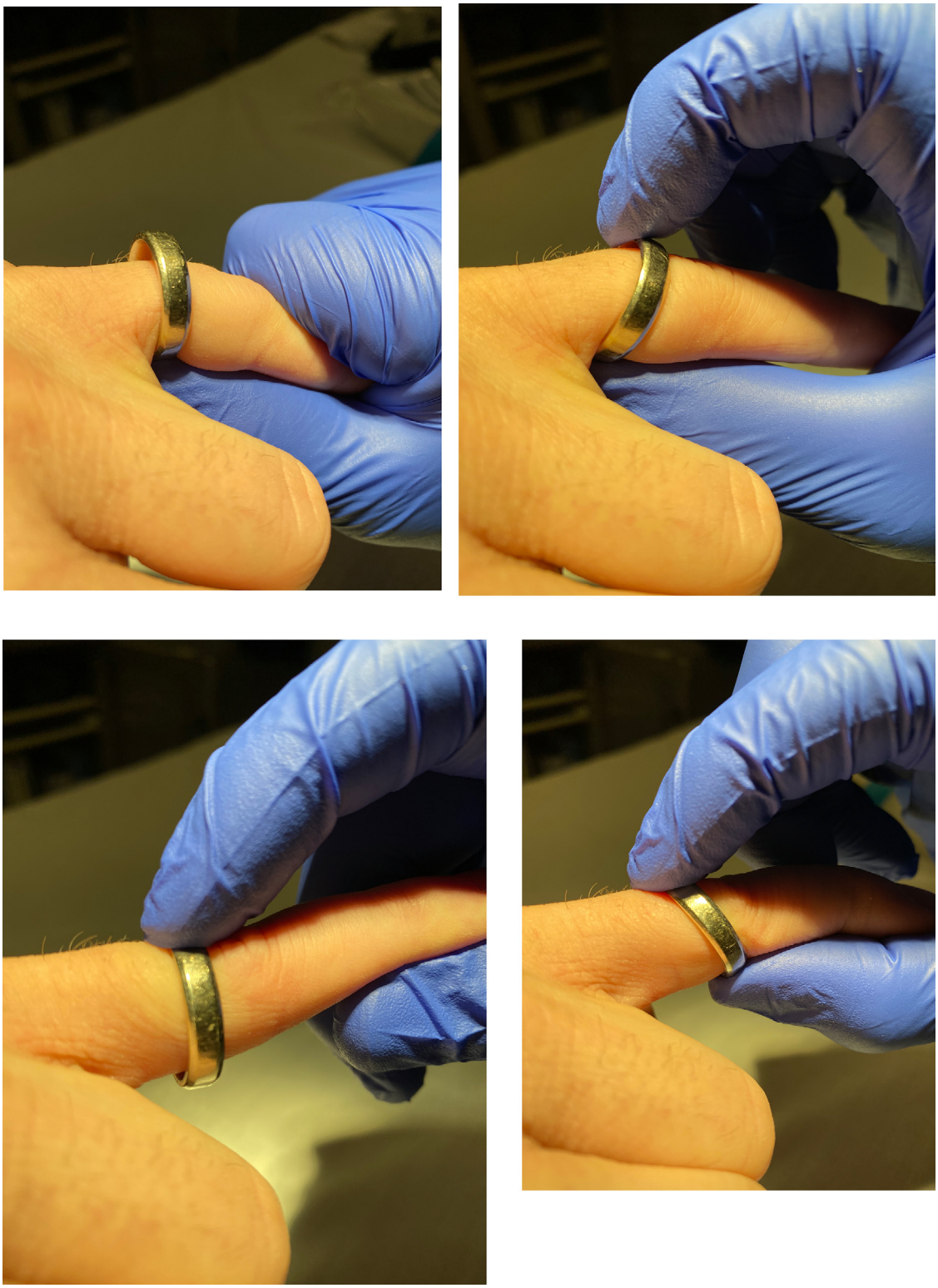

Figure 3. Caterpillar technique. (A) Push the ring in a dorsal direction. (B) Swing the top portion of the ring distally. (C) Push the ring in a volar direction. (D) Swing the bottom portion of the ring distally.

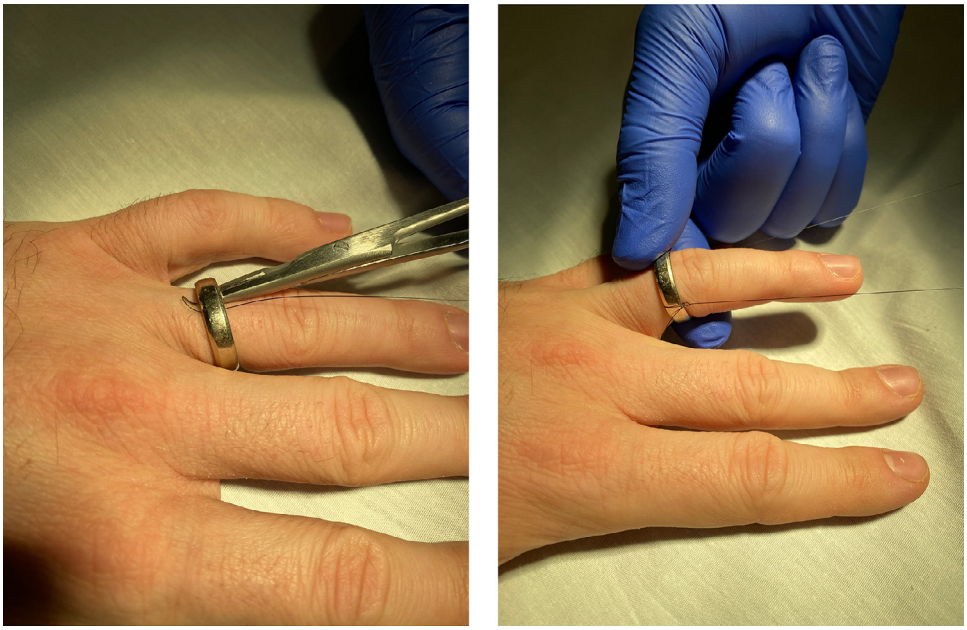

Figure 4. String pull method. (A) Advance the needle backwards to pass the string under the ring. (B) Repeat on the opposite side. Tie both sutures in place. Then apply moderate traction on the sutures to stabilize the ring while manually removing the ring.

Table 3. String Pull Technique (12,13).

Step	Description
Step 1	Select a strong suture with good grip (e.g., 2–0 or 3–0 silk or nylon).
Step 2	Advance the needle backwards (to reduce the risk of injury to the patient's finger) along the medial aspect of the ring between the ring and finger.
Step 3	Tie the suture to create a firm knot.
Step 4	Repeat steps 2 and 3 on the lateral aspect of the ring.
Step 5	Have an assistant apply moderate traction (approximately 5–8 pounds of pressure) to both sutures with their hands or a hemostat.
Step 6	While an assistant maintains the traction, the clinician uses their thumb and forefinger as a fulcrum to slowly remove the ring. This may take up to 1 min to complete.

In the original report, Mizrahi and Lunski reported a 100% success rate without any complications among 32 cases (12). Advantages of this technique include that the materials are easily available in most EDs and many outpatient settings. However, it is important to be careful with the needle to avoid injury to the patient or clinician.

There have been a number of modifications to this technique over time. Burbridge and Ritter proposed combining the string pull method with the caterpillar technique of alternating dorsal and palmar traction to walk the ring off of the finger (13). Another modification described the same approach but with eight strings (instead of two) to further reduce ring translocation (15). In contrast, de Silva and Sritharan suggested that the ring be rotated back and forth while applying greater force via axial traction on the strings to help facilitate removal (rather than using the strings to merely stabilize the ring) (14). They reported three successful removals without complication using that technique (14). Others have described using a paperclip, dental floss, or rubber bands as traction devices when sutures are not available (16,17). The rubber band approach (using two rubber bands at the medial and lateral position) was found to have a 92.5% success rate (62 of 69 patients) with a mean time to removal of 10.7 seconds (Figure 5) (17).

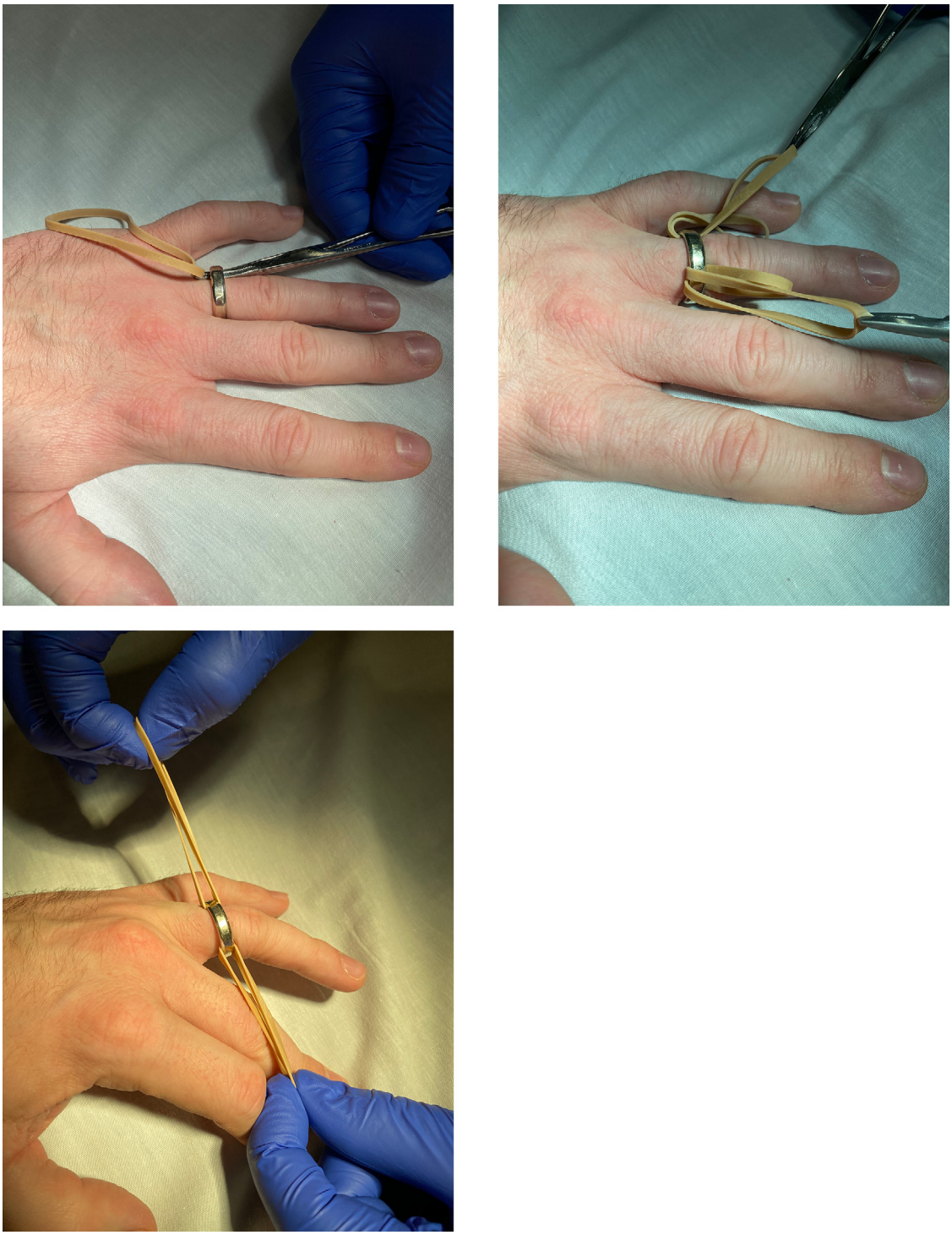

Figure 5. Rubber band method. (A) Pull the rubber band though the ring using a hemostat or forceps. (B) Repeat this on the opposite side. (C) Apply traction in opposite directions to stabilize the ring while manually removing the ring.

Surgical glove technique

The surgical glove technique was first described by Clarke and Spencer in 1991 (18). With this technique, the glove provides mild compression, while serving as a leading edge to guide the ring over the tissues (Figure 6, Table 4). This technique is ideal for those with soft-tissue injury (19).

In the original report, Clarke and Spencer reported successful removal in three cases (18). Inoue et al. reported five successful removals among those with failure of the

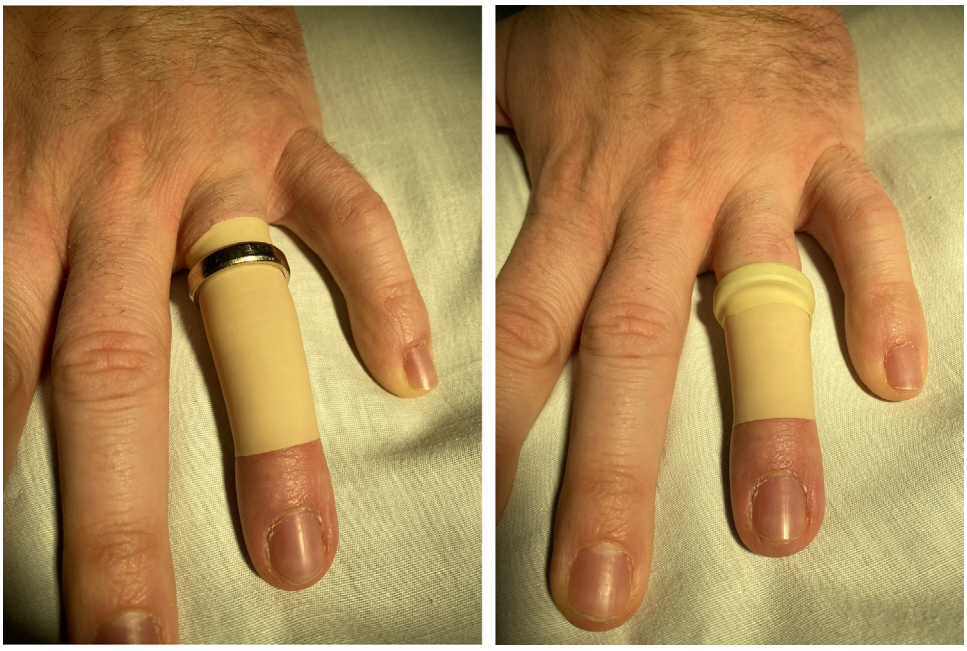

Figure 6. Surgical glove technique. (A) Place the cut piece of a glove between the finger and ring. (B) Pull the proximal portion of the glove distally, advancing the ring alongside it.

Table 4. Surgical Glove Technique (18,19).

Step	Description
Step 1	Cut the finger from an appropriately sized glove. Make sure the glove fits snugly. Use the patient's other hand to determine the glove size.
Step 2	Cut the tip of the glove finger to create a cylinder.
Step 3	Place the cut piece of glove distal to the ring and slide it underneath the ring using a hemostat.
Step 4	Apply lubricant to the glove finger and the ring.
Step 5	Pull the proximal portion of the glove finger distally with a hemostat, thereby advancing the ring distally along with it.
Step 6	The ring can be rotated back and forth to reduce surface tension.

string wrap technique, and Stromps et al described a case report of successful removal in a 7-year-old with an ischemic finger (19,20). The advantages of this technique are that it can protect soft-tissue injuries during removal and that gloves are readily available in most clinical settings. The major disadvantage is that it can be difficult to advance the glove between the finger and ring in very edematous cases. If a surgical glove is not available, a tight-fitting regular glove or plastic wrap may be considered as an alternative.

Rotation-Based Methods

Rotation-based methods have been described in the literature dating back to 1940, with the first reports using simple thread, such as twine (21). Other materials, such as surgical suture, nylon tape, a venipuncture tourniquet, gauze, umbilical tape, an oxygen mask strap, and Coban wraps have also been reported for this method (6,7,22–27). Regardless of the specific material used to wrap the finger, they all involve the same general technique (Figure 7, Table 5). This technique involves using compression to displace edema away from the site of ring entrapment, followed by unwinding the string that propels the ring distally while reducing surface tension (28). This method is ring-preserving and can be performed with any number of items available in most EDs.

Mizrahi et al. used this technique successfully on 32 patients without complications using a 1–0 suture (12). Other reports have described successful ring removal

Table 5. Rotation-Based Technique (1,12,21,22,27,29).

Step	Description
Step 1	Pass the string underneath the ring with aid of lubricant or forceps. Maintain the string in place with manual traction or clamp.
Step 2	Wrap the finger tightly from the proximal-to-distal direction at least one level beyond the proximal interphalangeal joint. Depending on the clinical scenario, wrapping in a distal-to-proximal direction may also be acceptable.
Step 3	Apply lubricant over the wrapped finger. Using the proximal tail as a lever, gently pull and unwind the proximal end of the string that was passed under the ring, advancing distally towards the tip of the finger.
Step 4	Continue to unwind and advance while the ring is propelled towards the distal tip until complete removal.

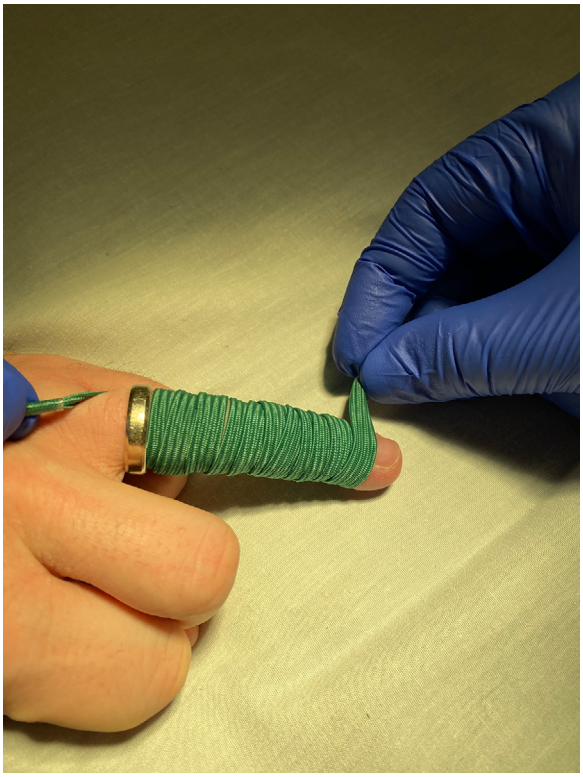

Figure 7. Rotation-based technique. Wrap the finger from the proximal-to-distal direction. Using the proximal portion as a lever, unwind the proximal aspect until the ring is removed.

without complications using ribbon gauze, nylon tape, umbilical tape, and Coban wrap (23–25,27). Of note, this technique should be avoided if there is a concomitant soft-tissue or bony injury to the finger (1). This technique may also prove difficult among patients with hypertrophied proximal interphalangeal joints (7). Passing the chosen form of string underneath the ring can also be challenging if there is significant edema or skin overgrowth. In these cases, it may be helpful to lubricate the ring entrapment site and use tools such as forceps, a hemostat, or a suture needle to facilitate string passage. In one case, a paperclip was even used to guide passage (23).

The specific direction of wrapping remains controversial. Some reports describe wrapping the finger in the proximal-to-distal direction, and others describe wrapping in the distal-to-proximal direction (1,2,6,12,21,22,23,27,29). To date, there are no data as to whether directionality confers a difference in success rate with this technique. In patients with significant distal edema, it may be more practical to wind in the distal-to-proximal direction. This could theoretically avoid pushing the edema into the terminal end of the digit, where resistance is more likely to be met, and instead displace the edema underneath the ring and into the larger reservoir of the hand. However, when the ring is severely impacted, proximal-to-distal wrapping may be needed if there is insufficient available space underneath the ring to displace the edema proximally.

There are a number of modifications to this technique in the literature. Most of them involve combining the string wrapping technique with a compressive technique using a more elastic and wider substance than a standard piece of string, suture, or dental floss. The rationale behind these modifications is that by first using a compressive technique, you displace the edema away from the site of the constricting band, thus allowing for easier passage of the string under the ring to facilitate removal. The only additional step in the modified techniques is to wait and allow 5–10 min of compression after wrapping for edema reduction before unwinding. The wider, compression-augmented modifications also speed up the process and may be more practical than the original string and suture techniques, as it could take up to 6 feet of string the size of a suture (or 100 turns) to wrap the average digit (6).

Table 6. Manual Ring-Cutter Removal (29).

Step	Description
Step 1	Pass the device's safety lever underneath the ring to protect the digit from blade injury.
Step 2	Hold the handle of the device with one hand, while using the other hand to twist the thumbscrew to cut through the ring.
Step 3	Once the ring is divided, use fingers or clamps to open the ring laterally. If unable, make a second division on the opposite side of the ring.
Step 4	Assess the digit for injury and foreign bodies.

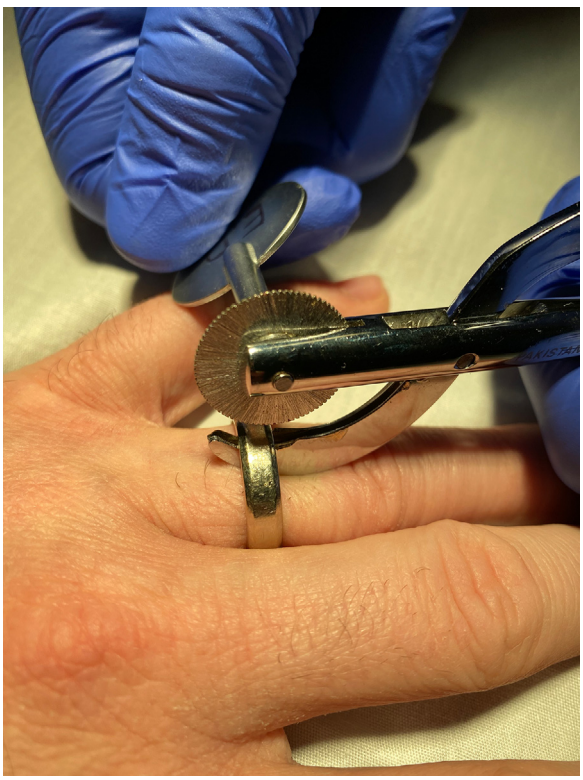

Figure 8. Manual ring-cutting device. Pass the safety lever underneath the ring. Hold the handle with one hand, while using the other hand to twist the thumbscrew to cut through the ring.

Ring-Cutting Devices

Although it is best to avoid destroying the ring when feasible, ring-cutting devices are the preferred method in patients with fractures, open wounds, arthritic fingers, or signs of neurovascular compromise requiring rapid ring removal (29). The hand-powered ring cutter is a simple to use tool commonly found in most EDs (Figure 8, Table 6). Most manual and electric ring-cutting devices involve a protective metal "spatula" or finger guard that slides underneath the ring to protect the finger from blade injury after severing the ring to relieve the constriction. If the edema is too significant to allow the spatula between the finger and ring, pincer pliers could be used to pull the ring in opposite directions, thereby converting it to an oval shape and creating space for the spatula to fit (30). Destructive removal of a constricting band with a ring cutter has been described in the literature dating back to at least the 1970s (31).

The primary advantage to ring-cutting methods is that they are rapid and highly successful for most rings. However, thermal injury and lacerations have been reported with these ring-destructive methods, particularly with crushing and electric tool–based techniques, as these generate more heat and can create shrapnel, which can be particularly problematic in patients with open wounds (29). One case report describes a foreign-body granuloma and synovitis that developed from metallic debris in a nearby wound after ring removal with a saw-based ring remover (32). Finally, it is important to consider the cost and sentimental value of the ring to the patient. This should be taken into consideration in patients without neurovascular compromise or injury when deciding on a removal method.

If electric hand saws or drill-based tools are being used to remove the ring, then the finger and ring must be kept wet while cutting to dissipate heat and prevent thermal injury. One case report described an iatrogenic third-degree burn requiring skin grafting that occurred secondary to removal of a titanium ring using a diamond cutter (33). Some saws include a protective cooling gel that can be applied (34). If that is not available, another technique involves sliding wet gauze underneath the ring while providing constant saline irrigation when cutting is performed (35,36). At a minimum, sawing should be limited to 30-s intervals with cold water irrigation before cutting and in between intervals (34). It is important to wear appropriate personal protective equipment when using these tools for removal (e.g., glasses and gloves) to protect from shrapnel and to remove all flammable materials from the sawing area to prevent combustion from sparks. Little force is needed by the operator when using

these devices. The Dremel saw, an electric handheld saw, was used successfully to remove constricting bands from inflated plastic gloves in 118 of 124 cases. This included 46 of 50 steel rings and 50 of 50 copper rings (37). This tool has also been used successfully to remove a riveted metallic nut and constricting steel ring, as well as a constricting ring crafted from a hardened steel ball bearing (38,39).

Many tools have been used successfully in the literature for destructive ring removal. In general, the material the ring is made of should inform tool choice. Simple hand or motorized ring cutters are useful for rings made of softer metals, such as silver, copper, and gold, but are generally unable to cut rings made of harder materials, such as steel, tungsten carbide, or titanium (29). The ring-cutter attachment on the Leatherman Raptor® Trauma Shears was noted to be able to successfully remove both steel and silver rings faster and with greater operator comfort compared with a motorized diamond disk cutter (40). Bolt cutters may be successful against some harder metals, but will not be effective against tungsten carbide (41). Tungsten carbide is 8.5–9.0 on the Mohs Hardness Scale (for reference, titanium is 6.0 and gold/silver are 2.5–3.0) (25). It is, however, a common misconception that tungsten carbide rings are "indestructible." The most commonly cited approach in the literature takes advantage of the low flexibility and brittle characteristics of tungsten carbide by using a "crush" technique with locking pliers. This technique is performed by firmly locking the pliers in place on the ring. Then, opening and removing them, tightening the locking screw by one half-turn and closing them back in the same position on the ring. This is repeated with successive half-turns of the locking screw until the ring shatters (41). This was reported to successfully remove tungsten carbide rings on six of six cadaveric subjects, with two having < 1-mm lacerations and one with local debris noted (41). This same method was shown to have a 100% success rate (10 of 10) on medical simulation manikins without injury and was significantly faster than the rotation-based method (24). Compared with the rotation-based removal method using umbilical tape, the locking plier crush method was significantly faster, with a mean removal time of 23.1 s compared with 135.4 s using the string method (25). There is one case report showing success in removing a tungsten carbide ring on a live patient using a locking plier without shrapnel or finger injury in approximately 30 s (42).

Dental drills have also been reported to be successful in difficult ring removal cases, particularly in rings made of harder metals, such as titanium or tungsten carbide. These tools are feasible to use in an ED with an in-house or affiliated dental institution. In one case, an electric dental saw with a diamond-edged grinding disc and a steel spatula was used to remove a ring made from an unknown metal in minutes by dividing the ring in two on opposite sides (35). Another case involved successful removal of a titanium ring in the ED in 15 min without complication or injury using a dental micromotor saw with a silicon carbide disc obtained from the maxillofacial department (36). A diamond-tipped dental drill has even been used in the ED to successfully remove a ring made of tungsten carbide without injury or complication (43). Others have reported successful removal of titanium rings with diamond-tipped traditional drill blades after other destructive methods (including an electric ring cutter) have failed (44,45). Potential disadvantages of these techniques are that some of the described tools, such as dental drills and electric hand saws, are expensive, may not be easily accessible in the ED, and require instruction regarding proper use.

Summary

There are multiple techniques for removing entrapped rings, with unique benefits and disadvantages to each type of approach. We recommend using a lubricant to facilitate removal, which can include traditional surgical lubricants or Windex® if available. When there is significant edema, compression should be applied, with sufficient time allotted for the swelling to reduce. If this technique is unsuccessful, then a traction-based or rotation-based method should be used. When these techniques are unsuccessful or there is concern for ischemia or neurovascular injury, a ring cutter should be used. By understanding multiple approaches and the unique benefits and limitations of each, the emergency medicine clinician can ensure the best likelihood of success with ring removal.

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