Battlefield Management of Facial Fractures Using Minnie Ties

An Innovative Technique for Maxillomandibular Fixation

*Joseph W. Ivory, DDS[1]; Andrew C. Jenzer, DDS[2]**

ABSTRACT

Application of maxillomandibular fixation (MMF) for the treatment of jaw fractures has a long history stretching back thousands of years. Modern methods of MMF require extensive training for correct application and are often not practical to perform in a forward operating environment. Most MMF methods carry inherent risks of sharps injuries and exposure to bloodborne pathogens. The authors present a method of MMF with Minnie Ties, which are simple, effective, and much safer than traditional methods of MMF.

KEYWORDS: *facial bones; facial injuries; mandible fractures; maxilla fractures; jaw fractures; military dentistry; oral surgery*

Introduction

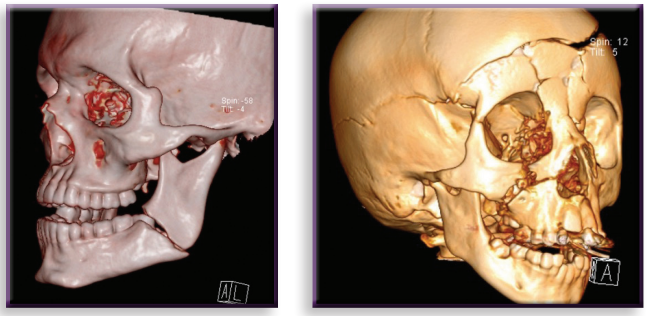
Craniomaxillofacial (CMF) trauma represents a large amount of trauma seen on the battlefield and in a wartime setting. A large retrospective studying looking at all injuries between 2001 and 2007 to Servicemembers in support of Operation Enduring Freedom and Operation Iraqi Freedom identified 2,014 CMF injuries out of the 7,770 battlefield injuries reported to the Joint Theater Trauma Registry.[1] Of the 2,014 CMF injuries, 27% were facial fractures.[1] Numerous other studies have described the prevalence of facial injuries dating back to World War II, with a historical average of 16–21% of battlefield injuries.[2,3] The increasing incidence of CMF injuries is considered by many to be a result of higher survivability due to better equipment and armor, faster and improving medical care with decreased evacuation times, more effective trauma management techniques, and increased prevalence of improvised explosive devices.[4,5]

As the US military has transitioned to lower intensity conflicts over the last decade, and considering the operation scope of Special Operations medicine, identification and stabilization treatment of facial fractures are real and necessary skills for the Special Operations Forces (SOF) medical provider. SOF medical personnel are often required to treat traumatic injuries on local national, foreign military, and US national military personnel with limited capability of evacuation to higher levels of care.

When facial fractures occur, either as an isolated injury or in conjunction with other injuries, it is necessary to immobilize, and possibly temporarily reduce, these fractures. Fractures to the bones of the jaws, namely the maxilla and mandible, are where this technique focuses (Figure 1). Fractures to other bony structures, like the skull, orbits, and nose, must be managed in a setting with a higher level of care (Figure 2), but immobilizing the maxilla and mandible, commonly called MMF is a critical skill. The purpose of this technique paper is to describe and explain a new, easy, and safe technique to accomplish MMF.

FIGURE 1 (LEFT) *Reconstructed 3D CT scan demonstrating a right mandibular displaced angle fracture.*

FIGURE 2 (RIGHT) *Reconstructed 3D CT scan demonstrating a complex panfacial fracture on a pediatric patient.*



Historical Context

The evolution of the treatment of mandibular fractures can be traced through history, with the first mention of the treatment of simple mandibular fractures in the Edwin Smith papyrus dated around 1600 BC.[6] Hippocrates, considered the father of modern medicine, seemed to be the first to recognize the importance of immobilization to allow bones to heal. He advocated wiring together adjacent teeth (the bridle wire technique) and the use of bandages to immobilize the jaw in 460 AD.[7] His approach was echoed by the Roman encyclopedist Celsus, who also instructed patients to stick to a liquid diet and refrain from speech. Various cultures throughout the centuries experimented with a combination of bandages and wires to immobilize the fractured mandible, including the Sushruta Samhita of India (500 AD) and the barbers of medieval Europe, who essentially duplicated the technique of Hippocrates.

The 18th century saw the advent of the use of various splints that were tied to the patient's teeth, using the dentition to stabilize the bony segments. This was a departure from the principle of MMF articulated by Hippocrates and was met with various degrees of success. The next major advancements were seen in the 19th century, to include the precursor to the

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modern arch bar, wire osteosynthesis of fractured bones, and return to the concept of MMF championed by Thomas Gilmer in 1887.[8] Angle, one of the fathers of modern dentistry, developed a method of MMF by which fractures were reduced by placing bands around teeth adjacent to a fracture and wiring them together, then wiring the jaws shut by placing bands on the opposing dentition and wiring the jaws together for immobilization.

What these pioneers in CMF trauma understood was that for bones to heal, they must be first reduced to their anatomic position and then immobilized. Stabilization of jaw fractures reduces the bony fracture and prevents it from moving, which decreases pain, minimizes damage from continued function, and stabilizes the patient until they can get to a higher level of care. Failure to stabilize jaw fractures was recognized to be a source of long-term health problems, malunion or nonunion, potential infection, and even death. Many of the techniques developed over the past few centuries have been discarded, but many have been further developed and remain to this day.

Current Therapies of MMF

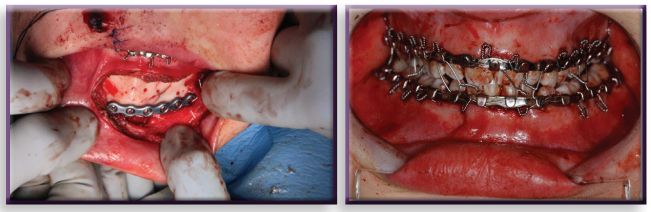
While modern fixation techniques using plates have largely replaced a reliance on MMF to definitively treat mandibular fractures, MMF remains a mainstay of reestablishing the occlusion prior to placement of plates and, in some cases, remains the definitive treatment of choice for some types of fractures, such as high subcondylar fractures (Figure 3). Stabilizing the jaw bones is a difficult task, even in a controlled setting like the operating room. It is dictated by the teeth and the patient's occlusion—that is the relationship of the top teeth and bottom teeth and how they come together. There can be confounding factors that can make this even more difficult, like missing teeth, periodontal disease resulting in tooth mobility, and the presence of multiple fractures. In general, all these techniques use some combination of wires, screws, or rubber bands to immobilize the teeth and thus the keep the jaws shut, and all of these techniques are developments of techniques developed by health care providers of the past.

The gold standard technique and a main stay in the armamentarium of any head and neck surgeon is Erich arch bars, simply called arch bars. Arch bars are a set of prefabricated metal braces that are adapted to both the top maxillary teeth and the bottom mandibular teeth and then tied into all the teeth using wires. Then, wires are used to tie together the metal braces, providing MMF and immobilizing the teeth and jaws (Figure 4). This technique is the gold standard because it allows for full control of teeth and fractures, is excellent when multiple fractures are present that require piecing segments back together, and controls the bite after surgery. It can also be left in place for 6–8 weeks for closed reductions that do not require opening and plating, allowing the bones to heal in their anatomic position without movement.

The disadvantage of using arch bars is that they are technique sensitive and time consuming and require extensive training to be done properly. Even with two experienced surgeons in the controlled environment of an operating room, arch bars typically take 30–60 minutes to apply.[9] Comminution of the fractures (multiple pieces), poor dentition, and inexperienced operators can make this time even longer. Doing it without general anesthesia is even more difficult as it requires essentially anesthetizing the entire gingiva (gums) in the mouth as

FIGURE 3 (LEFT) *Exposed mandible fracture that has been reduced and plated, maxillomandibular fixation was achieved with arch bars prior to plating the fracture.*

FIGURE 4 (RIGHT) *Intraoral photo of the arch bar technique and wired together to achieve maxillomandibular fixation.*

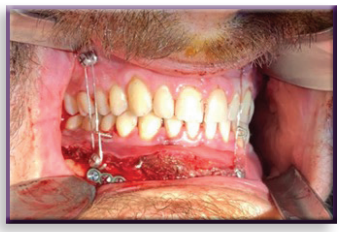


sharp wires are passed between most of the teeth. Even with profound local anesthesia, it results in significant patient discomfort and bleeding from lacerated gingiva, making it a very difficult technique to use in any type of forward environment and without extensive training. It also exposes the operating provider to the possibility of multiple sharps injuries and exposure to blood borne pathogens.[10]

Several other techniques are commonly used to achieve MMF. Interdental wiring is a technique where a large wire is passed between several teeth and tightened down. This is generally used as a very brief way to achieve MMF under ideal circumstances (isolated fractures, minimal displacement, a full dentition with excellent occlusion). Ivy loops are another older technique that involves making detailed wire loops, attaching them to several teeth to serve as an anchor, and then wiring together loops on the top and bottom jaws. It is a difficult and technique sensitive method that is not commonly used, even among surgeons.[11,12]

There are some newer methods of MMF. MMF screws are a system where multiple screws are put into the maxilla and mandible and then wired together (Figure 5). While useful in an operating room by an experienced surgeon, it is also technique sensitive and frankly requires a detailed understanding of the anatomy of the mandible and maxilla, which is typically relegated to CMF surgeons. Without extensive knowledge, serious damage can be done with the screws to teeth, various nerves, and blood vessels. MMF screws are also prone to loosening over time, particularly in the maxilla, making long-term MMF problematic using this technique.[13] Hybrid, or bone-supported, arch bars are made by several companies and are essentially a mix of arch bars but, instead of being wired to the teeth, are screwed into the bone, then tied together with wire. This system, while faster than Erich arch bars, has the same limitations as other techniques which require the placement of screws into bone.[14,15] This brings us to our newer technique, using Minnie Ties to achieve MMF.

FIGURE 5 *Intraoral photo demonstrating maxillomandibular screw fixation. Two or more screws are placed into bone in each jaw and used to wire the jaws shut. The mandible fracture is seen and plate fixation in place.*



Minnie Tie Application and Technique

Minnie Ties are essentially an oral zip tie (Figure 6). Made by Invisian Medical in three sizes, with an FDA approval in 2017, each Minnie Tie is a braided polyester structure with a bonded polypropylene coating, a blunt metal introducer tip,

and a single self-locking clasp (Figure 7). It is approved and on-label therapy for establishing MMF for up to 3 weeks. The concept is simple, pass the blunt introducer between the upper teeth and lower teeth, then tighten (Figures 8 through 12). The self-locking clasp creates a one-way function, so it will not release or slip after tightened.

FIGURE 6 (LEFT) *Minnie Tie product demonstrating the three available sizes in diameters of 1.0, 0.7, and 0.5 mm.*

FIGURE 7 (RIGHT) *Self-locking clasp is only able to go one way, allowing it to tighten but never loosen.*

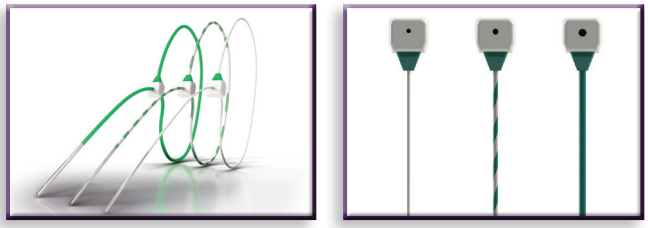


FIGURE 8 (LEFT) *The Minnie Tie is passed from the facial (buccal) side through the interproximal area between the teeth.*

FIGURE 9 (RIGHT) *Next, the Minnie Tie is passed between the lower teeth in a similar manner, from lingual to facial.*

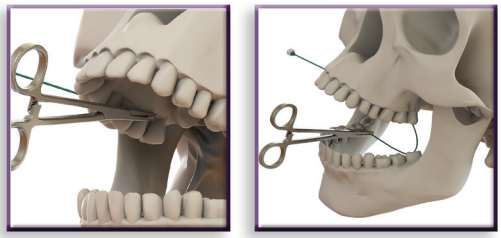
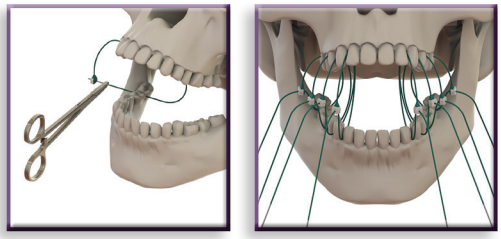


FIGURE 10 (LEFT) *The blunt metal introducer is then passed into the self-locking clasp.*

FIGURE 11 (RIGHT) *Once all are in place, placed from posterior to anterior, the tongue is verified to be out of the way of teeth (pushed back with an instrument if needed), the jaws held together into their proper relation, and the Minnie Ties tightened from anterior to posterior.*



To describe the process of application in more detail, the first step to see evaluate the fracture to see if it needs what is called a bridal wire reduction. This is simply a technique where traditionally a metal wire is passed on each side of the fracture, usually two teeth on each side, and tightened, which can help in reducing the fracture (Figure 13). This can be accomplished with a Minnie Tie as well and is generally recommended as it helps with the fracture and then the application of MMF (regardless of technique) (Figure 14).

For anesthesia considerations, if the patient is awake, one can try the technique without any anesthesia; there may be mild discomfort but it is often tolerated. If available, rinsing with viscous lidocaine prior to placement if a quick and effortless way to reduce the discomfort. If that patient cannot tolerate it, then injection of a local anesthetic into the gingiva at each site where a tie will be placed is recommended.

FIGURE 12 (LEFT) *Model with tightened Minnie Ties in place, placing the patient into maxillomandibular fixation.*

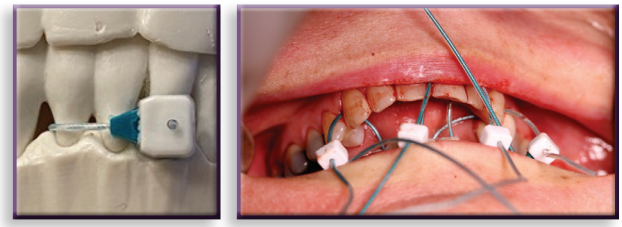
FIGURE 13 (RIGHT) *Mandible fracture with a bridal wire, securing two teeth on each side of the fracture, to help pull the fracture together and stabilize it, prior to maxillomandibular fixation.*

Next, starting in the posterior with the back teeth, the provider places six Minnie Ties, all left loose at this time. The provider passes the blunt metal introducer between two teeth, below the occlusal contact where the teeth touch, first on the maxillary teeth, then on the mandibular, as illustrated in the previous figures. The largest-size Minnie Tie should be used that fits between the teeth; the authors routinely use Minnie Ties and have found that most of the time the largest size is the best, because it is the strongest and fits between most teeth. The recommendation is for six Minnie Ties to be used for MMF, though the authors have used less. More Minnie Ties increase the strength of construct and are a sound idea, if possible, given limitations of the teeth and concomitant injuries.

Now, the provider has applied the Minnie Ties in a loose fashion (Figure 15). Next, the ties are tightened from the anterior to posterior (front teeth to back teeth). To facilitate this, the operating provider or team needs to do several things. First, use any instrument to push the tongue backward in the mouth to prevent it from getting caught between the teeth, easier on an awake patient but something that needs to be carefully checked on a patient with a decreased level of consciousness due to sedation, injury, or intubation. Second, we recommend, if more than one provider is present, to have someone hold the jaws together by standing at the head of the patient and using both hands to pull the lower jaw into full contact with the top jaw and hold this in place. This typically requires some force and is a similar technique to a two-handed mask ventilation, cupping the mandible with all fingers spread out to ensure both the front and back teeth are seated, and holding the jaws together while another provider tightens down the Minnie Ties.

FIGURE 14 (LEFT) *Similar bridal wire technique demonstrated using a Minnie Tie.*

FIGURE 15 (RIGHT) *Minnie Ties applied, not tightened down yet.*

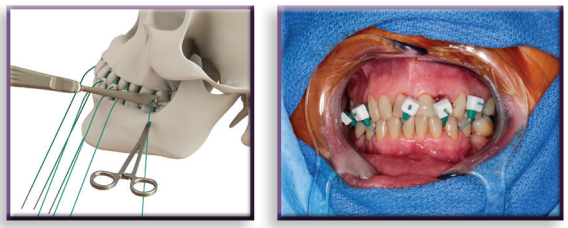


To tighten the Minnie Ties, a hemostat or wire driver can be clamped the slowly pulled. It is important to pull the tie straight out, that is not deviating up or down, to ensure the best result possible. A second instrument can be placed against the clasp to hold it in place against the teeth, simply to make it easier and prevent the complex from moving around (Figure 16). The authors recommend tightening all the Minnie Ties, then starting over and double-checking the tightness. Next,

the Minnie Ties can be trimmed and excess tie cut off, using any normal pair of scissors, or cutting implement (Figure 17). Because the clasp is one way, the Minnie Ties can be trimmed against the clasp.

FIGURE 16 (LEFT) *Technique of tightening; the clasp is stabilized with a secondary instrument and a hemostat or wire driver used to tightened. Ensure the tie is pulled directly out from the clasp and not deviating up or down, or side to side, to ensure maximal results.*

FIGURE 17 (RIGHT) *Minnie Ties placed on a patient, tightened, and trimmed.*



As mentioned above, Minnie Ties can be easily cut with almost any scissor type. The authors recommend that anytime a patient is placed into MMF (by any method), a pair of scissors (or wire cutters if arch bars are used) are placed on a cord around the patients neck to wear like a necklace in the event that they require immediate removal. In the event that something needs to be checked in the mouth or the airway accessed, the ties can be cut, the intervention or examination performed, and then a new set reapplied. In the patient who is intubated orally, the tube being between the teeth precludes any type of MMF. Therefore, providers can consider a nasal intubation, a submental intubation, or a surgical airway, but the considerations for each of those are beyond the scope of this article. These more complex situations are beyond the scope of the article, but worth discussing with a CMF surgeon in more detail for any interested parties.

Discussion

The use of this technique is FDA approved and indicated for establishment of MMF. It is novel in the sense that it has not been brought to the military context or battlefield. It is used routinely in the authors' clinical military hospital–based practice and is approved and available to order within the government ordering system as it has undergone the application and approval process by the government.

One of the advantages of Minnie Ties over traditional methods of MMF is operator safety. The application of arch bars and ivy loops, as discussed above, places the operator at risk for sharp injuries as multiple wires are passed between the teeth, causing bleeding, and between the arches. The introducer of the Minnie Tie is blunt, making them much safer than these techniques. Patient safety is a third advantage, as there is less trauma to the gingival tissues and there is no risk of damaging roots as there is with the application of MMF screws or hybrid arch bars. A third advantage is ease of application. Erich arch bars and ivy loops are technique sensitive and time-consuming, while Minnie Ties can be applied quickly and easily. One small case series showed an average placement time of 12–15 minutes.[16] A detailed knowledge of the underlying anatomy of the maxillomandibular complex, while essential to the placement of MMF screws and bone supported arch bars, is not required. Fourth, Minnie Ties are small and lightweight and would be an ideal addition to a simple dental trauma kit, while all other methods require additional instruments, such as wire drivers, wire cutters, screw drivers, screws, wires, arch bars, etc.

One of the disadvantages of the Minnie Tie technique is the fact that the patient needs a relatively full complement of dentition. Patients need solid interproximal contacts between teeth in order for this technique to be used successfully. Patients with multiple missing teeth or advanced periodontal disease with tooth mobility may not be good candidates for this technique. However, there are some various applications of Minnie Ties that can overcome some of these limitations. Minnie Tie cannot be used on edentulous patients (no teeth) or patients with no opposing teeth (missing all the top or bottom teeth). Minnie Ties are only FDA approved to be left in place for 3 weeks. However, many providers have used them for longer in an "off-label" fashion without complications, and with no appreciable loosening of the ties (we include for your information but do not recommend using them off-label). Minnie Ties may not be a suitable technique for a comminuted mandible fracture in which the maxilla or mandible is fractured into multiple pieces, though more experienced provider can and do treat these types of fractures using Minnie Ties. One noted problem is that they tend to floss between contacts when tightened, particularly if the teeth are mobile or the interdental contacts are not tight. This can be overcome by using more ties and using the larger-diameter ties.[16]

Another pertinent consideration is the airway. In patients who are unstable or have the potential to become quickly decompensated, we recommend caution with using the technique. On a patient who is otherwise stable, awake, oriented, and responsive, this is a safe technique, as well as on a patient with a secured airway. An oral intubation would preclude this technique since the tube would be between the teeth, but if a nasal tube, surgical airway, or submental intubation is present, then this technique works on a secured airway. We recommend on any patient to keep a set of scissors or wire cutters on a necklace or loop of material around the patient's neck so they can be quickly released if needed. Releasing the Minnie Ties is easily accomplished by simply cutting them and should take 15–30 seconds even by first-time users.

Summary

Fractures of the MMF complex are a common injury on the modern battlefield. These fractures can be challenging as there is often limited lighting, poor facilities, difficulty maintaining sterility, and little or no radiology support. Additionally, when treating local national patients, evacuation to higher levels of care may not be available, necessitating definitive care. Military providers, particularly those assigned to SOF, often treat patients in remote environments without the benefits of an operating room, sterilization, specialist consults, or specialized equipment. Having access to a technique for treating maxillomandibular fractures that has minimal equipment requirements, does not require advanced knowledge of the anatomy of the facial skeleton, and is relatively easy to perform is ideal to the SOF provider. We believe the Minnie Tie fixation technique would be a valuable technique to add to the arsenal of any SOF provider.

Disclaimer

The views expressed herein are those of the authors and do not reflect the official policy of the Department of the Army, Department of Defense, or the US Government.

Disclosure

None of the authors reported any disclosures.

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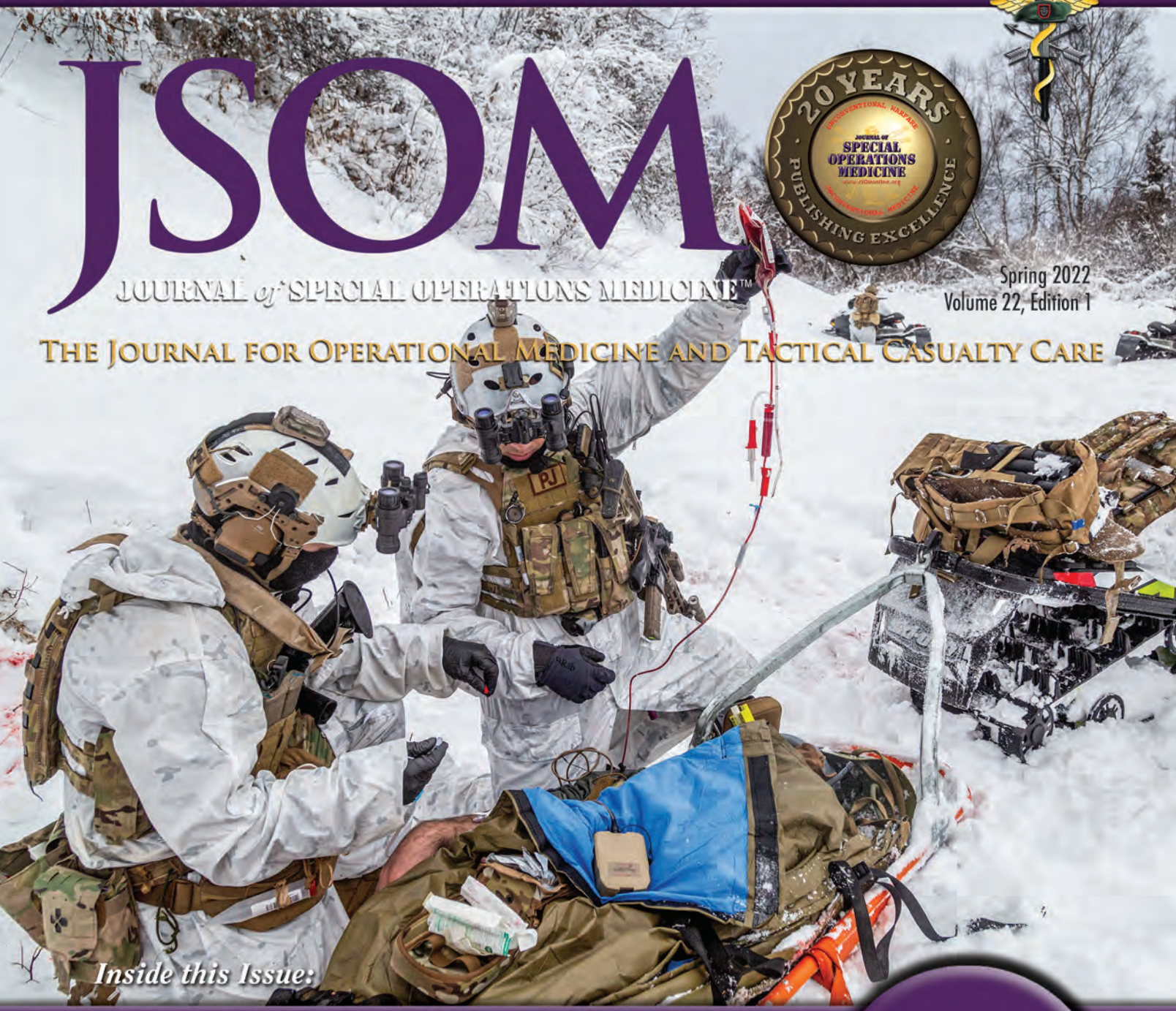

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