Hyaluronate-Rich Encasement for Soft Tissue Protection

Unwanted postoperative scarring tethers adjacent tissues and limits desired gliding and function, plaguing the outcomes of procedures in plastic, neurosurgery, hand, foot/ankle, and spine. This tethering is the body's natural, but overambitious, extrinsic healing response to the injury, surgery, or a combination of both. Early active motion seeks to physically disrupt this scar formation[1]. However, early therapy is often thwarted by pain, increased friction between adjacent, swollen tissues, or prolonged immobilization required for concomitant injuries. To support desired physical therapy, soft tissue protectors, such as nerve or tendon wraps, cover a repair or are placed between tissues, creating a plane of separation (**Fig 1**). The primary goals of these implants are to reduce friction, to protect a repair from reinjury, and to provide a gliding interface between healing and surrounding tissues.

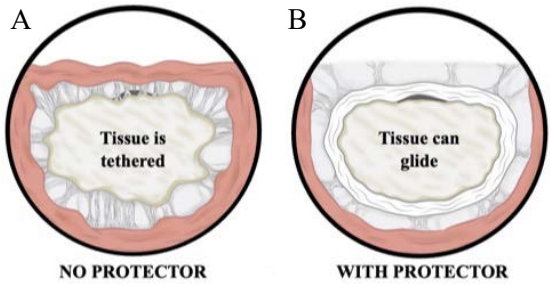
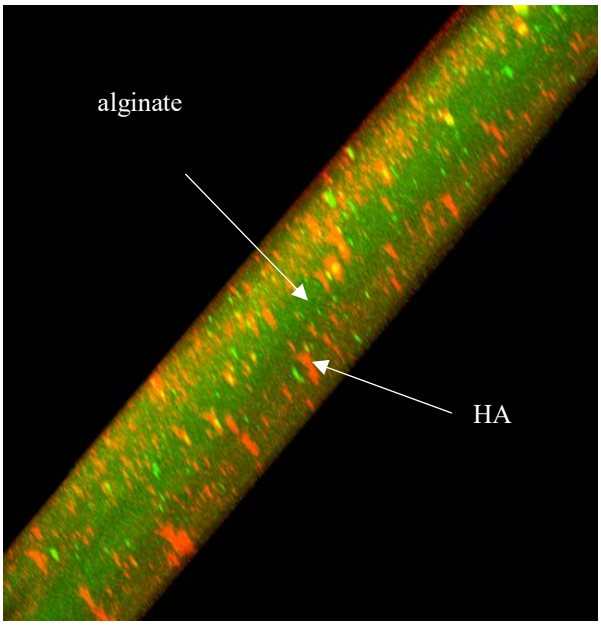


Fig 1 Illustration of A) postoperative scarring that tethers tissues and limits motion, B) use of a soft tissue protector that provides a plane of separation and allows motion

VersaWrap®: the hyaluronate-rich, non-collagen, non-placental tissue alternative

Fig 2 VersaWrap sheet images (A) ultrathin profile (< 30 microns) (B) translucent wrap making visualization of underlying tissues easy (C) applied with the VersaWrap solution, allowing relaxation and adherence of polymers onto target tissues

VersaWrap® is an absorbable soft tissue protector that is wrapped around or placed onto tendon, ligament, skeletal muscle, or peripheral nerve to separate tissues and to provide a gliding surface. The implanted *VersaWrap®* is an ultrathin, viscous hydrogel layer adherent to underlying tissues (**Fig 2**).



VersaWrap® is a hydrogel of natural, non-animal biopolymers alginate and hyaluronate (HA). Quantitative enzyme-linked immunosorbent assay (ELISA) confirms that device manufacturing retains the appropriate mass of biopolymer[2] (**Fig 3**). Both alginate and hyaluronate are widely commercialized for wound healing and anti-inflammation. Hyaluronic acid, or hyaluronate, is a poly-disaccharide responsible for hydration (such as in the eyes), tissue gliding (such as the eyeballs and knees), reduced inflammation, and debris removal (particularly following injury). Hyaluronate is usually abundant near the surgical site during early healing stages and is associated with faster healing, reduced inflammation, and tissue function most similar to an uninjured comparison[3]. Alginate is also a linear, polyanionic poly-disaccharide harvested from sea kelp[4]. Alginates have been used for centuries in tissue engineering and wound healing.

Fig 3 Confocal microscopy image of VersaWrap sheet (100x), labeled with alginate fluorescein (green) and hyaluronate (HA) rhodamine (red)[5]

VersaWrap vs. collagen-based or placental tissue-based technologies

Most available nerve and tendon protectors are collagen-based[6]. In addition to being easily available, collagen and extracellular matrix-based technologies (including placental tissue-based, porcine SIS-derived, and dermal tissue-derived technologies) have a precedence with regulatory agencies making the path to market less arduous. Collagen-based nerve and tendon wraps have long been the gold standard for soft tissue protection, but with mixed patient outcome results reported[7,8].

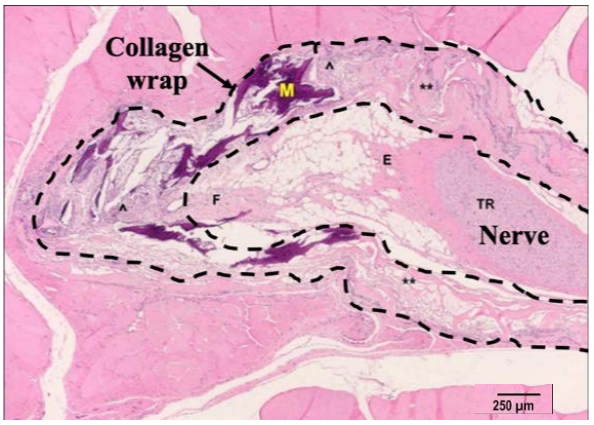


Fig 4 Transected rat sciatic nerve, 12 weeks postop. Mineralization (M) of collagen implant (**, denoted by black dotted perimeter) surrounding transected nerve (TR). Fibrosis (F), adipose tissue and inflammation (^) infiltrating implant and between implant and nerve. Epineurium (E) slightly thickened[10]

A 2021 study suggests that collagen-based nerve wraps not only do not provide a gliding surface, but also cause denser, stronger scar tissue when compared to no wrap[9]. A 2022 review of collagen and placental tissue-based technologies concluded that data did not support use of collagen-based wraps, weakly supported use of placental tissue-based wraps, and in general demonstrated limited outcome differences when compared to controls[7]. The primary reason that these implants are not satisfactory may be their cell-attractive nature; by recruiting cells to its surface, allowing protein deposition, mineralization, and calcification, the implant is bioresorbed via replacement with new tissue (**Fig 4**)[10]. This new tissue remains indefinitely, adding bulk to the healed tissues and minimizing the effect that the protector is intended to offer.

Unlike collagen products, the alginate and hyaluronate in *VersaWrap*® are viscoelastic and slippery, allowing smooth gliding of adjacent tissues following surgery[11,12]. As form follows function, alginate and hyaluronate's negative charge attracts and immobilizes water on its surface, repelling cellular deposition but allowing cellular migration. Hyaluronate and hyaluronate-cell surface receptors orchestrate several intracellular signaling pathways responsible for regulating inflammation and tissue healing[13,14]. Thus, hyaluronate maintains a balance in promoting and resolving inflammation and in facilitating and moderating tissue repair. Ultimately, alginate and hyaluronate bioresorb via hydrolysis and, therefore, are not replaced, reducing the opportunity for added bulk and optimizing the opportunity for healthy tissue gliding and improved patient outcomes.

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