The effects of elastin in biologic grafts

Dermis-based biologic grafts contain elastin.

Elastin is a structural protein that gives body tissues their elasticity. Normal elastin content varies widely across different tissue types. For instance, the aorta contains 37-57% elastin, dermis contains between 4-10%, and many tissues, like liver, spleen, or intestinal submucosa, contain none or very little.[1-3]

Many dermis-based biologic grafts are harvested from human cadaveric tissue. Although tissue banking regulations ensure that they are carefully tested for their disease transmission potential, they may not be screened for the donor's age, smoking history, or sun exposure history. Both smoking and sun exposure have been shown to dramatically increase the appearance and size of elastic fibers in the skin. This apparent increase is due primarily to elastin damage.[4] Thus, many of these harvested dermis-based biologic grafts may contain damaged elastin.[5]

Elastin and collagen ratios in tissues affect their function.[6] For dermis-based biologic grafts, the elastin contributes elasticity, significantly affecting the graft's mechanical characteristics following implant. Because the turnover rate of elastin in humans is exceptionally slow, with an average residence time in tissues of approximately 74 years,[7] grafts made from dermis never completely remodel and remain within the patient, stretching over time. This laxity, also termed "diastasis," is a significant side effect of hernia repair that impacts patient quality of life and can lead to the appearance of a hernia recurrence.[8]

Complete tissue graft remodeling requires that all parts of the implant be replaced by newly formed patient tissue over time. Because elastin is stable within tissues and, unlike collagen, is not rapidly metabolized, the elastin from the graft remains in the patient throughout the process of tissue remodeling, contributing to the late-term laxity that is seen when dermis-based products are implanted.[8]

Elastin is like rubber, collagen like steel.

Collagen and elastin are both structural proteins. They are arranged together within tissues to provide the appropriate strength (collagen) and elasticity (elastin) the tissue needs for its required function.[6] A review of the mechanical properties of elastin and collagen demonstrates that collagen is nearly 100 times stronger and about 1,000 times stiffer than elastin (Table 1).[9] Additionally, collagen has one-tenth the strength of steel, while elastin is very weak.[9]

Table 1: Material Properties[9]

Material	Strength σ_{max} (GPa)	Stress in use (MPa)	Stiffness E_{init} (GPa)
Elastin	0.002	0.55	0.0011
Collagen	0.12	60	1.2
Spring steel	1.5	600	200

The ratio of collagen to elastin in biologic grafts can affect the ability of the device to completely remodel. Animal studies and human studies out to 2.5 years post-implantation demonstrate that elastin remains present in the tissue after non–cross-linked dermis-based biologic grafts are used.[10,11] If elastin is still present in the repaired tissue, the ability of the implant site to stretch over time remains.

Long-term outcomes are sacrificed with dermis, but not with Biodesign.

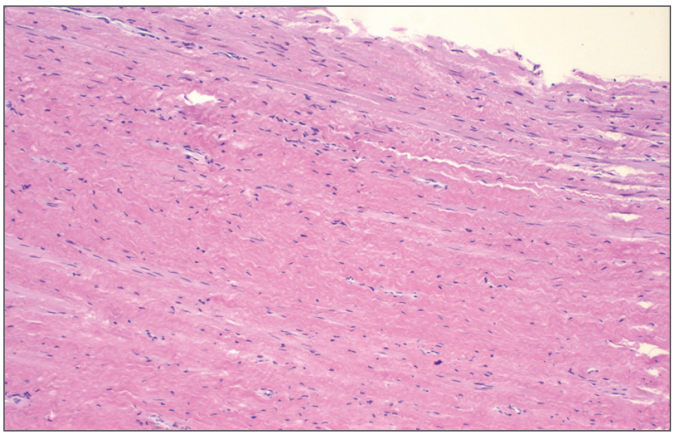
One dermis-based biologic graft has been shown histologically to retain elastin in the patient tissue, even 2.5 years after implant.[11] Clinical evidence demonstrates that the use of dermis-based biologic grafts results in diastasis and/or hernia recurrence even with "pre-stretching" of the graft.[8,12,13] At least one manufacturer of human dermis-based biologic grafts advocates suturing the graft under significant

tension at the time of implant in order to minimize laxity as much as possible.[14] Even so, placing a highly elastic tissue in a low-elasticity site is inadvisable because the graft will still relax over time when placed under tension. As one group states, "[Human acellular dermis] should not be used as an interposition graft because of unacceptably high recurrence rates."[13] The requirement of a follow-up operation to repair laxity is not an insignificant consequence.[8]

A 2016 study comparing outcomes of various dermis-based biologic grafts in hernia repair demonstrated failure rates as high as 59% at 18 months.[15] This is significant, as hernia recurrence rates tend to increase over time. Conversely, recurrence rates as low as 13.6% after 3 years have been reported when the Biodesign Hernia Graft, an advanced tissue-repair graft made from small intestinal submucosa, is used in open ventral hernia repair procedures.[16]

Biodesign Advanced Tissue Repair products provide a natural scaffold that allows the body to restore itself through site-specific tissue remodeling.[17,18] As healing occurs, Biodesign grafts initially act as scaffold materials to support the population of the extracellular matrix with patient-derived cells.[17] Over time, Biodesign grafts are gradually remodeled and integrated into the body, leaving behind organized tissue that provides long-term strength.[19] The final result is completely remodeled, strong, vascularized patient tissue within 3-6 months, without the presence of a permanent material or significant residual elastin (Figure 1).[20]

Figure 1



Biodesign completely remodels, creating complex tissues appropriate for the site of repair after only a few months. (Biopsy courtesy of Dr. Henry Flournoy, Coastal Associates of Obstetrics & Gynecology, Brunswick, Georgia).

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