Collagen has been taking many new forms lately, proving itself trouble-free and highly adaptable across a broad spectrum of surgical applications. The following is a brief sampling of some of the research and development relating to innovative uses for collagen:

**Wound repair and tissue augmentation**

Due to its valuable adaptive qualities, collagen has become indispensable in clinical wound care. Nowhere is this more noticeable than in treating the increasing population of diabetics. For these patients, chronic wounds of the lower extremities are a substantial health risk, and too often unreparable diabetic wounds lead to infection and amputation. An extra-cellular matrix (ECM), made up primarily of Type I and Type III collagens, offers a superior framework for the delicate process of healing. There are a variety of new ECM products that aid in maintaining the balance of the protein activity in the chronic wound environment while contributing to the vascularization of new tissue. [1]

As best practice guidelines are issued for various surgical procedures, collagen use is frequently cited. The resorbable characteristics of a porcine-sourced membrane of collagen I / III is highlighted in the journal Cartilage [2] as a best practice for cartilage repair of the knee. Previously, an autologous periosteal flap had to first be harvested and then sutured over the debrided lesion. Furthermore, it was noted that this flap frequently required repeated surgical intervention due to graft hypertrophy. The advent of collagen-based biomaterials has ushered in what Cartilage calls a “second generation of ACT” (autologous chondrocyte transplantation). The journal points out that this “established therapy for full thickness cartilage defects” allows for easier handling as well as for an innovative new cell-suspension technique.
Bioprosthetics

Biological scaffolds made from collagen are becoming more available, and surgeons are turning to these mesh or matrix forms for many different procedures. Resorbable collagen-based bioprosthetics are now being used in musculoskeletal and tendon repair, breast reconstruction, cranial/facial defects, gynecological reconstruction, and more. [3] Where once only synthetic scaffold materials were available, their biocompatibility problems have led them to be rapidly supplanted by the more effective biological products.[3]

Extra-cellular matrices are made from collagen together with laminin, fibrinectin and elastin. These may be sourced from either human (allograft) or non-human mammalian (xenograft) sources

In the surgical repair of abdominal wall defects, a porcine dermal matrix (Permacol) has been shown to provide the needed tension-free support for the abdominal wall, while mitigating the risk of contamination. Surgeons reporting on a pediatric multi-trauma case [4], point out that use of the Permacol bioprosthetic mesh resulted in superior incorporation of host tissue as well as better infection resistance. They note that the synthetic prosthetic meshes that had previously been in use were associated with high rates of infection as well as complications such as skin erosion, adhesions, and the formation of fistulas.

In a discussion of such biological scaffolds, surgeons at University of California [3] state “grafts composed of collagen are beneficial because they support natural cell interactions such as proliferation and migration.” These researchers found that although the biological collagen grafts may produce occasional immunogenic responses, the incidence of such problems is far lower than when synthetic graft materials are used. The synthetic materials, being non-resorbable, also provoke stronger inflammation reactions.

For spinal surgery, The Journal of Neurosurgery [5] notes that biodegradable collagen scaffolds are “an effective and safe cranial and spinal dural substitute” which caused no adverse reaction in any of the 112 patients followed by their study. Furthermore, they go on to point out that this collagen matrix spinal graft is indicated even if there is an existing local infection.

Injectable collagen

For plastic surgeons, the availability of human and mammalian sources for injectable collagen is opening up a range of possibilities. Typically this form of collagen is most useful for soft tissue augmentation. Injectable collagen filler can smooth and fill wrinkles, depressions and scarring in the skin’s surface. In some instances, the presence of introduced collagen tends to stimulate the body’s own production of its natural collagen,
and this phenomenon can provide substantial patient benefit by extending the time period between necessary injections.[6]

Research on lip augmentation procedures using an injectable form of human-sourced collagen showed that in the clinical trial, not one procedure resulted in any rejection or displacement. Some injectable collagen products contain 0.3% lidocaine, removing the necessity for separate anesthesia when filling superficial wrinkles and lines.[7]

**Experimental extension of collagen uses in surgery**

Because natural collagen is tolerated so well by the body, medical science has devised some creative uses for it. For example, atelocollagen is used as a “carrier substance” [8] which can immobilize physiologically active substances. One example of this type of use is described by thoracic surgeons in Annals of Thoracic Surgery [9]. These surgeons experimented with adding methylene blue dye and contrast medium to 0.8% atelocollagen. This mixture, which they termed “colored collagen,” allowed the marking of small pulmonary nodules for a period of up to ten days without any toxicity. The advantage of this colored collagen marking procedure is that it solves two practical dilemmas: First, it frees surgical teams from the need to simultaneously use an operating room and a computed tomographic scan, and second: it results in more accurate marking of the nodule because of the two different types of dye that are used.

Another revolutionary use of collagen is being pioneered at Cornell University Medical Center, where two surgeons have won the 2014 Apfelbaum Award [10] for the use of a novel high-density collagen gel in repairing herniated discs. The gel has demonstrated that it actually is capable of sealing and repairing defects in the discs. This exceptional repairing capability is very different from traditional herniated disc surgery, which removes material but does not address the underlying defect in the intervertebral disc, which caused the problem in the first place.

Surgeons working on reconstructing soft tissue following liposuction procedures are exploring the use of enriched collagen matrices. Their research [11] found that the adipose-derived stem cells were shown to adhere well to the collagen matrices, and they suggest further clinical trials to optimize this technique.

While the use of collagen in very basic forms has been known to medical science since the late 1800s, the new era of bioengineering has greatly expanded its possible applications. Whether in the form of powders, sheets, sponges, mesh, gel, or nodules, this building block of tissue will continue to open up new surgical practice possibilities.
Footnotes:


[2] Cartilage 2012: 3 (1) 5-12


http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006564/


[6] University of Maryland Medical Center: Collagen Fat Injectable Fillers
http://umm.edu/programs/plastic-surgery/services/cosmetic/collagen

[7] emedicine: Collagen and Other Injectable Fillers

http://www.reference.md/files/C059/mC059821.html


[10] Weill Cornell Brain and Spine Center: Collagen Gel Study Wins 2014 Apfelbaum Award

http://www.biomedcentral.com/1471-2482/14/10

Uses and Benefits of Collagen in Surgical Settings
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September 2014