SYNTHECEL® Dura Repair — Biosynthesized Cellulose for Dura Repair

SYNTHECEL® Dura Repair is the first-in-its-class product manufactured from a novel building block called bionanocellulose (BNC, Figure 1). BNC is entirely non–animal-derived and is associated with an inherently low risk of prion transmission.[1] Produced through a biofabrication process, using a proprietary strain of vinegar bacteria, SYNTHECEL® Dura Repair belongs to a category of organic materials that closely resembles human dura in terms of appearance, feel, and function.[2]
These characteristics were evaluated in a prospective, randomized, multi-center clinical trial comparing SYNTHECEL® Dura Repair to other dura repair products. This study demonstrated that SYNTHECEL® Dura Repair has superior handling characteristics (including strength and seal quality) and non-inferior safety and efficacy compared to the other dura repair products tested.[1]

Figure 1 – **Biofabricated SYNTHECEL® Dura Repair provides a balance of mechanical strength and conformability, and is free of animal derived components.[2]**

Bionanocellulose

In the field of natural polymer-based biomaterials, nanocellulose has received considerable attention from global research and development (R&D) and industry leaders as a promising new building block material for various applications, including soft tissue and bone repair devices, drug delivery systems, lightweight parts for cars and aircraft, and even food and cosmetic additives.[3,4] Although plant-derived nanocellulose is utilized for many of these applications, medical experts have focused on the unique potential of bacterially derived nanocellulose for biomedical applications (Figure 2). This type of nanocellulose (bionanocellulose, BNC) is a biofabricated membrane, characterized by high mechanical strength, high water-holding capacity, and conformability to irregular surfaces and anatomical contours.[2,4] Bionanocellulose also has a three-dimensional structure that closely resembles the structure of native extracellular matrices of human tissue.[2] Due to these properties, it is particularly well suited for human soft tissue repair applications.

Although BNC has been the subject of extensive research for many years, attempts to commercialize this material as an implantable medical device have been unsuccessful due to the lack of sustainable, high-quality Good Manufacturing Practices (GMPs). After years of dedicated research and development, DePuy Synthes has overcome this obstacle with the release of SYNTHECEL® Dura Repair as a dura replacement for the repair of dura mater in adults.

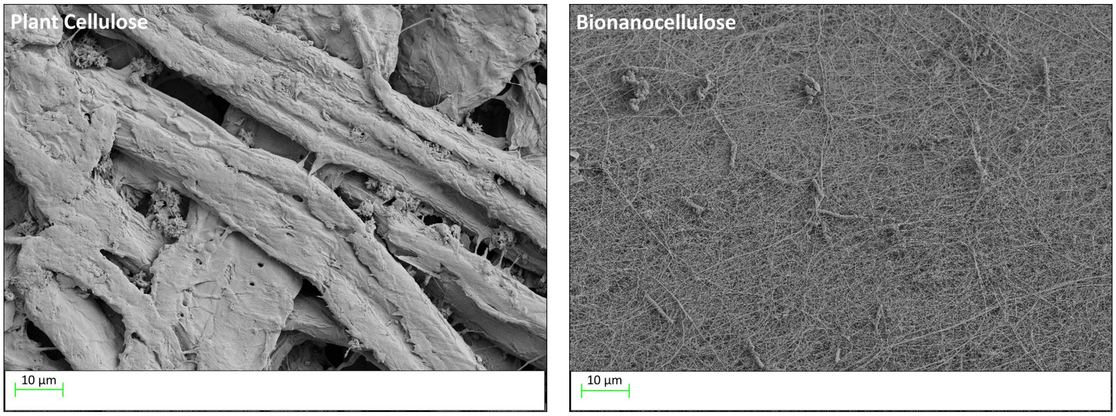
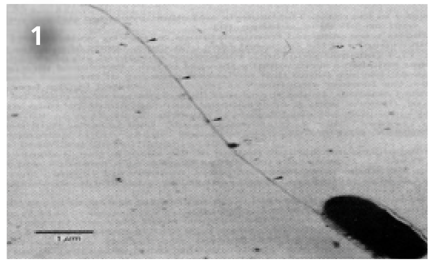


Figure 2 – **Plant-based cellulose, such as cellulose derived from wood pulp (left) lacks the three-dimensional structure of well-dispersed nanofibers of bionanocellulose (right).**

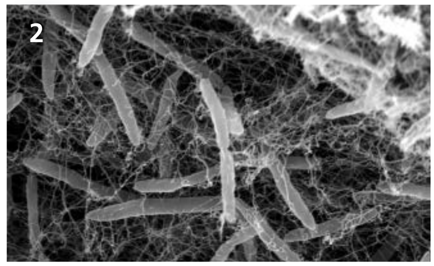
DePuy Synthes
PART OF THE Johnson & Johnson FAMILY OF COMPANIES

How Is BNC Made?

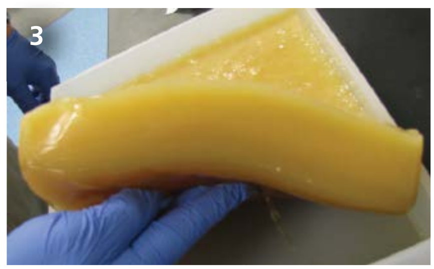
SYNTHECEL® Dura Repair is produced via a biofabrication process using a bacterium called *Komagataeibacter nataicola* (previously known as *Gluconacetobacter* or *Acetobacter*) and advanced fermentation methods.[5] This bacterium has a unique ability to metabolize and convert various sources of sugars into pure and highly crystalline nanocellulose (Figures 3-1, 3-2). In nature, this bacterium produces tiny amounts of cellulose in the form of a thin biofilm to protect itself from harsh conditions and to safeguard its food source.[6] During the SYNTHECEL® Dura Repair manufacturing process, nanocellulose forms as a biofilm (otherwise known as pellicle) on the surface of liquid nutrient media (Figure 3-3). This pellicle is then harvested and rigorously purified to remove any bacteria, endotoxins, and residual media to meet medical implant requirements (Figure 3-4). Although chemically identical to plant-derived cellulose, BNC is characterized by a unique three-dimensional fibrillar nanostructure and high porosity which translate into high mechanical strength and conformability. Together, these traits make BNC suitable for both suture and onlay dura repair applications (Figure 3-5).



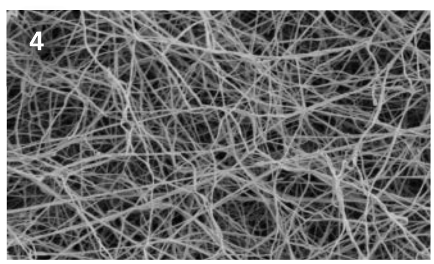
Gram-negative *Komagataeibacter nataicola* bacterium converts various sugars into pure cellulose ribbons that are extruded outside of the bacterium



Spaghetti-like *Komagataeibacter nataicola* embedded in the matrix of produced cellulose fibers



Cellulose pellicle harvested upon completion of the fermentation process consists of bacteria and media components embedded in the 3D structure



A robust purification process removes bacteria, endotoxins, and residual media

Purified cellulose pellicle formed into SYNTHECEL® Dura Repair

Figure 3 – SYNTHECEL® Dura Repair manufacturing process utilizes biofabrication with living bacteria through advanced fermentation technology.

How Is BNC Different From Collagen?

Currently, many dura repair products consist of bovine collagen. Unlike bovine collagen, which is an animal-derived protein, BNC is a polysaccharide and does not contain any animal-derived components. Both cellulose and collagen often serve as primary mechanical support structures for their tissues of origin.[7] Structurally, both materials have similar fibrillar structure; however, BNC fibers are smaller in diameter and more spatially dispersed (Figure 4). Due to these physical features, a BNC mesh is highly porous with average pore sizes as small as several nanometers. In addition, unlike collagen, BNC cannot be resorbed in the human body due to the body's lack of enzymatic machinery to break down a highly crystalline cellulose, thus representing a non-degradable dura repair solution.

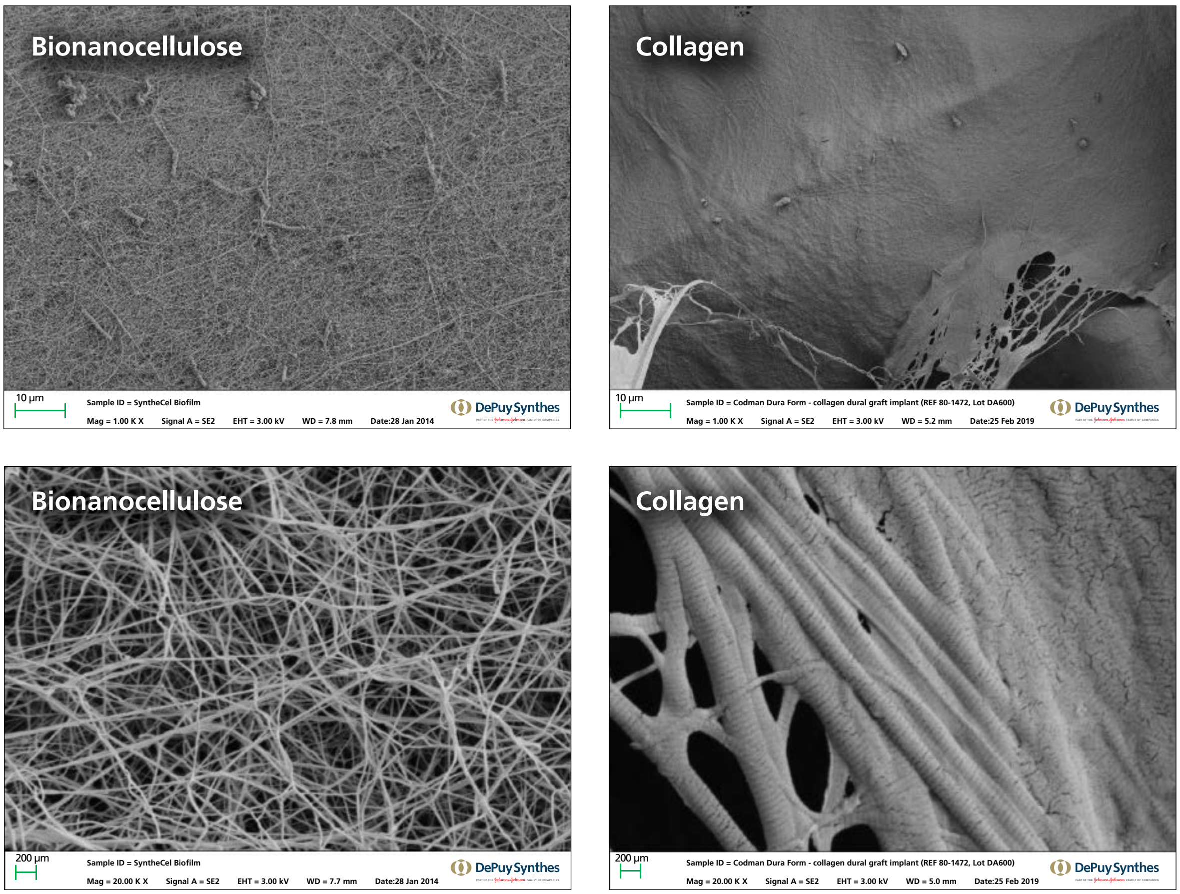


Figure 4 – **Cellulose and collagen have a similar structure consisting of three-dimensionally oriented fibers.**

Summary

Bionanocellulose is a natural, non–animal-derived material characterized by high mechanical strength, high water-holding capacity, and conformability.[2,4] Furthermore, due to its non–animal-derived nature, BNC has an inherently low risk of prion transmission.[1] Due to these advantageous characteristics, BNC is being utilized by SYNTHECEL® Dura Repair to provide a distinctive dura repair solution.

Indications: SYNTHECEL® Dura Repair is intended for use as a dura replacement or the repair of dura mater in adults.

Contraindications: SYNTHECEL® Dura Repair must not be implanted in patients who have known allergy or sensitivity to the implant materials (cellulose).

Author profile:
Wojciech Czaja, PhD
Research Fellow
Biomaterials Research & Development
DePuy Synthes

REFERENCES

1. Rosen CL, Steinberg GK, DeMonte F, et al. Results of the prospective, randomized, multicenter clinical trial evaluating a biosynthesized cellulose graft for repair of dural defects. *Neurosurgery*. 2011;69(5):1093-1104.
2. Czaja WK, Young DJ, Kawecki M, Brown RM Jr. The future prospects of microbial cellulose in biomedical applications. *Biomacromolecules*. 2007;8(1):1-12.
3. Milanez DH, Amaral, RM, Faria, LIL, Gregolin, JAR. Assessing nanocellulose developments using science and technology indicators. *Mat Res*. 2013;16(3):635-641.
4. Lin N, Dufresne A. Nanocellulose in biomedicine: current status and future prospect. *Eur Polymer J*. 2014;59:302-325.
5. Yamada Y, Yukphan P, Lan Vu HT, et al. Description of Komagataeibacter gen. nov., with proposals of new combinations (Acetobacteraceae). *J Gen Appl Microbiol*. 2012;58(5):397-404.
6. Williams WS, Cannon RE. Alternative environmental roles for cellulose produced by Acetobacter xylinum. *Appl Environ Microbiol*. 1989;55(10):2448-2452.
7. Petersen N, Gatenholm P. Bacterial cellulose-based materials and medical devices: current state and perspectives. *Appl Microbiol Biotechnol*. 2011;91(5):1277-1286.

DePuy Synthes

PART OF THE Johnson & Johnson FAMILY OF COMPANIES

127235-191107 DSUS 05/20 DV