Development of warp knitted tubular mesh for medical implants – Investigation of variable stretchability and mechanical behaviour

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Abstract

Medical textiles have a given role in many different surgical applications today, where specific mechanical properties are required. They place a critical role in prepectoral implant-based breast reconstructions, where acellular dermal matrix (ADM), or synthetic meshes, provide structural support by reinforcing the implant pocket and help maintain the position of the implant. Furthermore, the mesh creates an additional layer between the implant and the skin which distributes the pressure and reduce stress on the overlying skin. However, conventional 2D sheet fabrics require intraoperative cutting and suturing to achieve a proper fit to the implant, which leads to excess material. In turn, this can increase complication risks and prolong surgical time. This study aimed to develop a novel warp-knitted tubular mesh structure with variable stretchability to streamline the implant coverage process while minimizing excess material and accommodate a range of implant sizes. Single needle bar combinations of three warp knitted patterns (Cord, Satin and Velvet) were produced to evaluate the mechanical performance during deformation, assessing impact from pattern positioning and directional properties. Four double needle bar tubular structures with varying dimensions and pattern distributions were then constructed to test their suitability as an implant pocket. The amount of excess material, deformability, and stability were also evaluated for different implant sizes. The results showed that pattern combination significantly influenced tensile properties ($p < 0.05$), while the positioning of patterns relative to each other only affected warp-directional force and weft-directional elongation. Distension behaviour was influenced by both pattern combination and their relative position within the fabric structure. Tubular implant pockets demonstrated variable stitch density depending on implant size, though some combinations were more stable. Excess material was reduced for higher implant sizes and none of the tubular meshes caused visual implant deformation. Warp-knitted tubular structures with strategically combined patterns offer a promising alternative to conventional 2D mesh sheets for prepectoral reconstruction, reducing excess material and intraoperative manipulation. Future work will focus on systematic optimization of seamless tubular mesh production to further minimize material redundancy and preparatory steps during surgery.

Keywords: Warp knitting, Surgical mesh, Medical Textiles, Tubular structure, Implant based reconstruction

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