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Development of a Hybrid UHMWPE Core-Silk Sheath Suture Architecture Using Standard Braiding Technology

Executive Summary

A development programme was undertaken to evaluate the feasibility of producing a hybrid core-sheath suture architecture using standard braiding equipment and commercially established fibre systems.

The concept combined:
A UHMWPE multi-filament core (400 d) to provide load-bearing performance and fatigue resistance
A braided silk sheath to modify surface characteristics and improve handling behaviour

Rather than relying on coatings or material treatments, the architecture introduced functional separation within a single construct, assigning mechanical performance to the core while independently engineering surface interaction through the sheath.

Using a conventional 8-carrier braiding process, the project demonstrated stable formation of a continuous silk sheath around a UHMWPE substrate without process redesign, establishing feasibility for scalable development of multi-material braided surgical constructs.

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The Challenge

UHMWPE fibres offer exceptional tensile strength and long-term mechanical durability but present known handling challenges due to their smooth, low-friction surface characteristics.

The engineering objective was to introduce a secondary functional layer without compromising the mechanical benefits of the UHMWPE substrate or exceeding practical suture profile limits.

Key technical challenges included:

- Maintaining stable positioning of a low-friction UHMWPE core during braiding
- Preventing core migration and inconsistent centring
- Achieving continuous sheath encapsulation without exposure or gapping
- Preserving flexibility and tactile performance
- Maintaining low-profile geometry suitable for surgical handling
- Producing a stable hybrid structure using existing manufacturing infrastructure

The architecture required careful control of both material interaction and braid formation to maintain structural integrity throughout processing.

Engineering Objectives

The programme focused on:

- Developing a stable UHMWPE core-silk sheath structure
- Preserving load-bearing performance of the UHMWPE core
- Improving handling characteristics through surface modification
- Maintaining low-profile suture geometry
- Achieving uniform and continuous sheath coverage
- Demonstrating compatibility with standard braiding platforms

Development Approach

Functional Core-Sheath Architecture

The engineering strategy introduced functional separation within the suture design.

Core Function

UHMWPE multi-filament (400 d):

- Mechanical strength
- Fatigue resistance
- Structural load transfer

Sheath Function

- Braided silk layer:
- Surface modification
- Handling enhancement
- Increased tactile softness
- Controlled tissue interaction

This architecture enabled independent optimisation of bulk mechanical properties and external handling characteristics.

Manufacturing Configuration

Hybrid constructs were produced using a standard 8-carrier braiding platform.

Process conditions included:

- Continuous UHMWPE multi-filament core feed
- Full carrier engagement for complete silk coverage
- Standard braid setup without equipment modification
- Controlled yarn tension to minimise core displacement
- Compatibility with conventional inspection workflows

The process demonstrated that hybrid core-sheath structures could be produced using existing manufacturing infrastructure.

Validation & Feasibility Assessment

Validation focused on confirming process feasibility and structural integrity rather than complete mechanical benchmarking.

Assessment activities included:

- Visual inspection of sheath continuity
- Evaluation of core positioning stability
- Structural inspection for collapse or discontinuity
- Coverage assessment across construct length

Key outcomes demonstrated:

- Stable formation of a continuous silk sheath
- No observed structural collapse within the hybrid architecture
- Consistent encapsulation supported by full carrier utilisation
- Preservation of UHMWPE core integrity during processing

These findings confirmed the technical feasibility of producing hybrid braided structures using standard braiding systems.

Process Control & Repeatability

Repeatable output was achieved through controlled management of:

- Braiding conditions
- Carrier engagement
- Material tension balance
- Core positioning stability
- Structural inspection procedures

These controls enabled:

- Repeatable sheath formation
- Consistent sheath formation
- Consistent material behaviour
- Stable hybrid geometry
- Compatibility with existing coating and inspection workflows

The programme demonstrated potential for scalable prototype manufacturing without introducing additional process complexity.

Engineering Outcome

The project successfully demonstrated that multi-material suture architectures can be manufactured using conventional braid platforms while preserving functional separation between structure and surface performance.

Key engineering outcomes included:

- Successful integration of UHMWPE and silk into a hybrid braided construct
- Stable core positioning and sheath encapsulation
- Independent control of strength and handling attributes
- Preservation of low-profile geometry
- Scalable manufacturing compatibility

The development established a platform for future optimisation of mechanically reinforced, surface-engineered surgical textiles.

Application Relevance

Orthopaedics & Sports Medicine

Relevant to high-load repair environments where strength retention and handling performance must coexist, including:

- Tendon repair systems
- Ligament reconstruction
- Soft tissue fixation devices
- Sports medicine reinforcement constructs

Soft Tissue Repair & Surgical Closure

Hybrid architectures may support applications requiring:

- Improved knot handling
- Controlled flexibility
- Enhanced tactile response
- Long-term mechanical stability

Minimally Invasive & Robotic Surgery

Potential relevance where surgeons require:

- Predictable handling under reduced tactile feedback
- Controlled friction during delivery
- Reliable knot formation in constrained access procedures

Advanced Implants & Tissue Technologies

The architecture reflects broader movement toward:

- Functionally differentiated implant textiles
- Multi-material reinforcement structures
- Surface-engineered implant platforms
- Textile systems with independently tuned performance characteristics

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Key Takeaways

- Hybrid core-sheath design enables separation of structural and surface functions.
- UHMWPE provided load-bearing capability while silk modified handling characteristics.
- Stable hybrid formation was achieved using standard braiding equipment.
- Controlled tension and carrier engagement supported repeatable sheath coverage.
- The project established a scalable foundation for future multi-material surgical textile development.

"By separating mechanical performance from surface behaviour, the hybrid architecture demonstrated a new route to engineering surgical textile performance."

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