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Role of Textile Materials in Orthopaedic Appications

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Abstract

The use of textile in the medical field is not new; this has given rise to a new branch known as medical textiles. These are being used to repair or replace various other musculoskeletal tissues. The most common uses of biomaterials are to create aseptic conditions for protection, general health care, and hygiene including bedding and clothing, surgical gowns, face masks, head and shoe covers, sterilization wraps, suture anchors, fiber cast and braces/orthotics. These are also used as materials for preparation of wipes, swabs, wound dressings, bandages, gauzes, plasters, pressure garments, orthopedic belts and for new applications, such as heart valves, vascular grafts, artificial veins, artificial ligaments, artificial joints, artificial skin, and artificial cartilage. The truth is that nowadays the use of biomedical textiles is more rampant than anyone realizes. Commonly used materials for preparation of biomedical textiles includes Cotton, Nylon, Silk, Ultra-high molecular weight polyethylene, Polyester, Polypropylene, Poly tetra-fluoro ethylene, Polyether ether ketone, and Polyether ketone. These are prepared from various monomers in varying proportions as per the requirement of the material to be used. Various methods are used in their preparation like Braiding, Knitting, and Weaving, which helps in the development of certain kinds of materials with different specificity and character. Other important measures in the preparation of the medical textile include Denier (the filament counts in multifilament fibers), Tenacity (the strength per denier) and Heat shrink (the amount of shrinkage at a particular time and temperature).

Keywords: Medical Textiles, Surgical Gowns, Face Masks, Shoe Covers, Sterilization Wraps, Suture Anchors, Fiber Cast Braces, Cotton, Nylon, Silk, Ultra-high Molecular Weight Polyethylene, Polyester, Polypropylene, Poly Tetra-Fluoro Ethylene, Polyether Ether Ketone, Polyether Ketone.

Introduction

The use of textile in the medical field is not new; this has given rise to a new branch known as medical textiles. Novel use of new and existing biomaterials in musculoskeletal procedures ranges from bone grafting to segmental fusion for spinal instability [1-3]. These are also being used to repair or replace various other musculoskeletal tissues like articular cartilage, meniscus ligaments, and tendons [4-8]. The focus is now shifting towards lighter and softer implants instead of the old hard material implants.

The human body has dynamic complex biomechanical processes and therefore the material implanted or used over the human body should be inert and harmless. Mechanical properties play a significant role in the selection of materials for human use. Analysis of the biological behavior of synthetic materials is used to check the biocompatibility, using various in-vitro and in vivo standardized tests. Hench et al [9]. divided biomaterials into three different generations based on the evolution in the field of biomaterials and also as a result of learning from failed implantation.

First Generation Biomaterials – Bio Inert Materials

The choice of the material for a particular product is governed by matching the material properties with the indication of its implementation. Biological properties need to be added in the case of biomaterials, to the mechanical, chemical and physical properties. In the recent past, other conditions such as foreign body reaction (particularly due to wear debris), stress shielding, biocompatibility, bioactivity, and osteoinduction have also been introduced for the biomaterials used to design various implantable devices. Hench et al. were the pioneers in introducing the materials which fit the first generation. According to them, the implanted material should do the job which the original structure was performed with no or minimal host response, and these materials were essentially 'inert.' They made use of metallic, ceramic materials and polymers such as silicone, rubber, polyethylene (PE), acrylic resins, polyurethanes, polypropylene (PP) and polymethyl methacrylate (PMMA). The most widely used amongst orthopedics is PE and ultra-high molecular weight PE (UHMWPE) as liners for acetabular cups in total hip arthroplasty (THA), as tibial inserts (Fig. 1), a patellar component in total knee arthroplasty (TKA), and as a spacer in intervertebral artificial disc replacement. These materials became popular in quick time due to their superior mechanical properties such as low friction, high abrasion resistance, toughness, low density, ease of fabrication, biocompatibility, and biostability [10, 11]. Swanson et al. popularised silicone polymers in small joint replacements [12]. The most common complication faced with this material is a fracture, apart from the other drawbacks such as bone and implant abrasion, subluxation and loosening of the implant [13-15].

Figure 1: Poly-insert used in total knee Arthroplasty for Stabilization of Implants and Smooth Movement

Another widely used biomaterial gaining quick popularity is carbon fibers. These have been mainly used to reinforce polymers for different applications such as in THA and internal fixation. The long-term benefits of these implants have been reported in surgeries of the ear with satisfactory results [16, 17]. The primary concern regarding the use of carbon implants was the release of carbon debris into the surrounding tissues causing an allergic reaction. There could be adverse cell response in some cases, such as collagenase synthesis, cell detachment, lysis and the release of cell-activating factors that activate other cells in the culture [18-20].

Ligamentous injuries are very common nowadays. In athletes, there are incidences of multiple ligament injuries due to high-intensity training. Hence materials like polyester and poly tetra fluoro ethylene come into play. These are used to manufacture synthetic cruciate ligaments. After implantation, proteins get adsorbed over the implant surface which activates the graft versus host reaction. It throws fibrous tissue which engulfs the implant completely over a period. This was the reason why scientists explored the possibility of second-generation biomaterials.

Second Generation Biomaterials

Bioactive materials can enhance the biological response and the surface bonding of the tissue. At the same time, they degrade quick enough while new tissue regenerates and heals. Biodegradable materials which showed gradual chemical breakdown was being rampantly tested such as polyglycolide (PGA), polylactide (PLA), polydioxanone (PDS), poly-3-caprolactone (PCL), polyhydroxy butyrate (PHB), poly-2-hydroxyethyl-methacrylate (PHEMA), and hyaluronic acid (HA). These materials are extensively used in orthopedics from bone substitution to replacement of ligaments, cartilage, meniscus and intervertebral discs. These are also used in spine and trauma cases widely [21]. Biodegradable implants hold the advantage as they reduce the stress shielding effect by gradually getting absorbed and also eliminates the need for implant removal surgeries (Fig. 2). After resorption, any post-operative diagnostic imaging does not show any residual artifacts.

Figure 2: Bio-inference Screw Used in ACL Reconstruction.

Third Generation Biomaterials

These materials mainly stimulate specific cellular responses at the molecular level and must be biocompatible [22]. Its degradation by-products should resorb at the same rate as the tissue is repaired and should be non-cytotoxic. The scaffold should be biodegradable and must possess a highly interconnected porous network, formed by a combination of macro and micropores that enable proper tissue ingrowth, vascularization, and nutrient delivery. However, during the initial stages of the new bone formation, these materials must keep their structural integrity. Important methods in the preparation of medical fabrics include braiding, knitting, and weaving. Medical textiles have also been described based on the use, type of fibers used and the structure of the fibers.

Braiding

Braiding is completed by interlacing fibers to achieve a customized construction or more basic pattern. Combining fibers is common mixing polyester with an absorbable material for partial degradation over time is one example as are complex engineering alterations to produce a customized structure with specific measurement requirements [23]. Braiding around mandrels to create hollow tubes or flat braiding is also possible. Because it enables precise dimensions and exact geometry, the technique can be used for applications such as ligament and tendon repair.

Knitting

Knitting is a common textile process. The techniques involved include warp knitting and weft knitting (the latter, like braiding, also common for making tubes). Involves more individual fibers than braiding (to provide either machine- or cross-machine-direction strength or stretch, depending on the application), the intricacy of the resultant structure is greater, and the performance capabilities, therefore, are even higher [24-26]. Applications that require a higher degree of performance and undergo more severe instances of movement and stretch include containment sleeves for spinal disk repair and replacement, and implantable and procedural assistance pieces for the knee, shoulder, and spine.

Weaving

Longitudinal fibers held together by perpendicular cross-fibers. A woven fabric will provide thickness and strength without the stretch of knitted or braided fabrics. With high tenacity, woven structures are lightweight and stable but hold their shape for support/repair or replacement functions that must retain their original form. Spinal Restoration and tendon repair are two orthopedic applications that benefit from these advantages [27, 28]. Moreover, because they must be strong and require a certain amount of space to retain their form even during joint or system movement, density is also a necessity.

Other important measures in the preparation of the medical textile includes

- Denier – the filament count in multifilament fibers, which can affect density and processability.
- Tenacity – the strength per denier, which is often necessary regarding implant performance.
- Heat shrink – the amount of shrinkage at a particular time and temperature, which can be an important factor for decisions based on further downstream processing including sterilization.

The most common uses of biomaterials are to create aseptic conditions for the protection, general health care, hygiene, bedding, clothing (Fig. 3), mattress covers, surgical gowns, face masks, shoe covers, apparel, sterilization wraps (Fig. 4), dressing materials (Fig. 5), suture anchors (Fig. 6), incontinence care pads, nappies, tampons, fiber cast for immobilisation of the fracture (Fig. 7), and braces/orthotics (Fig. 8). These are also used for the preparation of wipes, swabs, wound dressings, bandages, gauzes, plasters, pressure garments, orthopedic belts and for new applications, such as heart valves, vascular grafts, artificial veins, artificial tendons and ligaments, artificial bones, artificial skin, and artificial cartilage [29-33].

Figure 3: Sterile Gowns and Drapes used to Create an Aseptic Environment During Surgeries in Operation Theatre.

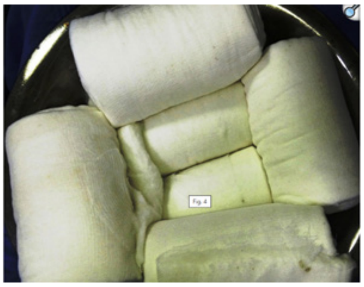

Figure 4: Bandages used to cover wounds.

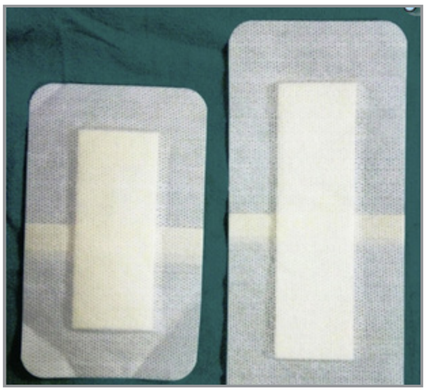

Figure 5: Sterile Bandage with Cotton Pad used for Dressing.

Figure 6: Suture Anchor, Used in Repair of Tendons and Ligament Avulsion.

Figure 7: Fibre Cast, Used for Supporting and Immobilizing a Fractured Limb.

Figure 8: Orthotics Used for Supporting and Immobilizing a Limb.

The demand for these medical textiles is rising exponentially as it offers a variety of technical & functional properties rather than for just their aesthetic or decorative characteristics.

Commonly used materials for preparation of biomedical textiles includes Cotton, Nylon, Silk, Ultra-high molecular weight polyethylene (UHDPHE), Polyester, Polypropylene, Poly tetra-fluoro ethylene, Polyether ether ketone (PEEK), and Polyether ketone (PEKK).

The advantages of using biomaterials in medicine are tremendous such as they may reduce the incidence of cross infection apart from being cost-efficient and recommended by the WHO surgical material usage guidelines. The ability to modify the structure at molecular level gives a cutting edge in seeking the desired interaction with the biological environment.

The problem which was faced in the initial years with implants was its reaction in the host as well as the longevity [34-36]. However, with the advent of third generation biomaterials, this problem has been taken care off. Now the biggest problems in the postoperative period are multifactorial rather than implant based. The difference perhaps was mainly due to research in the field of textiles and applying these to manufacture more biocompatible and sturdy implants. For instance, there was a significant reduction in abrasion by the introduction of highly cross-linked polyethylene (PE), antioxidant stabilized PE, new ceramics and the development of ceramic and protective surfaces [37].

Conclusion

The truth is that nowadays the use of biomedical textiles is more rampant than anyone realizes. Therefore, an adequate knowledge about these materials is of paramount importance. It will help in the better management of patients by further improving its usage. There are numerous papers available freely which discuss the mechanical and chemical properties of the variously available biomaterials. Therefore, this is not touched upon in this article as the main aim here was to instill awareness and curiosity in the reader's mind. In future, it is possible to acquire an ideal biomaterial which is inert, wear resistant, durable, affordable and easily available if the quest for learning and delivering prevails.

References

1. Ambrosio, L., Netti, P., & Iannace, S. (1996). Composite hydrogels for intervertebral disc prostheses. Journal of Materials Science: Materials in Medicine, 7(7), 525-530.
2. Vaccaro, A. R., Singh, K., & Haid, R. (2003). The use of bioabsorbable implants in the spine. The Spine Journal, 3(3), 227-237.
3. Jiya, T. U., Smit, T., & van Royen, B. J. (2011). Posterior lumbar interbody fusion using non-resorbable poly-ether-ether-ketone versus resorbable poly-L-lactide-co-D, L-lactide fusion devices: Clin-

ical outcome at a minimum of 2-year follow-up. European Spine Journal, 20(4), 618-622.
4. Iuchi, R., Mae, T., & Shino, K. (2017). Biomechanical testing of transcapsular meniscal repair. Experimental Orthopaedics, 4(2).
5. Ahlfeld, S. K., Larson, R. L., & Collins, H. R. (1987). Anterior cruciate reconstruction in the chronically unstable knee using an expanded polytetrafluoroethylene (PTFE) prosthetic ligament. American Journal of Sports Medicine, 15(4), 326-330.
6. Pasa, L., Pokorný, V., & Adler, J. (2001). Arthroscopic treatment of the unstable knee joint by ligament reconstruction using allografts. Acta Chirurgiae Orthopaedicae et Traumatologiae Cechoslovaca, 68(1), 31-38.
7. Schepsis, A. A., & Greenleaf, J. (1990). Prosthetic materials for anterior cruciate ligament reconstruction. Orthopedic Review, 19(11), 984-991.
8. Andrish, J. T., & Woods, L. D. (1984). Dacron augmentation in anterior cruciate ligament reconstruction in dogs. Clinical Orthopaedics and Related Research, 183, 298-302.
9. Hench, L. L. (1980). Biomaterials. Science, 208(4446), 826-831.
10. Fisher, J., & Dowson, D. (1991). Tribology of total artificial joints. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 205(2), 73-79.
11. Sutula, L. C., Collier, J. P., & Saum, K. A. (1995). The Otto Aufranc Award: Impact of gamma sterilization on clinical performance of polyethylene in the hip. Clinical Orthopaedics and Related Research, 319, 28-40.
12. Swanson, A. B. (1968). Silicone rubber implants for replacement of arthritic or destroyed joints in the hand. Surgical Clinics of North America, 48(5), 1113-1127.
13. Blair, W. F., Shurr, D. G., & Buckwalter, J. A. (1984). Metacarpophalangeal joint implant arthroplasty with a silastic spacer. Journal of Bone and Joint Surgery—American Volume, 66(3), 365-370.
14. Bass, R. L., Stern, P. J., & Nairus, J. G. (1996). High implant fracture incidence with Sutter silicone metacarpophalangeal joint arthroplasty. Journal of Hand Surgery—American Volume, 21(5), 813-818.
15. Hirakawa, K., Bauer, T. W., & Culver, J. E. (1996). Isolation and quantitation of debris particles around failed silicone orthopedic implants. Journal of Hand Surgery—American Volume, 21(5), 819-827.
16. Adams, D., Williams, D. F., & Hill, J. (1978). Carbon fiber reinforced carbon as a potential implant material. Journal of Biomedical Materials Research, 12(1), 35-42.
17. Podoshin, L., Nodar, R. H., & Hughes, G. B. (1988). Long-term histologic study of a new carbon–carbon ossicular replacement prosthesis. American Journal of Otology, 9(5), 366-375.
18. Olson, E. J., Kang, J. D., & Fu, F. H. (1988). The biochemical and histological effects of artificial ligament wear particles: In vitro and in vivo studies. American Journal of Sports Medicine, 16(6), 558-570.
19. Shiratsuchi, A., Kaido, M., & Takizawa, T. (2000). Phosphatidylserine-mediated phagocytosis of influenza A virus-infected cells by mouse peritoneal macrophages. Journal of Virology, 74(19), 9240-9244.
20. Greis, P. E., Georgescu, H. I., & Fu, F. H. (1994). Particle-induced synthesis of collagenase by synovial fibroblasts: An immunocytochemical study. Journal of Orthopaedic Research, 12(2), 286-293.
21. Ciccone, W. J., Motz, C., & Bentley, C. (2001). Bioabsorbable implants in orthopaedics: New developments and clinical applications. Journal of the American Academy of Orthopaedic Surgeons, 9(5), 280-288.
22. Hench, L. L., & Polak, J. M. (2002). Third generation biomedical materials. Science, 295(5557), 1014-1017.
23. Vaishya, R., Agarwal, A. K., Tiwari, M., Vaish, A., Vijay, V., & Nigam, Y. (2018). Medical textiles in orthopedics: An overview. Journal of Clinical Orthopaedics and Trauma, 9(Suppl 1), S26-S33.
24. Gokarneshan, N. (2024). Evaluating the therapeutic effect of nanofibers on diabetic foot ulcers – An innovative approach. Journal of Nanotechnology and Nanomedicine.
25. Gokarneshan, N. (2018). Analysis of the compression behaviour of warp knit spacer fabrics for evaluating suitability in cushioning applications. Journal of Textile and Apparel, Technology and Management.
26. Gokarneshan, N. (2023). Antibacterial finishes on textile materials with eucalyptus. EC Emergency Medicine and Critical Care.
27. Gokarneshan, N., Jothimanikandan, A., Periyasamy, P., Ponmaniselvam, M., & Sridhar, K. (2024). Development of silk scaffolds for newer areas of applications in tissue engineering. Clinical Research and Studies, 3(4), 2835-2882.
28. Gokarneshan, N., & Velumani, K. (2018). Some significant advances in spacer fabric technology for newer areas of applications. Journal of Textile Science and Engineering.
29. Gokarneshan, N. (2018). Nano finishing of textiles. Abhishek Publications.
30. Gokarneshan, N. (2020). Antimicrobial properties of bamboo fibres. Biomedical Journal of Technical and Scientific Research.
31. Gokarneshan, N., & Ratna, U. (2021). Textile applications of carbon nanotubes. International Journal of Creative Research Thoughts.
32. Gokarneshan, N., & Velumani, K. (2018). A review of some recent breakthroughs in medical textiles research. Current Trends in Fashion Technology and Textile Engineering.
33. Gokarneshan, N. (2017). Advances in nano textile finishes – An approach towards sustainability. Textiles and Clothing Sustainability, Nano Textiles and Sustainability.
34. Gokarneshan, N. (2024). Application of pomegranate rind extract for improvement of functional properties of various materials – A critical review. Open Journal of Composite Materials.
35. Gokarneshan, N., & Jenita, D. M. (2023). Mathews Journal of Case Reports.
36. Gokarneshan, N., & Dhatchayani, U. (2017). Advances in medical knits. Journal of Textile Engineering and Fashion Technology.
37. Gokarneshan, N. (2018). Role of knit spacer fabrics in the treatment of pressure ulcers. Global Journal of Addiction and Rehabilitation Medicine.