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Short Communication

Medical Textiles - Vascular Graft

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ABSTRACT
Vascular graft supports the patient having cardiovascular problem to continue their normal life. PET and PTFE are chemically stable material after implant when compared with others. PTFE is most successful material for small diameter vascular graft. Good handling property of graft includes kink and preclotting resistant during implant and it should be high resistant to in vivo biodegradation, low thrombogenicity and high breaking strength.

KEYWORDS: Vascular Graft, Myocardial Infarcts, Biopolymer, Artery, Polydioxanone

INTRODUCTION

Atherosclerosis is a coronary heart disease which is one of the greatest contributors of cardiovascular disease. Within the artery plaque are build up that are made of low density lipoproteins, fatty acid, collagen, and calcium. Plaque make the blood vessels rigid, the blood platelets are adhere with the plaque and begins thrombus formation which causes the reduction in oxygen and nutrient delivery to the heart muscle and leads heart stroke (myocardial infarcts). 2220 deaths per million people are caused by cardiovascular disease in 2005 at USA. Treatment after diagnosis is essential to replace the diseased arteries having blockage with the synthetic one [1]. They are generally made of
P.E.T (poly-ethylene-teraphthalate)
PTFE (poly-tetra-fluroethylene)
Many other materials are also utilized but in small quantity and few of them are on experimentation level. These materials are polyurethane, nylon, silicon rubber graft and more than one polymer vascular graft structure are also developed. They are used in the form of woven, knitted, non woven and the effort is going on to develop low diameter vascular graft by means of electro spinning using bio- polymer.

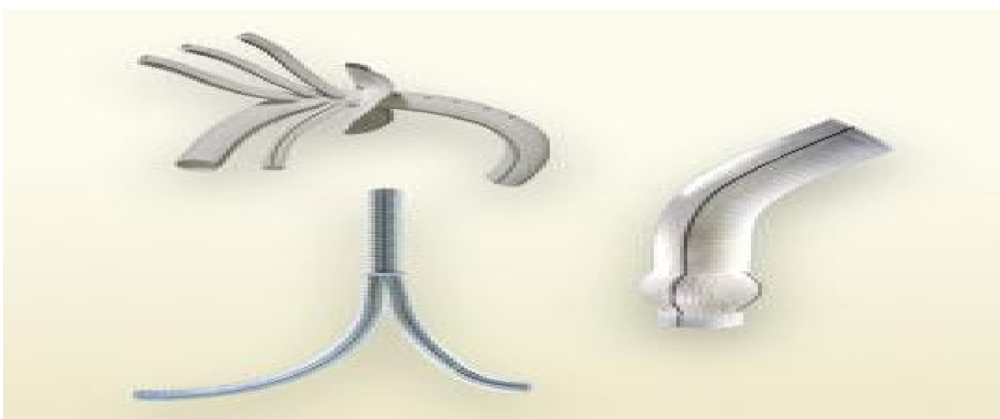


FIGURE 1: Pictorial view of vascular graft

Requirement of Vascular Graft

Porosity, stiffness and type of surface coating are also significant for vascular graft. The major development in this area is bioabsorbable material is being used with semi-absorbable structure. The fibers like collagen have an application and the future material to coat the graft will be protein structure as albumin or gelatin.

- Design Requirements of Graft
- Desirable biocompatibility.
- Sufficient viscoelastic properties similar to blood vessels so that it is sufficiently compliant but will not allow for over expansion or bursting.
- Long-term mechanical stability.
- Prevent graft leakage which can lead blood loss and also it should be abrasion resistant. Presumably, biomaterial surfaces will be more compatible with the human body if they have similar chemistry, morphology and mechanical properties to cell surfaces [2].

Properties of an ideal vascular graft

- Capable of withstanding long-term hemodynamic stress without failure.
- Availability, storability, and simplicity of handling to minimize operating time, risks, and expense.
- Resistance to thrombosis and infection.
- Complete incorporation by the body to yield a neovessel resembling a native artery in structure and function.

3 Material used for the manufacturing of vascular graft

3.1 PET, Dacron Vascular Graft

PET is a synthetic fiber made of thermoplastic polymer have a multiple application from plastic and resin to fiber and now it is completely recyclable. Here the vanderwall force holds the repeating unit so it can be melted or moulded with the heat. The aromatic ring contribute to high melting point (Tm 257° C) , high tensile strength (40 to 80 Mpa), as well as high Young modulus up to 3000 Mpa which higher is than the PTFE and polyurethane, so the structure made of PET required higher load to deform.

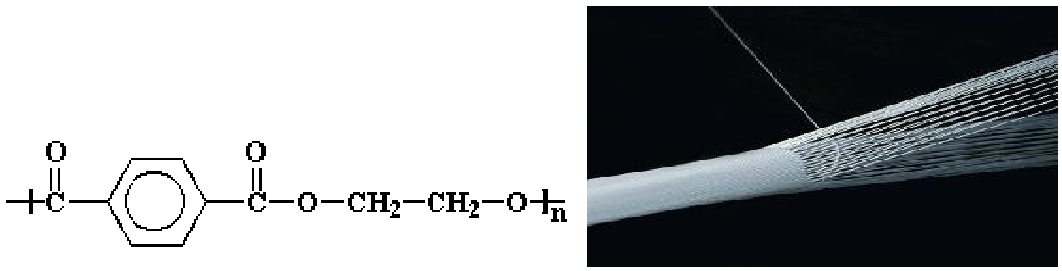
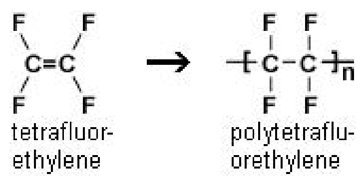


FIGURE 2: Pictorial view of PET structure and weaving of vascular graft.

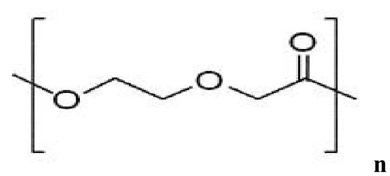
As the vascular graft application PET is available in the form of knitted and woven with particular coating that enhance the hydophilicity as well as it is compatible with the human body have least adherence with the blood platelets. Many of the biological components as albumin protein, or any bioabsorbable can be incorporated to promote the faster healing. It was a past when the integrity of Dacron graft depends on the coating of patient blood here the blood fills up the air present in the woven or knitted structure. Now new technology is employed as a sealant that seals the graft. In this process the graft surface is sealed with the gelatin or albumin coating [3].

3.2 PTFE

Polytetrafluoroethylene is a fluoro polymer, it has high molecular weight and hydrophobic in nature as well as it is material has lowest coefficient of friction. Porosity of the graft is important for the in growth of tissue healing process. The porous structure of vascular graft is manufacture by the hollow body of PTFE by means of expanding of fluoroplastic body. That is characterized by the microporous node and fibril structure. Another type of vascular graft is also made by the one or more polymer fiber wound about the mandrel, these fibers are wound in such a manner that they form a solid structure, and the pores are defined by the adjacent fiber spacing. Different types of fiber combination can used to obtain desired physical and chemical property. The disadvantage of this graft is larger pore size so it promotes bleeding. According to US a patent the inventor has made the vascular graft with two layer of PTFE. They suppose to eliminate the basic drawback of PTFE graft. The graft includes first ePTFE tubular structure and second structure is circumferentially disposed about the first structure, the porosity and physical strength of both of layer can be varied. The first tubular structure provides porosity that promotes sufficient indothelization and the second layer exhibit strength vice-versa can also be used to promote rapid tissue incorporation [4].



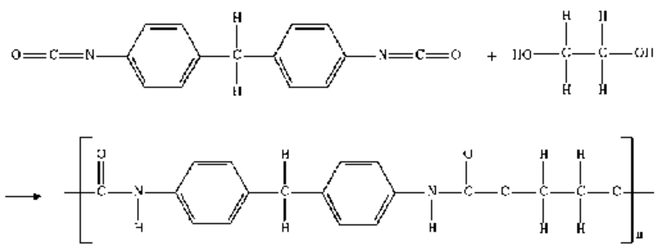
3.3 Polydioxanone



Polydioxanone is a polymer of multiple repeating unit of ether and ester unit, and obtained by the ring opening polymerization. In the form of fiber it is generally extruded with enough care. Polydioxane has a biomedical application particularly in the form of surgical sutures another application includes plastic surgery, drug delivery, and promotes tissue ingrowths. Researchers at Virginia Commonwealth University (VCU), USA, have developed a bio-composite vascular graft made of Polydioxanone (PDO, a synthetic biodegradable polymer) and Elastin, (natural polymer, which is also a major component of the arterial wall) by means of electrospinning techniques. The composition of the material reinforces the graft's mechanical strength, which is critical in order to hold the blood pressure and forces while the regeneration process is taking place. The PDO-Elastin blend undergoes slow degradation and causes few adverse reactions. The purpose of the new material would be to help a patient regenerate a new artery. If it works as designed the researchers hope that at six months post-surgery, there would be no more synthetic structure left [5].

3.4 Polyurethane Vascular Graft

Poly(carbonate)urethane.



PET and PTFE vascular graft have application in large diameter graft. In small diameter (<6mm) the rate of failure is high, this is because the compliance does not match with the surrounding host tissue or there may be inability of graft to support endothelial mono layer as well as PET and PTFE are two to five times stiffer than the natural arteries . For small diameter graft polyurethane material has investigated where mono layer of endothelial present at the surface to circulate the blood. Here the endothelial cell has major significance as vascular permeation and regulation, secretion of anticoagulants as well as it control the trafficking of leukocytes platelets and red blood cell. Here the process is to extrude polymer solution onto the smooth surface of a mandrel. The mandrel and extrusion head rotate in synchronization, minimizing shear and residual stress. Mandrel rotation and transverse speed, extrusion head rotation speed and polymer pump pressure are all electronically controlled and coordinated to give the desired structure and geometry to the graft wall. By controlling the process conditions, grafts can be produced with a wide range of physical and mechanical characteristic. Porous graft allowing rapid cellular ingrowths which could be suited to venous application [6, 7].

4. Coating of vascular graft

Polysaccharides

The class of natural polymers can be divided in two main group's polysaccharide and protein based polymers. The polysaccharide based polymers comprise of chitosan, starch, alginate, hyaluronic acid and chondroitin sulphate and can be obtained from different sources, such as microbial, animal, or vegetable and show good hemocompatibility and non-toxicity. Protein based polymers include collagen, gelatin, fibrin, and albumin. The availability of large quantities and the good biocompatibility of these natural polymers make them an attractive alternative for drug delivery devices [8].

Collagen is the primary and major structural protein of vertebrates and representing almost 30% of total protein present in a body. Due to biocompatibility and biodegradability with the property of controlled release of therapeutic agents makes it a useful material to coat the vascular graft. Here the method of cross linking by means of chemical and physical method prevents the rapid degradation of collagen based biomaterial during in vivo application. It also improves the mechanical property. The degradation of biomaterial is allowing the ingrowths of periprosthetic tissue. It convert the hydrophobic polyester surface into hydrophilic by chatal bond using metal ion.

5. Vascular graft surface modification by plasma

Plasma in argon, oxygen or ammonia has converted the normally hydrophobic surface of ePTFE tubing to a stable hydrophilic surface. The change has been maximized by statistical selection of the plasma parameters and has been analysed by contact angle measurements with three liquids, in order to obtain the dispersive and polar components of the surface energy, and by XPS. Argon produced the most hydrophilic surfaces (and oxygen the least) due to a much-increased polar component of their surface energy [9]. Radio frequency plasma technique is used for the surface modification of synthetic implant as vascular graft whether it is made of PET or PTFE. It enables covalent immobilization of cell-binding peptides derived from the extra cellular matrix proteins as fibronectin. Here the mono layer of grafted peptide promotes healthy endothelial cell proliferation from the natural blood. The biocompatibility is then improved so there has reduction in antigenicity and thrombogenicity. Tetrafluoroethylene plasma coatings on small-diameter Dacron vascular grafts have demonstrated a dramatic improvement in patency. Plasma or corona discharge where electrode activate the surrounding gas layer and activated ion reacted with the fabric surface and there by hydophilicity getting increased [10]

Biomimetic approaches those are rely on bioabsorbable synthetic or natural materials as a scaffolding to provide a temporary biomechanical profile until the cells produce their own extracellular matrix is the feature of vascular graft where 'hemodynamic' competence and suturing characteristics are critical. A continuous loss of mechanical properties is parallel to the biodegradation-related decrease of the mechanical strength of the scaffold material. Since the scaffold was supposed to provide only a temporary biomechanical profile until the cells produce their own matrix proteins the structural integrity and biomechanical profile of the tissue-engineered vessels ultimately depended on this matrix formation [11].

6. Test required for vascular graft

Vascular graft made of woven fabric should be tightly woven rigid structure which possesses low permeability. The knitted prosthesis is easier to handle than woven fabric because they are easily elongated. Thinner construction of these knitted vascular grafts is not effective because of they cannot support cyclic stress of the arterial circulation over a long time. The porosity of knitted vascular grafts is reduced by compression method to the acceptable water permeability. Crimping technique provide the prevention of graft from wrinkling and kinking. Permeability test of vascular graft provides the information of leakage of prosthesis wall before preclotting. Water and blood of dog is used for the permeability test. Relative density is evaluated in the terms of fiber density in the woven or knitted structure as well as the tightness factor of knitted graft. The diameter of yarn in vascular graft is measured by using optical microscopy. Fatigue test is evaluated in terms of bursting and crimp extension test. Bursting test provides information of stress sustainability in terms of pressure and crimp extension evaluates the stretch ability [12].

FIGURE 3: Pictorial view of vascular graft with kinking property [13].

Currently (PET) Dacron is used for aortic replacement and large diameter lower-extremity bypass surgery. Several researchers are trying to concentrate to improve available material for surgical modification, coating and endothelial cell seeding to overcome the vascular graft failure. Vascular graft required manufacturing precision due to their small size. Now modern technology has been developed to produce these medical devices by weaving of very fine polyester or UHMWPE (Ultra high molecular weight polyethylene) and other fibers. They are suitable for sensitive implant because these materials are stronger and flexible.

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