Ninth lecture

Soft Tissue Replacement

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Fourth Stage

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2023 -2022

Soft Tissue Replacement — I: Sutures, Skin, And Maxillofacial Implants

In soft tissue implants as in other applications that involve engineering, the performance of an implanted device depends on both the materials used and the design of the device or implant. The initial selection of material should be based on sound materials engineering practice. The final judgment on the suitability of the material depends on observation of the in vivo clinical performance of the implant. Such observations may require many years. This requirement of in vivo observation represents one of the major problems in the selection of appropriate materials for use in the human body. Another problem is that the performance of an implant may also depend on the design rather than the materials per se.

It should be recognized that different applications require different materials with specific properties. The following are minimal requirements for all soft tissue implant materials:

1. They should achieve a reasonably close approximation of physical properties, especially flexibility and texture.

2. They should not deteriorate or change properties after implantation with time.

3. They should not cause adverse tissue reaction. 4. They should be noncarcinogenic, nontoxic, nonallergenic, and nonimmunogenic.

5. They should be sterilizable.

6. They should be low cost.

Sutures, Surgical Tapes, and Adhesives

The most common soft tissue implants are sutures. In recent years, surgical tapes and tissue adhesives have been added to the surgeon's armamentarium. Although their use in actual surgery is limited to some surgical procedures, they are indispensable.

Sutures

There are two types of sutures, classified as to their long-term physical in vivo integrity: absorbable and nonabsorbable. They may also be distinguished by their raw material source: natural sutures (catgut, silk, and cotton) and synthetic sutures (nylon, polyethylene, polypropylene, stainless steel, and tan- talum). Sutures may also be classified according to their physical form: monofilament and multifilament. The absorbable suture, catgut, is made of collagen derived from sheep intestinal submucosa. It is usually treated with a chromic salt to increase its strength and is cross-linked to retard resorption. Such treatment extends the life of catgut suture from 3-7 days up to 20-40 days. Table 9-1 gives initial strength data for catgut sutures according to their sizes. The catgut sutures are preserved with needles in a physiological solution in order to prevent drying, which would make the sutures very brittle and thus not easily usable.

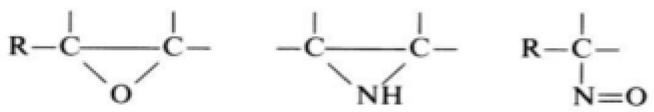
Surgical Tapes and Staples

Surgical tapes are intended to offer a means of avoiding pressure necrosis, scar tissue formation, problems of stitch abscesses, and weakened tissues. The problems with surgical tapes are similar to those experienced with Band-Aids: (1) misaligned wound edges, (2) poor adhesion caused by moisture or dirty wounds, (3) late separation of tapes when hematoma, wound drainage, etc. occur. The wound strength and scar formation in the skin may depend on the type of incision made. If the subcutaneous muscles in the fatty tissue are cut and the overlying skin is closed with tape, then the muscles retract. This in turn increases the scar area, resulting in poor cosmetic appearance compared to a suture closure.

Tissue Adhesives

The special environment of tissues and their regenerative capacity make the development of an ideal tissue adhesive difficult. Past experience indicates that the ideal tissue adhesive should be able to be wet and bond to tissues, be capable of rapid polymerization without producing excessive heat or toxic by-products, be resorbable as the wounds heal, not to interfere with the normal healing process, have ease of application during surgery, be sterilizable, have adequate shelf life, and ease of large-scale production.

The main strength of tissue adhesion comes from the covalent bonding between amine, carboxylic acid, and hydroxyl groups oftissues, and the functional groups of adhesives such as



There are several adhesives available of which alkyl-a-cyanoacrylate is best known. Among the homologues of alkyl-cyanoacrylate, the methyl- and ethyl-2-.

Percutaneous and Skin Implants

The need for percutaneous (trans or through the skin) implants has been accelerated by the advent of artificial kidneys and hearts, and by the need for prolonged injection of drugs and nutrients. Artificial skin (or dressing) is urgently needed to maintain the body temperature of severely burned patients. Actual permanent replacement of skin by biomaterials is beyond the capability of today's technology.

Maxillofacial and other Soft-Tissue Augmentation

In the previous section we have dealt with problems associated with wound closing and wound/tissue interfacial implants. In this section we will study (cosmetic) reconstructive implants. Although soft-tissue implants can be divided into (l) space filler, (2) mechanical support, and (3) fluid carrier or storer, most have two or more combined functions. For example, breast implants fill space and provide mechanical support.

Maxillofacial Implants

There are two types of maxillofacial implant (often called prosthetics, which implies extracorporeal attachment) materials: extraoral and intraoral. The latter is defined as "the art and science of anatomic, functional or cosmetic reconstruc- tion by means of artificial substitutes of those regions in the maxilla, mandible, and face that are missing or defective because of surgical intervention, trauma, etc." There are many polymeric materials available for the extraoral implant, which requires: (l) color and texture should be matched with those of the patient, (2) it should be mechanically and chemically stable, i.e., it should not creep or change colors or irritate skin, and (3) it should be easily fabricated. Polyvinyl chloride and acetate (5-20%) copolymers, polymethyl methacrylate, silicone, and polyurethane rubbers are currently used.