SUTURES:

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

There are two types of sutures according to their physical in vivo integrity, that is, absorbable and nonabsorbable. They may be distinguished according to their source of raw materials, that is, natural sutures (catgut, silk, and cotton) and synthetic sutures (nylon, polyethylene, polypropylene, stainless steel, and tantalum). Sutures may also be classified according to their physical form, that is, monofilament and multifilament. The absorbable suture, catgut, is made of collagen and is derived from sheep intestinal submucosa.

It is usually treated with a chromic salt to increase its strength and retard resorption by cross-linking. Such treatment extends the life of catgut suture from 3-7 days up to 20-40 days. It is interesting to note that the stress concentration at a surgical knot decreases the suture strength of catgut by half, no matter what kind of knotting technique is used. It has been suggested that the most effective knotting technique is the square knot with three ties to prevent loosening. According to one study there is no measurable difference in the rate of wound healing whether the suture is tied loosely or tightly. Therefore, loose suturing is recommended because it lessens pain and reduces cutting soft tissues.

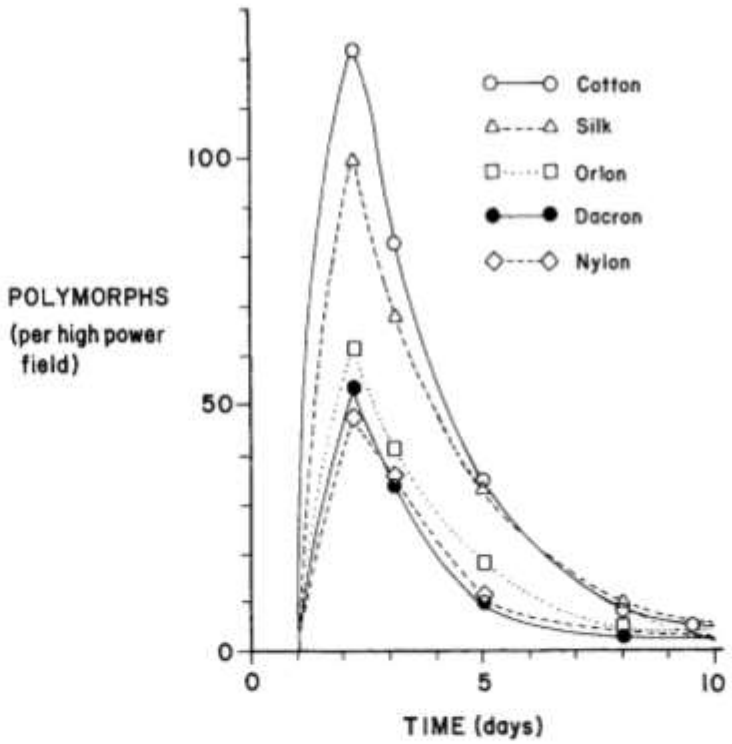


Figure 11-1. Cellular response to sutured materials. (From Ref. 4.)

Catgut and other absorbable sutures [nylon, polyglycolic acid (PGA)] invoke tissue reactions although the effect diminishes as they are being absorbed. This is true of other natural, nonabsorbable sutures like silk and cotton, which show more reaction than synthetic sutures like polyester, nylon, and polyacrylonitrile. As is the case in the would-healing process, the cellular response is most active 1 day after suturing and subsides in about a week.

It is interesting to note that if the suture is contaminated even slightly, the incidence of infection increases manyfold. The most significant factor is that the chemical structure and the geometric configuration of the suture seem to have no influence on the infection. Polypropylene, nylon, and PGA sutures cause less infection than other sutures, e.g., stainless steel, plain and chromic catgut, or polyester sutures.

SURGICAL TAPES:

The use of surgical tapes is supposed 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, that is,

(1) misaligned wound edges,

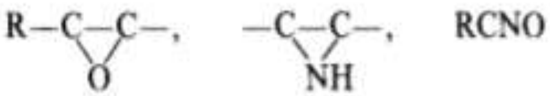
(2) poor adhesion due to moisture or dirty wounds,

(3) 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 were cut and the overlying skin was closed with tape, then the muscles retract. This in turn increases the scar area, resulting in poor cosmetic appearance when compared to a suture closure. However, due to the higher strength of scar tissue, the taped wound has higher wound strength than the sutured wound only if the muscle was not cut. Because of this, tapes have not enjoyed the success which was anticipated when they were first introduced, although early studies recommended their use enthusiastically. Tapes have been used successfully for assembling scraps of donor skin for skin graft, correcting nerve tissues for neural regrowth, etc.

TISSUE ADHESIVES:

The special environment of tissues and their regenerative capacity make the development of an ideal tissue adhesive difficult. Through past experience, the ideal tissue adhesive should be able to be wet and bind to tissues, be capable of rapid polymerization without producing excessive heat or toxic by-products, be resorbable as the wounds heal without interfering with the normal healing process, have ease of preparation for use in the operating theater, 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 of tissues, and functional groups such as



There are several adhesives available of which alkyl-a-cyanoacrylate is best known. Among the homologs of alkyl-cyanoacrylate, the methyl- and ethyl-2-cyanoacrylate are most promising. With the addition of some plasticizers and fillers, they are commercially known as Eastman 910 and Alpha S-2, respectively. An interesting comparison is illustrated in Figure 11-2, which shows that the bond strength of adhesive-treated wounds is about half that of the sutured wound after 10 days.

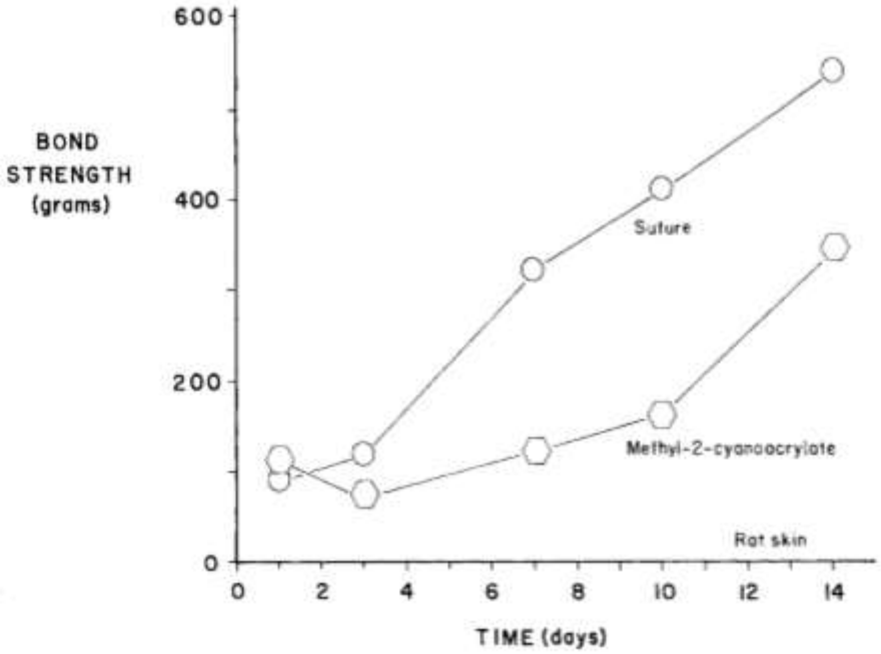


Figure 11-2. Bond strength of wounds with different closure materials. (From Ref. 11.)

Because of the lower strength and lesser predictability of in vivo performance of adhesives, their application is limited to use after trauma on fragile tissues such as spleen, liver, and kidney or after an extensive surgery on soft tissues such as lung. The topical use of adhesives in plastic surgery and fractured teeth has been moderately successful. As with any other adhesive, the end results of the bond depend on many variables such as thickness, porosity, and flexibility of the adhesive film, as well as the rate of degradation. A polyurethane prepolymer type of adhesive was first used to bond bone fractures in 1959 and has since been studied for use in soft tissue repair. Beech experimented with three types of adhesives for dental application. Therefore, bond strength is decreased when used in dentin, which has less calcium bonding sites than enamel. If the dentin is hypercalcified by a saturated solution of calcium hydrogen phosphate ("Brushite") and 100 ppm fluoride ion at pH 6.5, the bond strength increases. The alkyl-2-cyanoacrylates have been shown to form covalent bonds with proteins. The TBB-MMA (tributyl, boron-initiated methylmethacrylate) system bonds to protein by graft copolymerization. The P / A-MMA (peroxide, amine-treated methylmethacrylate) system shows almost negligible bonding capacity to any of the substrates when no primary bonding mechanism is present. Others have demonstrated that the interdiffusion and precipitation of polyelectrolytes on a dentin surface can lead to a strong adhesion of the applied, cured polymer layer. Adhesives have been prepared from fibrinogen, one of the clotting elements of blood. This material has sufficient strength (0.1 MPa) and elastic modulus (0.15 MPa) to sustain the adhesiveness for the anastomoses of nerve, microvascular surgery, dural closing, bone graft fixation, skin graft fixation, and other soft tissue fixation. This material is available commercially in Europe and will be in the U.S. pending FDA approval.