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Material science from the implant industry point of view

A Spiegel[1], H Polzhofer[1], M Ammann[1]
[1]*Medartis AG, Basel, CH*

Implants may be used for different purposes and hence the requirements placed on them vary widely. It follows that the industry producing these implants is rather heterogeneous. Rather than bundling all implants as one, different applications and classes of implants must be distinguished. A fundamental differentiator is the intended period of implantation. Implants that are to permanently replace a biological structure such as joint replacements, dental implants, or mammal implants must be biostable and remain localized in the human body. Stable integration into hard or soft tissue is typically a requirement independent of the mechanical demands which may vary widely. Hip or knee implants are subjected to high mechanical loading and difficult tribological conditions, dental implants must be abrasion resistant and meet stringent cosmetic criteria, and mammal implants should provide satisfactory tactile properties, integrate with soft tissue while preventing capsule formation.

In the following article, we will focus on plates and screws for craniomaxillofacial and trauma applications intended for bony fixation after an accidental fracture or a planned intervention. These have to meet a wide range of often contradicting requirements (shown in Table 1).

Table 1. Requirements of bone-plates and -screws

	High	Low
Mechanical Strength	Secure fracture fixation	Can be adapted during surgery
Elasticity, E	Prevent micro-motion	No cut-through in bad bone
Tissue integration	No liquid filled fibrous capsules	Free gliding of tendons

Whereas the mechanical requirements can usually be met through an appropriate design, the correct tissue response has proven to be more difficult to provide. Especially, as there is still no general consensus as to what actually constitutes the desired response.

Traditionally, good tissue integration has been desirable even for non-permanent implants. Formation of a fibrous capsule around an implant [1] is not desirable as this may lead to the formation of a liquid-filled immunoincompetent zone prone to pathogen proliferation [2]. Whether this is actually the case, especially in cases of large tendon displacements e.g. for finger implants is still under debate [3].

In recent years, the factors governing interaction between tissue and metal implants have been studied extensively. The questions as to whether material or topography play the main part in this interaction seems to be mostly answered in favour of topography. Summarized very briefly, the smoother a surface the less tissue integration will occur [4]. However, topography is not independent of the material chosen. And while technology to produce smooth stainless implants is cheap and readily available in the form of electropolishing the same is not true for other materials such as commercially pure Ti (cp Ti) or its alloys.

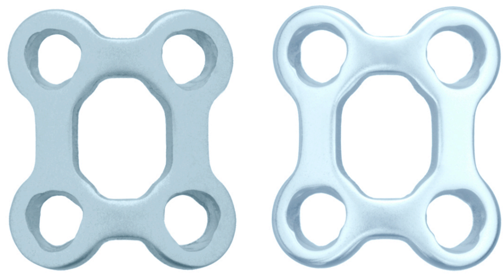

Fig. 1: Images of hand implants with 'standard' microrough surface (left) and highly polished surface (right).

Medartis has investigated methods for producing smoother cpTi implants for specific applications (e.g. hand) and has gone from simple mass finish processes followed by pickling and anodization to more sophisticated processes thereby reducing surface roughness by a factor of 2. Whether this will actually result in better clinical results still remains to be seen.

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