TITANIUM, A METAL FOR SURGERY

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J. Bone Joint Surg. Am. 33:473-474, 1951.

27. MURRAY, M. R.; STOUT, A. P.; and POGOGEFF, I. A.: Synovial Sarcoma and Normal Synovial Tissue Cultivated *in Vitro*. Ann. Surg., **120**: 843–851, 1944.
28. SHACKMAN, RALPH: Malignant Synovioma of the Left Elbow. Proc. Royal Soc. Med., **40**: 273–275, 1947.
29. SMITH, L. W.: Synoviomata. Am. J. Pathol., **3**: 355–364, 1927.
30. SPRINZ, HELMUTH: A Case of Synovial Sarcoma With Metastases. Bull. U. S. Army Med. Dept., **9**: 131–140, 1949.
31. STANFORD, S., and HORNE, E. A.: Malignant Synovioma. J. Bone and Joint Surg., **25**: 883–891, Oct. 1943.
32. WAGNER, L. C.: Malignant Tumor of Synovial Membrane of Knee-joint. Excision; Recurrence; Second Excision and Post-operative Treatment. Ann. Surg., **101**: 809–810, 1935.
33. Warren, SHIELDS: Synovial Sarcoma of the Soft Tissue of the Leg. J. Missouri State Med. Assn., **45**: 351–354, 1948.
34. WILLIAMS, R. D., and MAHAFFEY, H. W.: Synovioma: A Case Report with Pulmonary Metastases that Regressed Following Irradiation. Ohio State Med. J., **45**: 988–990, 1949.

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Vitallium and SMo stainless steel have been used for several years; both alloys have usually been found to be satisfactory for the fixation of fractures. At times, however, the work of the surgeon has been ruined by screws becoming loose, even without infection, prior to the complete organization of the fracture; at other times, screws and plates have been broken, nullifying the attempts at fixation of a fracture.

Clay Ray Murray [2], in reporting for the Committee on Fractures and Other Traumas, of the American College of Surgeons, stated: "The ideal metal for use in the fixation of fractures . . . would be a metal having the physiologically inert characteristics of Vitallium, the mechanical and physical characteristics of the SMo metal". Bothe, Beaton, and Davenport, testing various metals implanted in laboratory animals, found that "the response of bone to titanium was as good, if not better, than to the non-corrosive alloys, in that there was more tendency for the bone to fuse with it". Titanium * has been known as an element for over a century and a half, but it has been very difficult to extract for commercial purposes. At the present time, extraction of the metal is being carried out more extensively, and there promises to be a fairly good supply within a short time at a reasonable price.

Titanium has a tensile strength of 75,000 pounds per square inch and a yield strength of 50,000 pounds per square inch. These properties of titanium are almost identical with those of SMo stainless steel. Titanium is silver-white in color; its weight is about 60 per cent. that of stainless steel, and it is about 60 per cent. heavier than aluminum. It machines in about the same way as stainless steel, and it can be forged and welded. Titanium is highly resistant to corrosion.

Stainless-steel plates and screws have to be handled very carefully; for, if nicks are produced, eddy currents will develop when they are used in the tissues. Since titanium is an element, there is no chance of eddy currents developing, and one does not have to be so

* Titanium was supplied through the courtesy of Remington Arms Co.

careful. Screws with nicks in them, however, should be discarded, for such a mechanical imperfection will not produce clean threads in the bone.

Soft-tissue reaction to titanium was studied by implanting bars of known weight and size into the subcutaneous tissue layer of the dorsal aspect of rabbits. The subcutaneous tissue was examined at intervals of two, four, six, eight, and ten weeks. At no time was there any evidence of induration. At the end of two weeks, a glistening, but slightly cyanotic, synovial-like layer was found at the site of the implant. Study of the tissue revealed nothing that could account for this discoloration. In subsequent weeks, the glistening layer was still present, but the cyanotic appearance had entirely disappeared. A microscopic examination revealed a flattened layer of endothelial-like lining similar to what one would find on the exposed serous surface of any joint. No reaction to the metal was found. The subcutaneous tissue presented a perfectly normal appearance, except for the flattened layer of cells. The walls of the "cyst" enclosing the implant could be gently glided over the titanium implant, but an excess of fluid in the cavity was not found.

Bone reaction was studied by the insertion of 0–80 screws into the femora of rats. A hole was first drilled, and the screw was then inserted. The animals were sacrificed at six, twelve, and sixteen weeks. In no animal was there any infection, induration, or discoloration about the site of the screw in the soft tissues. The site at which the screw was inserted was not enlarged with excessive bone, and the screw head remained outside the bone just as it had been inserted. At the end of six weeks, the screws were slightly tighter than when originally put in; at twelve weeks, the screws were more difficult to remove; and at the end of sixteen weeks, the screws were so tight that in one specimen the femur was fractured when an attempt was made to remove the screw. Microscopic examinations of the bone structure revealed no reaction to the implants. The trabeculation appeared to be perfectly normal.

Flat plates of titanium were studied for weight loss by insertion into the subcutaneous tissue layer of rabbits. The average bar presented a surface of 7.5 square centimeters. After two and one-half months the amount of loss was .0002 gram. This weight loss is insignificant and is really within the limit of error in weighing.

From these studies it would appear that titanium is a metal which may be useful in surgery, because of its strength and its failure to cause tissue reaction. The fact that bone becomes attached to titanium may be a disadvantage in cases where screws or pins are placed temporarily. In the past, the use of some prostheses has not become popular because it has been felt that these would remain separate from the bone and eventually loosen. Since titanium adheres to bone, it may prove to be an ideal metal for such prostheses. Some plates and screws have been used in humans with no reaction clinically or as shown by roentgenograms. A titanium plate one-sixteenth of an inch in thickness is partially radiolucent to roentgen rays. This radiolucency may be an advantage in some cases.

SUMMARY

Studies on titanium made by implanting into subcutaneous tissue of rabbits, and femora of rats, have demonstrated that titanium is an inert metal which appears to be ideal for fixation of fractures. A sufficient number of plates and screws have not been used to determine whether or not they will break in the treatment of fractures. It is hoped that eventually plates and screws can be produced which will not readily break.

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REFERENCES

1. BOTHE, R. T.; BEATON, L. E.; and DAVENPORT, H. A.: Reaction of Bone to Multiple Metallic Implants. Surg., Gynec., and Obstet., 71: 598–602, 1940.
2. COMMITTEE ON FRACTURES AND OTHER TRAUMAS, American College of Surgeons, Proc. Twenty-third Annual Meeting, Atlantic City, New Jersey, January, 1945.