(FROM THE ORTHOPAEDIC HOSPITAL, DEPARTMENT II, COPENHAGEN, CHIEF: SVEN KIÆR, AND FROM THE AGRICULTURAL EXPERIMENTAL STATION, DEPARTMENT OF ANIMAL PHYSIOLOGY, COPENHAGEN, CHIEF: H. MØLLGAARD)

EXPERIMENTAL INVESTIGATION OF THE TISSUE REACTION TO ACRYLIC PLASTICS[1]

By

E. HENRICHSEN, K. JANSEN and W. KROGH-POULSEN

Copenhagen

A property essential for any plastic material used in bone and joint surgery is that it should be biologically inert. Any reaction would be followed by a chemical osteitis with loosening of the material and failure of the operation. Further such material must possess suitable physical properties with regard to strength, elasticity and hardness. It must be easily worked into the shape desired, and it must be capable of being sterilized.

Several acrylic plastics (methyl-metacrylate) prove to be suitable for surgery. Besides ordinary clear heat-polymerized acrylic we have used self-polymerizing acrylic of the "powder and fluid" type. Catalytic agents added to the material make the polymerization take place by room temperature. This material sets like cement in 5–20 minutes.

By this cement acrylic bodies can be fixed to the bone surface, the acrylic and bone becoming one solid unit. By this technique nails and screws can be dispensed with. The cement is furthermore useful for filling out defects and cavities in bone or joint surfaces.

Over the last year we have also used with success caps of acrylic previously shaped for this special purpose. The acrylic bodies were made according to our design by Odus Dental A/G, Dietikon, Zürich. Caps were made for the femoral head, the head of the mandibula, the radius, and humerus. The caps are clear, smooth, and possess the special property of being soft and mouldable at a temperature of 60 centigrades but hard at body temperature. The caps can therefore be cut and modelled exactly during the operation.

[1] Paper read before the fifth congress of S.I.C.O.T., Stockholm, May 1951.

The acrylic monomer is highly toxic to the tissue, and probably the inertness of the plastic depends upon the degree of the polymerization. Further it is likely that the agents added (catalytics and inhibitors) are of some importance.

After testing the plastic materials available some types were selected all possessing the physical properties mentioned. The most difficult estimation is that of the capacity to resist wear, as the conditions

Fig. 1. Left hindleg.
After 2 months. Burr hole with a curled acrylic plate–now removed. A column of connective tissue has grown into an interspace in the acrylic curl. New bone can be observed in the deeper parts of the connective tissue.

in the joints are impossible to reproduce in experiments. Fortunately we have had the opportunity to examine acrylic protheses which have been functioning in a hip joint for periods of about one year. The clear acrylic proved to be satisfactory. The superficial loss of material was less than 0.25 mm. The caps of self-polymerized acrylic demonstrated, however, a serious loss of material and must be considered not suitable for weight-bearing joints.

The acrylics selected were

1) Clear acrylic ("Metex").
2) The same material mixed with barium sulphate 5 per cent, which makes the material radio-opaque.

3) Acrylic cement ("Hesacryl" and "V-15").
4) The caps mentioned.

THE ANIMAL EXPERIMENTS

The acrylics were tested on quick-growing young pigs, the animals being kept under well known conditions.

Fig. 2. Left foreleg.
After 2 months. Residual particles of acrylic cement are seen close to new bone tissue.

In two operations we removed the articular cartilage on the femoral head and replaced it with a plastic cap which was fixed to the bone with self-polymerizing cement. Two months later at autopsy the caps were seen solidly fixed to the bone just like the normal covering of cartilage.

Cylindric rods made of the acrylics were implanted in burr holes in the long bones, in the diaphyses, and in the epiphyses as well. Smaller masses of the acrylic cement were also implanted in burr holes –separately or mixed with other acrylics.

Two till three months later the bones were examined by autopsy, and radiographic and histological examinations were made. The investigation comprised forty experiments.

At autopsy no reaction at all could be found. The acrylic material was in intimate contact with the tissue, and even when the acrylic had been inserted into the bone marrow no reaction was visible. As we had observed clinically, mechanical removal of the acrylic by itself was quite impossible, and a layer of bone always separated with it.

Radiological examination showed neither sclerosis nor rarefaction.

Only twenty out of forty specimens were successfully carried through the difficult preparation for histological examination. In practice it is very difficult indeed to dissolve the acrylic mass with

Fig. 3. Right foreleg.
After one month. Residue of acrylic cement and acrylic body. New bone tissue has formed with a cancellous structure. In the connective tissue a bone island.

chemical solvents and afterwards to decalcify the bone and make sections.

With regard to histological examination this revealed no difference in the reaction between any of the plastics used.

If we follow the changes around the acrylic body, we find that at first the layer of connective tissue fills any space left between the plastic and the bone surface. This tissue contains few cells, apart from occasional groups which may represent a minimal reaction, but which may be nothing more than normal cells derived from the bone marrow.

Later this connective tissue is replaced by new bone tissue. In

relation to cortical bone this new bone has a lamellar structure, while in relation to the cancellous part it also is cancellous. Some areas show that the bone is in intimate contact with the acrylic body without any intermediate connective tissue. The longer the postoperative period, the closer this contact becomes.

SUMMARY

Preliminary experiments with acrylics are reported with special reference to self-polymerizing plastics. Specimens of different acrylic plastics were implanted in the long bones of pigs. After a period of about 2 months the bones were examined by autopsy, radiologically and histologically. The examination revealed no reaction of the acrylics examined. At autopsy the acrylic bodies were found solidly fixed in the bone tissue, and the histological examination showed no sign of osteitis, the bone tissue forming a lamellar wall around the bodies. The results of this preliminary investigation appear to justify further work with acrylic plastics.

ZUSAMMENFASSUNG

Es wird über vorläufige Versuche mit Acryl-Stoffen unter besonderer Berücksichtigung von selbst-polymerisierenden plastischen Stoffen berichtet. Verschiedene Arten von Acryl-Plastik-Stoffen wurden in die Röhrenknochen von Schweinen eingepflanzt. Nach einem Zeitraum von ungefähr 2 Monaten wurden die Knochen autoptisch, röntgenologisch und histologisch untersucht. Die Untersuchung ergab, dass keinerlei Reaktion gegenüber den eingpflanzten Stoffen aufgetreten war. Die Autopsie zeigte, dass die Akrylstücke fest im Knochen verankert waren und die histologische Untersuchung erwies keine Zeichen von Osteitis. Das Knochengewebe bildete eine lamellare Wand um die Fremdkörper. Die Ergebnisse dieser vorläufigen Untersuchungen scheinen ein weiteres Arbeiten mit plastischen Akrylstoffen zu rechtfertigen.

RESUME

Des expériences préliminaires avec matières acryliques sont rapportées et plus particulièrement avec matières plastiques auto-polymérisantes. Des spécimens de différentes matières acryliques ont été implantées dans les os longs chez des porcs. Au bout d'une période de deux mois environ, les os ont été examinés après autopsie et soumis

à un examen radiographique et histologique. Aucune réaction n'a été constatée dans les matières acryliques et l'autopsie a montré que les corps acryliques étaient solidement fixés dans les tissus osseux. L'examen histologique n'a permis de déceler aucun signe d'ostéite, le tissu osseux formant une paroi lamellaire tout autour de ces corps. Les résultats de ces recherches préliminaires semblent démontrer qu'il convient de poursuivre les travaux avec les matières acryliques.