CLINICAL AND HISTOPATHOLOGIC EVALUATION OF TISSUE REACTION TO COMPLETELY EMBEDDED ACRYLIC AND TICONIUM IMPLANTS IN DOGS

By

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A Thesis

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INTRODUCTION

Attempts to replace missing teeth by inserting some type of substitute into the oral tissues are as old as dentistry itself (1). One such substitute is the endosseous implant, a device made of material other than living tissue, which is anchored in bone. Until the advent of inert materials, implants were not tolerated by the tissues (1, 2, 3, 4).

Today we possess two types of substances which have given encouraging results when used as implant materials. These are chrome-cobalt alloys and plastics (4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35). While it is generally agreed that chrome-cobalt alloys are inert and well-accepted by body tissues (4, 8, 15, 16), the role of plastics as implant materials is still controversial. One of these plastics, methyl-methacrylate (denture base acrylic), has attracted special interest as an oral endosseous implant material (23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39), but there are few studies published which include histologic evaluation of the reaction to this material (30, 33, 34, 35, 36, 37, 38). Furthermore, those few studies which have been published are not in agreement.

There are many factors, particularly in the oral region, which may influence the success or failure of endosseous implants. These factors include:

1.0 The implant

1.1 Chemical and physical structure

1.2 Design

1.3 Relationship to oral environment and functional stress

1.3.1 Extent to which embedded

1.3.2 Exposure to the oral environment

1.3.3 Exposure to masticatory stress

1.4 Surgical technique

2.0 The host

2.1 Local oral conditions

2.2 General health status

3.0 Duration of the study

The significance of these variables becomes apparent when one reviews the literature. The investigations of different research workers cannot be compared validly and it is impossible to establish baselines for continued logical experimentation. In the hope of developing such baselines, the present study was initiated with the following specific goals:

1. To evaluate the tissue response to self-curing, heat-sterilized acrylic when embedded in the jaws of dogs by comparing it to the tissue reaction to chrome-cobalt type implants.
2. To determine on a preliminary basis if histologic features can be found which will augment or be related to clinically observable reactions when acrylic and Ticonium implants are used.

REVIEW OF THE LITERATURE

Tissue Response to Chrome-Cobalt Alloy Implants

Chrome-cobalt alloys are inert and in general well-accepted by body tissues (4). In the oral region, chrome-cobalt implants have been uniformly well-tolerated as long as they were buried within tissues and not exposed to the oral environment or to masticatory stress (8, 15, 16, 19). When exposed to the oral environment or masticatory forces, results have varied (5, 6, 7, 8, 9, 11, 12, 13, 14, 17, 18, 20, 21, 22). In the case of those exposed endosseous implants judged to be successful, it is noteworthy that there have been no histologic data to accompany clinical findings. In the one exception, the author (9, 10, 11, 12) considered his results successful but the microscopic sections showed inflammation adjacent to the implant.

In Seidenberg and Lord's study of completely buried mandibular implants (16) healing had proceeded as follows:

At four weeks, the implants were surrounded by a wide band of loose connective tissue with fine new bony trabeculae present peripheral to the connective tissue area. At eight weeks, the connective tissue band was much thinner and bone formation more prominent. At ten weeks, the connective tissue was reduced to a thin collagenous band and the implants were surrounded completely by bone.

Tissue Response to Acrylic Implants

Autian, in a review (40), states that plastics, including acrylic, may be well accepted by body tissues on a short-term basis. However, there

is no baseline study substantiating the inertness of this material. Various investigators (41, 42, 43, 44) have produced sarcomas in rodents with several plastics, including methyl-methacrylate. These studies do not show conclusively that the malignancies were caused by the material itself. The malignancies occurred in significant numbers only when the plastic was embedded in film or sheet form. When embedded in other forms such as textiles, sponges or powders, they produced malignancies so rarely that no reliable cause and effect relationship could be established. Furthermore, all these studies used inbred, susceptible strains of rodents and the implant materials were embedded subcutaneously. Similar materials embedded in other tissues in different species were noncarcinogenic (32, 33, 34, 45, 46, 47). One of the latter studies (45) also indicates that the reaction to plastics varies with their physical form.

Acrylic Implants in the Oral Tissues

A number of authors have used acrylic implants in clinical trials in humans with varying results (23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33). Flohr (30) and Hodosh (32, 33, 34, 35) have reported on functioning endosseous acrylic implants and included histologic preparations as part of their evaluation.

In Flohr's study (30), he replaced single missing teeth in two human patients, using prefabricated screw-type acrylic implants with a central metallic post. Flohr biopsied one of his implants after one year; the other was followed only on a clinical basis for three years. The biopsy revealed that the implant was embedded in fibrous connective tissue. In addition there was a focus of inflammation in the photomicrograph illustrating this case.

Hodosh et al. (32, 33, 34) implanted acrylic replicas of extracted teeth into recent extraction sites in humans, monkeys and dogs. The implants were splinted to adjacent teeth, or in some of his animals, were fixed by an intraosseous metallic pin. They were exposed to the oral environment and functioned in mastication from the time of their placement. He found microscopically that the implants were encompassed by circumferentially arranged collagen fibers. No inflammation or minimal inflammation was reported. Occasionally, epithelium did proliferate downward around the implant, but this did not seem to interfere with the implant's function.

The same author, in a more recent study (35), reports on implants with channels cut through the roots. The implants were prepared and splinted as in the earlier experiments (32, 33, 34). The development of osseous bridges through these channels was noted grossly and confirmed by histologic examination.

In Hodosh's experience heat-cured acrylic is well-accepted by the oral tissues and acrylic implants offer a unique and valuable method of tooth replacement.

Waerhaug and Zander (36) prepared and placed acrylic implants into recent extraction sites in dogs prior to the work of Hodosh et al. These implants had no crowns but were replicas of the extracted roots and therefore were not splinted in place, nor did they function in mastication. They were exposed, however, to the oral environment. The majority of the implants exfoliated by 95 days. Those which remained were sectioned and the tissue response to them evaluated. The findings varied in that some implants were surrounded by bone, others by fibrous connective tissue. Inflammation was not a prominent feature, but epithelial

downgrowth along the implants was present in most cases. Waerhaug and Zander concluded that even though acrylic implants might be inert, their fate was invariably exfoliation.

Hegedus and Inke (37) placed cured acrylic implants and also cemented cured acrylic implants by means of a mixture of uncured acrylic and despeciated bone into recent extraction sites in dogs. Their implants were reproductions of the extracted teeth; some of them were splinted, others were not. The unsplinted implants fell out first, the splinted implants exfoliated spontaneously upon removal of the splint. Exfoliation was never accompanied by clinically manifest signs of inflammation, but histologically the implants were surrounded by granulation tissue and inflammatory cells. In the opinion of these investigators, the prognosis for acrylic as an implant material was guarded.

Pasqualini's series of implants (38) consisted of precured implants made of self-curing and heat-cured acrylic as well as implants made of other materials. His implants were not exposed to function or the oral environment but were completely embedded in the jaws of dogs. Of the heat-cured acrylic, one out of four exfoliated whereas in the case of self-curing acrylic, three out of four exfoliated. He concluded that the implants which fell out were rejected by the tissues and that acrylic, particularly the self-curing variety, was not inert.

Fogarty and Howes (39) placed preformed heat-cured acrylic implants into the mandibles of rats. The implants were completely embedded and not exposed to the oral environment. Their publication, which is an abstract, concludes that, "...it would seem feasible to use materials of this type for prosthesis." (pp 33).

PRELIMINARY STUDIES

This investigator has reproduced the Hodosh method using a miniature pig rather than a dog because Hodosh felt that his method when used in dogs had only limited success due to the dog's masticatory physiology. Two implants of self-curing, heat-sterilized acrylic, exposed to function and splinted, were observed for four and six weeks. Both were loose after the splint was removed. They exfoliated spontaneously. Microscopic sections revealed granulation tissue, inflammation and bone resorption adjacent to the implant.

This investigator has also repeated the method of Waerhaug and Zander. The procedure varied in only one respect, that of extracting opposing teeth to eliminate masticatory stress. Thirteen out of twenty-four implants remained in place until the end of the observation periods of one, five, nine and sixteen weeks. The observation period of sixteen weeks (one hundred and twelve days) exceeded the longest observation period of Waerhaug and Zander, which was ninety-five days. All of the implants which exfoliated did so within the first two weeks without any clinical signs of inflammation. The animals did not react uniformly; in two of the dogs, almost all implants exfoliated, whereas in the other two almost all implants remained in place. In one of the former two dogs, the first implant remained in situ. Then the dog became sick with a skin disease which, in the examining veterinarian's opinion, was related to stress. All implants placed during the period of illness fell out. Finally the dog recovered, and the last implant, placed when the

dog was healthy again, remained in place until sacrifice. Histologic evaluation of these implants has not yet been made.

Table 1

Anatomic Distribution of Experimental Units

Kennel number	Five Weeks	Ten Weeks
3474	Mandibular Right Molar	Mandibular Left Molar
	Mandibular Right Premolar	Mandibular Left Premolar
3475	Mandibular Left Molar	Mandibular Right Molar
	Mandibular Left Premolar	Mandibular Right Premolar
4630	Mandibular Right Molar	Mandibular Left Molar
	Mandibular Right Premolar	Mandibular Left Premolar
4632	Mandibular Left Molar	Mandibular Right Molar
	Mandibular Left Premolar	Mandibular Right Premolar
4598	Mandibular Left Molar	Mandibular Right Molar
	Mandibular Left Premolar	Mandibular Right Premolar
6004	Mandibular Right Molar	Mandibular Left Molar
	Mandibular Right Premolar	Mandibular Left Premolar
6007	Mandibular Left Molar	Mandibular Right Molar
	Mandibular Left Premolar	Mandibular Right Premolar
6043	Mandibular Left Molar	Mandibular Right Molar
	Mandibular Left Premolar	Mandibular Right Premolar

MATERIALS AND METHODS

Experimental Units

Thirty-two experimental units were placed into the edentulous mandibles of eight dogs, four in each dog. Each experimental unit consisted of an acrylic implant, a Ticonium implant and a sham-operated site containing no implant. Thus each dog had twelve test sites. The anatomic distribution of the units is indicated in Table 1. All sites were in the mandible, since mandibular bone and maxillary bone are quite different. Sixteen units were placed in molar areas and sixteen were placed in premolar areas. The cuspid and incisor areas were not included as implant sites. The units which were inserted first are listed in column 3 of Table 1, under the heading "ten weeks". Five weeks later the units listed in column 2 under the heading "five weeks" were inserted. Thus at the time of sacrifice each animal had two units which were in place for five weeks and two units which were in place for ten weeks. These time periods were chosen on the basis of reported healing rates of mandibles receiving chrome-cobalt implants. (The healing rates associated with acrylic implants are unknown.)

Ticonium was chosen to represent chrome-cobalt type alloys which have been shown to be well accepted when completely embedded in bone. Since the Ticonium and acrylic implants were of the same design and were placed in adjacent anatomical sites in the same animal using the same surgical technique, any differences in tissue reaction should be attributable to the nature of the acrylic per se. The sham-operated sites

Table 2

Distribution of Sequences within Experimental Units

Sequence	Molar Units (By kennel number)	Premolar Units (By kennel number)
Ticonium - sham - acrylic	3475, 6043, 6043	3475, 6043, 4598
Ticonium - acrylic - sham	3474, 4630, 4632	3474, 6007, 6004
Sham - acrylic - Ticonium	6004, 6007	4630, 4632
Sham - Ticonium - acrylic	3475, 4598, 4598	6007, 4598
Acrylic - Ticonium - sham	3474, 6004, 6007	6004, 6043, 3475
Acrylic - sham - Ticonium	4630, 4632	3474, 4630, 4632

served to show the effects of the surgical procedure and the consistency of the operator's technique. To investigate possible variations in tissue reaction due to differences in anatomic location of the experimental units, both molar and premolar sites were used. There were six possible combinations of the sequence "acrylic implant-Ticonium implant-sham operated site" containing all three components. The sequences were allotted in such a manner that each sequence would occur at least twice at each anatomical site. The distribution of sequences with respect to dogs was random and is shown in Table 2. The sequence proceeds from distal toward mesial.

Implant Design and Manufacture

Size and shape of implants

The size and design of the implants in this study were determined by the following requirements, in which it was mandatory that they:

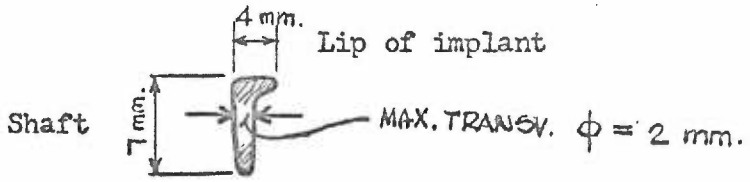
1. Fit the mandible of the smallest animal. Hence, they were to be somewhat shorter than the distance between the top of the crest and the mandibular canal, and of such a width that sufficient bony support would remain on the buccal and lingual sides of the alveolar ridge.
2. Conform to the size and shape of a commercially available surgical bur to correspond exactly to the socket drilled with such a bur.
3. Be of sufficient bulk to minimize fracture of the acrylic implants during insertion.
4. Be mechanically removable without destroying the surrounding tissues.
5. Be in contact with osseous as well as soft tissues.

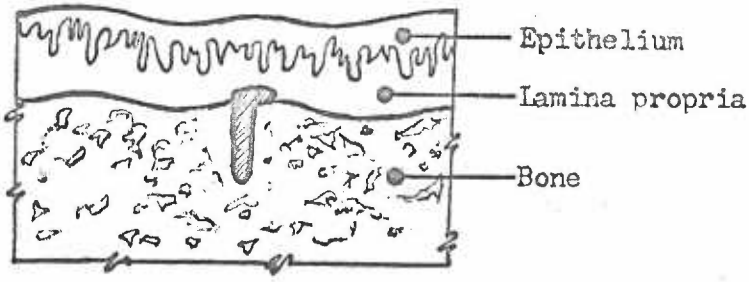
6. Be of a simple design which would interfere as little as possible with the vascular supply of the adjacent tissues.

The drawing in Figure I illustrates the implant design, which represents a compromise solution to the above requirements.

Figure I

IMPLANT DESIGN





The "shaft" or vertical part of the implant conformed to the lower end of a Clev-Dent surgical bur #12.

Preparation of implants

The methods for preparing both acrylic and Ticonium implants were standardized. Both methods were designed to minimize contamination of the implants with other materials and in the case of acrylic implants, to minimize the amount of residual monomer. (See appendix, pp 184).

Table 3

Vital Statistics of Dogs

Kennel Number	Sex	Parents	Age at Start (In months)	Weight at Start (In pounds)	Weight at End (In pounds)
3474	Female	Sire BR Dam BR	18	25.0	27.5
3475	Male		18	40.0	43.0
4630	Female	Sire R Dam BG	17	34.0	41.5
4632	Female		17	33.0	32.0
4598	Female	Sire BR Dam BR	17	33.0	38.0
6004	Female	Sire BR SG BR Dam BR	9	34.0	39.0
6007	Male		9	45.0	45.0
6043	Male	Sire BR SG BR Dam RBG	8	37.0	36.0

Bracketted pairs are littermates

The implants were of a standard size. However, since minute variations of size were unavoidable, the acrylic implant was a direct replica of the Ticonium implant in each experimental unit.

The implants were carefully prepared for surgery and autoclaved together with the surgical instruments (see appendix pp 186).

Experimental Animals

Selection of the animal

The dog was selected as the experimental animal in this study for the following reasons:

1. Previous implant studies (9, 10, 11, 12, 15, 16, 33, 36, 37, 38) have utilized this animal.
2. The healing of wounds comparable to our sham-operated sites has been studied in dogs (49, 50, 51).
3. Dogs are of sufficient size to facilitate oral surgical procedures and have tolerated these procedures well.
4. The dog's jaw is of sufficient size to permit the execution of implant designs which might be applicable to humans.

Vital statistics of the animals selected

The dogs were obtained from the breeding colony of the University of Oregon Medical School. Their vital statistics are summarized in Table 3.

Maintenance and care of the animals

Upon receipt from the kennels of the University of Oregon Medical School, each dog was given a general physical examination by the veterinarian in charge of animal care at the University of Oregon Dental School. In addition, careful inspection of the oral cavity was made by the author. Dog 6043 had suffered a traumatic brain injury when a puppy,

but was otherwise confirmed to be in good physical condition. All other animals were free of defects and in excellent health.

During the two weeks following their arrival, the animals were left alone to permit them to get used to their new surroundings.

They were housed in separate metal cages and fed a standard diet of dry kibble (Purina Dog Chow) supplemented by canned meat. After surgical procedures, the kibble was mixed with water to a bland consistency. However, one of the dogs (4598) refused the bland kibble and had to be fed dry kibble at all times. Feeding was done twice daily at regular hours except for the days of surgery. The animals were fasted prior to anesthesia, and were fed the normal amount of food as soon as they had recovered. There were individual differences in their eating habits and the amounts of food consumed, which accounts in part for their differences in weight (see Table 1, pp 26). During the course of the experiment they were weighed and inspected at least once a week. At the conclusion of the experiment each dog again received a complete physical examination by the veterinarian in charge of animal care at the University of Oregon Dental School.

Surgical Procedures

Anesthesia

The animals were anesthetized in the morning on the days of surgery. Their afternoon feeding on the preceding day was omitted, but water was given as usual.

Before each anesthesia procedure, they were weighed and examined by the author. They were routinely premedicated with Acepromazine maleate (Ayerst) at a dose of 0.25 to 0.4 mg per pound of body weight and atropine sulfate U.S.P. (Lilly) at a dose of 0.04 mg per pound of body weight. Both drugs were given subcutaneously thirty to sixty minutes before

Table 4

Lower Roots Accidentally Fractured During Extraction

Kennel number	Side	Root	Extracted With Elevator	Required Bone Removal for Extraction
3474	None	None	No	No
3475	Left	Mesial 2nd Premolar	Yes	No
4630	Right	Mesial 2nd Premolar	Yes	Yes
	Left	Mesial 3rd Premolar	Yes	No
4632	Right	Mesial 1st Molar	Yes	Yes
4598	Right	Mesial 2nd Premolar	Yes	Yes
	Left	Mesial 3rd Premolar	Yes	No
6043	None	None	No	No
6004	Right	Mesial 2nd Premolar	Yes	Yes
	Left	Mesial 3rd Premolar	Yes	No
6007	None	None	No	No

administration of the anesthetic solution.

Areas of skin overlying the cephalic vein in the foreleg and the saphenous vein in the hind leg were shaven and cleaned with Phiso-Hex (Winthrop). Nembutal Sodium (Abbott) was injected intravenously to effect. Dosages varied with each individual animal, but ranged between 4.5 to 6.5 mg per pound of body weight. After anesthesia had been obtained, a plastic intravenous catheter was threaded into the vein which had not been used for the previous injection and a saline drip started. The sterile intravenous catheter facilitated the administration of further drugs during surgery without interrupting sterility.

With the combination of drugs used, good superficial anesthesia was obtained on all occasions. During anesthesia, heartbeat and respiration were monitored by the author. Minor complications arose only in two instances and were successfully overcome by the use of oxygen and 0.5 ml of a 1:1000 solution of Adrenaline chloride.

The recovery was uneventful but prolonged. On occasions when a second dose of Nembutal and/or Acepromazine was used, eight to ten hours lapsed between the administration of the anesthetic and the time the animal was able to stand and walk normally.

During their recovery periods, the animals were maintained in their cages covered with blankets, and were kept under surveillance by the author.

Preparation of animals to receive implants

The upper and lower molar and premolar teeth of all animals were extracted under general anesthesia. The exodontia instruments and gloves were sterilized. Clean, non-sterile gowns were worn.

Radiographs of all upper and lower molars and premolars were taken

and the surgical approach was planned for each animal. The lower molars and premolars were extracted in one session, the upper molars and premolars in another session two to three weeks later. The method was as follows:

The gingiva was carefully separated from the tooth with a sharp periosteal elevator. All multirooted teeth were sectioned with a high-speed bur and each root was elevated and then extracted, usually with a lower universal forceps.

All dogs, but particularly the younger ones, had thin, shell-like teeth with large pulp chambers, which fractured very easily. Table 4 shows which roots had fractured and which required removal of bone for their extraction.

Following extraction, an incision was made in the center of the ridge from the retromolar area to the canine tooth, a mucoperiosteal flap elevated on the buccal and lingual sides and the ridge checked for broken bone spicules and debris. Alveoloplasties were performed, the area cleaned, irrigated with saline, the flaps repositioned in such a manner that the sockets would be covered by mucoperiosteum and the flap sutured in place by an uninterrupted mattress suture. In the author's previous experience with oral surgical procedures in dogs, this was one type of suture which they would not remove by constant licking. Radiographs were taken to detect broken root fragments. The sutures were removed three to five days later and the wounds inspected and irrigated with a 1:700 Zephiran solution.

Implantation procedures

Implantation procedures were started two weeks after radiographs showed that bone had filled the alveolus of the extraction site and the

lamina dura no longer apparent.

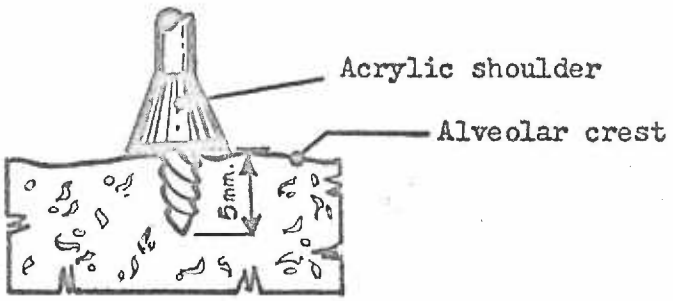
All implantation procedures were performed under anesthesia as previously described (pp 28), and with a careful aseptic technique to minimize contamination

Two specially modified instruments were used:

1. Several Clev-Dent No. 12 surgical burs were prepared with acrylic shoulder stops so that the bur would penetrate the bone to a depth of exactly 5 mm. (See Figure 2).

Figure 2

Modification of the Surgical Bur



2. The cutting edge of a straight chisel was ground off to provide a 2 mm. wide flat surface which corresponded to the lip of the implants.

The remaining instruments were those commonly used in oral surgery for humans.

The procedure was as follows:

An incision was made approximately in the center of the alveolar ridge. Mucoperiosteal flaps were elevated on the buccal as well as lingual sides and the flaps were retracted. The location of the sockets for both molar and premolar implant units and the distance between these units had been planned in advance and marked on a model. The sockets

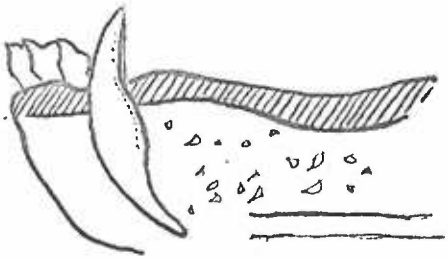
Figure 3

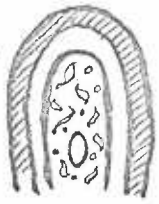
Implantation Procedure

Edentulous Ridge

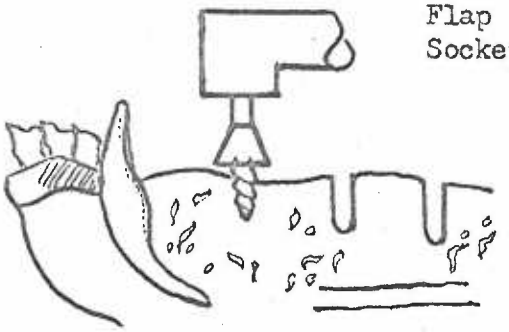
Mesio-distal plane

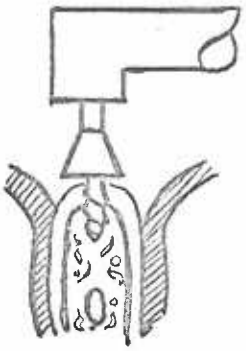
Bucco-lingual plane



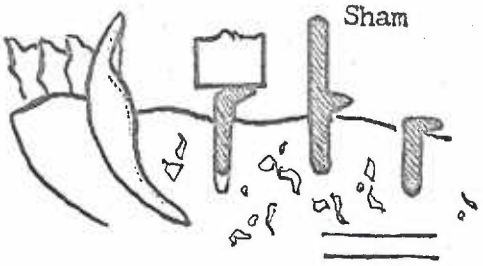


Flap is reflected
Sockets are drilled

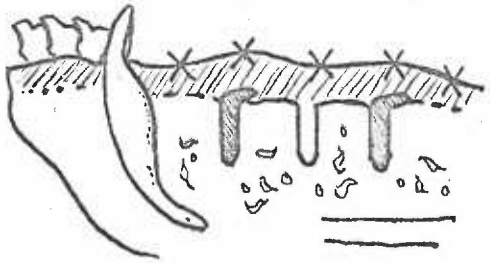




Implants are placed



Flap is repositioned and sutured



were drilled at the sites planned. The cortex of the mandible was perforated with a No. 2 round high speed carbide bur rotating at 200,000 rpm when entering the tissues under a stream of sterile saline squirted from a syringe by the assistant. Under the same type of saline irrigation, the socket was completed with the specially prepared Clev-Dent #12 stainless steel bur. This bur was carefully centered and driven into the bone with a single motion at 10,000 rpm until the shoulder touched the top of the alveolar crest. The sockets were irrigated with saline and gently curretted to remove loose bone fragments. The implant was placed in the socket with the specially prepared flat ended chisel and a nylon surgical mallet until the lip lay flat on the alveolar ridge and the implant was firmly fixed. (The implant was 7 mm. long, the socket drilled to 5 mm.; the implant was tapped the remaining 2 mm.). A piece of gauze was interposed between the surfaces of the Ticonium implant and the chisel to avoid direct contact between dissimilar metals.

The sham sites were surgically prepared in the same manner as the implant sites. A Ticonium implant was inserted and tapped into the sham socket. The implant was withdrawn by grasping a shaft provided for this purpose (see Figure 3c, pp 33).

The surgical area was again irrigated and cleaned of debris; the flaps were repositioned and sutured in place using an uninterrupted mattress suture with 000 silk.

The procedure is illustrated in Figure 3.

In general, the above described procedure was performed successfully. Six out of thirty-two acrylic implants fractured during insertion into the socket; however, the major portion of the shaft remained in the socket and the mucosa was sutured over these implants as over all others.

Table 5

Acrylic Implants Accidentally Fractured during Insertion

Dog Kennel Number	Experimental Unit
3475	Right Premolar
4598	Left Premolar
4632*	Right Premolar*
6004	Right Molar
6007	Left Molar
6043	Left Premolar

*The fracture of this implant was deep, in its shaft, and was discovered only at the gross examination.

Table 5 (pp 35) lists the implants which had fractured.

Post-operative care

After implantation, a single dose of a broad-spectrum antibiotic (Penstrep, Ayerst, 500,000 units) was administered intramuscularly.

As mentioned previously, the animals were watched until they had completely recovered from anesthesia. After recovery, there were no signs of pain, such as withdrawal. All animals were friendly as usual, and ate and drank normally.

Three to five days after surgery, the sutures were withdrawn, the wounds irrigated with a 1:700 solution of Zephiran, inspected and palpated. This was done under the tranquilizing action of Acepromazine maleate, of which 4 mg per pound of body weight had been previously given by subcutaneous injection.

Autopsies

Sacrifice of animals

The animals were sacrificed by perfusion with formol-saline solution. The technique was as follows:

On the date of sacrifice, each animal was anesthetized as usual (see anesthesia, pp 28). After a final clinical examination, more anesthetic was administered to obtain a profound plane of anesthesia. Two vertical lateral incisions were made in the neck and the jugular veins and carotid arteries located. The carotid arteries were cannulated and perfusion with the fixative was begun. Immediately thereafter the jugular veins were sectioned to permit the escape of blood and fixative solution. Death invariably ensued within a short period of time.

Autopsy procedure

Immediately after the perfusion procedure had ended, an autopsy

limited to the thoracic and abdominal organs was performed on all dogs. On 6043, examination of the brain was included. This dog's brain was asymmetric and smaller than normal. Dog 3474 had a tumor in the right ovary. Apart from these incidental findings, the organ systems of all animals were free of disease.

Histologic Preparation

Fixation

Following perfusion with a 10% buffered formol-saline solution, the mandibles were disarticulated and their inferior border split up to the inferior mandibular canal using an electric saw and a hand saw. (Formula of perfusing solution Appendix, pp 189). The soft tissues from the inferior portions of both buccal and lingual sides were stripped and the mandibles placed in 10% buffered formalin. After gross examination, each hemimandible was sectioned into a molar and a premolar segment. The segments were marked by notching the disto-buccal side so that they could be oriented later. Then they were wrapped in gauze, labeled and placed into formalin for ten days. During this time, the solution was stirred by a mechanical stirrer.

Decalcification

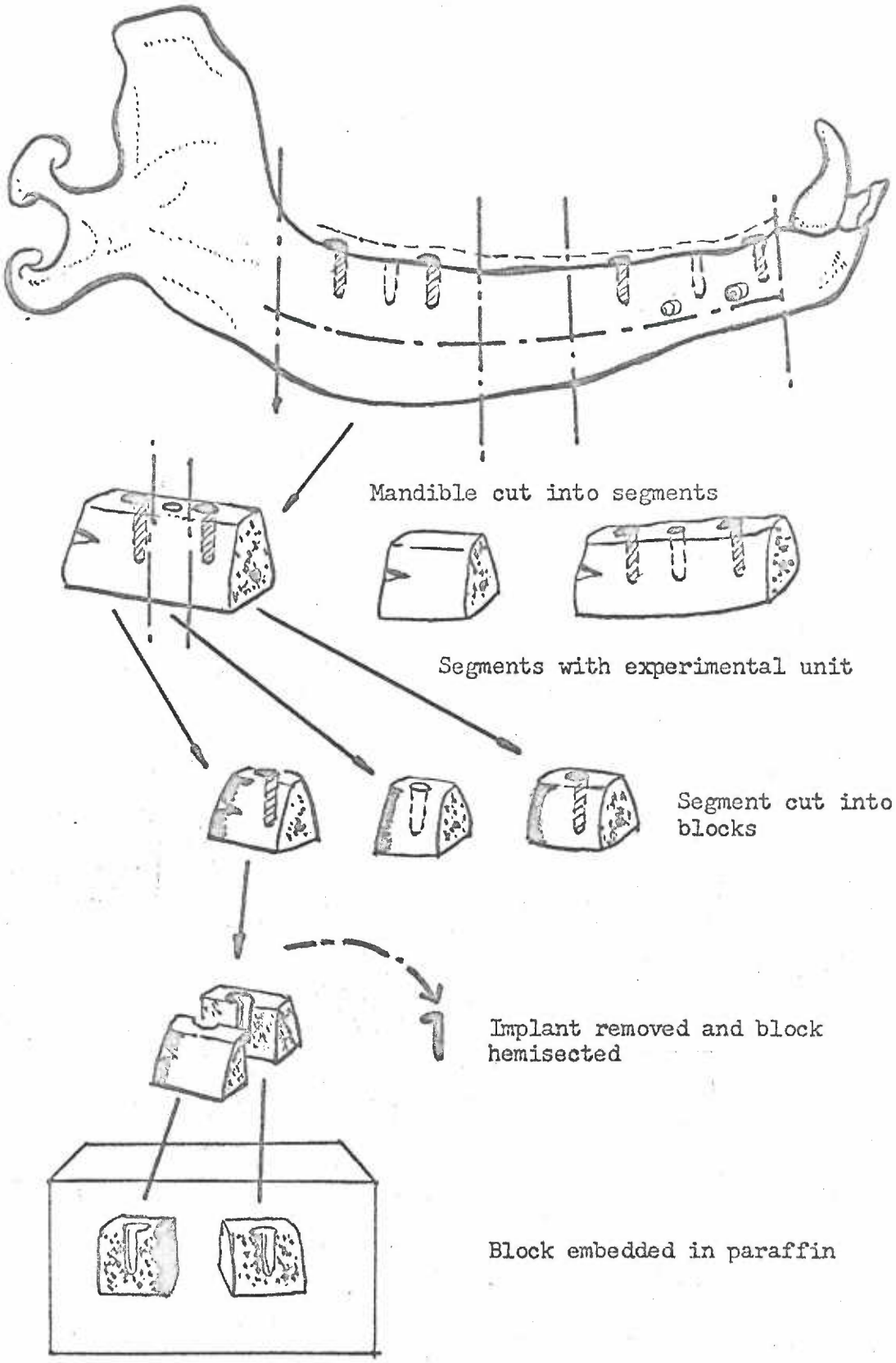
The specimens were decalcified in a buffered formic acid solution (formula pp , Appendix). The solution was changed daily and stirred constantly by a mechanical stirrer. The end point of decalcification was established by radiographic examination, by repeatedly testing for the presence of calcium in the decalcifying solution (52) and finally by the empirical needle test which was used as the final criterion.

Processing and coding

After decalcification, the specimens were washed in running tap

Figure 4

Preparation of Blocks for Paraffin Embedding



water for twenty-four hours, then soaked in a saturated solution of Lithium carbonate for eight hours, and washed again in running tap water.

Each segment, corresponding to one experimental unit, was sectioned further into blocks containing one implant or sham-operated site only (See Figure 4). The implants were removed by gently prying them from their sockets, grasping the lip portion and extracting them through the section made previously in the mucosa, or by cutting the tissue away from the implant. In either case, the block was sectioned in a mesio-distal plane approximately through the center of the implant area and the distal side of the buccal half painted with India ink. The same was done for the blocks containing sham-operated sites. The two halves of each block were kept together. Each block was coded with a random number from one to ninety-six by a second operator. A list was prepared identifying each block by dog kennel number, side (right or left), area (molar or premolar), type of implant (acrylic, Ticonium, or sham) and code number. In addition, the code number was written on each original label. The labels were checked against the list and preserved.

Dehydrating, clearing and embedding

The tissue blocks were dehydrated by passing them through a series of ethyl alcohol solutions of ascending concentrations. The solution was changed twice daily and the blocks left twenty-four hours in each solution.

The blocks were cleared in methyl-benzoate or cedarwood oil and xylol and embedded in paraffin.

The two halves of each block were embedded in such a way that the first sections cut were from the central portion of the implant or sham

site; the sections were oriented with regard to buccal, lingual, mesial and distal sides.

Sectioning and staining

Serial sections, seven to ten microns thick, were cut from all blocks and every twentieth section from the implant was mounted. This spacing of sections has been shown to be satisfactory when studying periodontal tissues and disease (53). The remainder of the block, corresponding to areas distant from the implant and consisting mostly of the buccal and lingual cortical plates, was also serially sectioned, but only five sections, spaced at equal intervals, were mounted initially. All mounted sections were preserved for further study and used as necessary. The mounted sections were routinely stained with hematoxylin and eosin (54). Special staining was done as needed. The special stains used were Brown and Brenn to demonstrate bacteria (54), Giemsa to differentiate types of inflammatory cells, and Von Kossa's method for demonstrating calcium (54).

Methods of Evaluation

Clinical examination

The oral cavity of each dog was examined weekly by visual inspection and digital palpation. This was supplemented by Kodachromes when deemed necessary. Radiographs were taken during sessions requiring general anesthesia if this could be accomplished without giving more of the anesthetic solution.

The findings with respect to each implant were expressed as follows:

1. Free of grossly detectable abnormality. (If an abnormality was found, it was recorded.)
2. Affected by grossly detectable abnormality.

3. Implant present.

4. Implant absent.

5. Cannot determine absence or presence of implant.

At the time of examination, the examiner did not know whether the area examined corresponded to an acrylic implant, a Ticonium implant, or a sham-operated site, unless the implant had perforated the mucosa and had become visible. The examiner could not remember the sequence in which the implants and sham-operated sites had been placed and did not refer to her records until after the animals had been sacrificed. Each examination was performed independently and the recorded observations were not compared until after the animal had been sacrificed. The animals were examined in a random order each week.

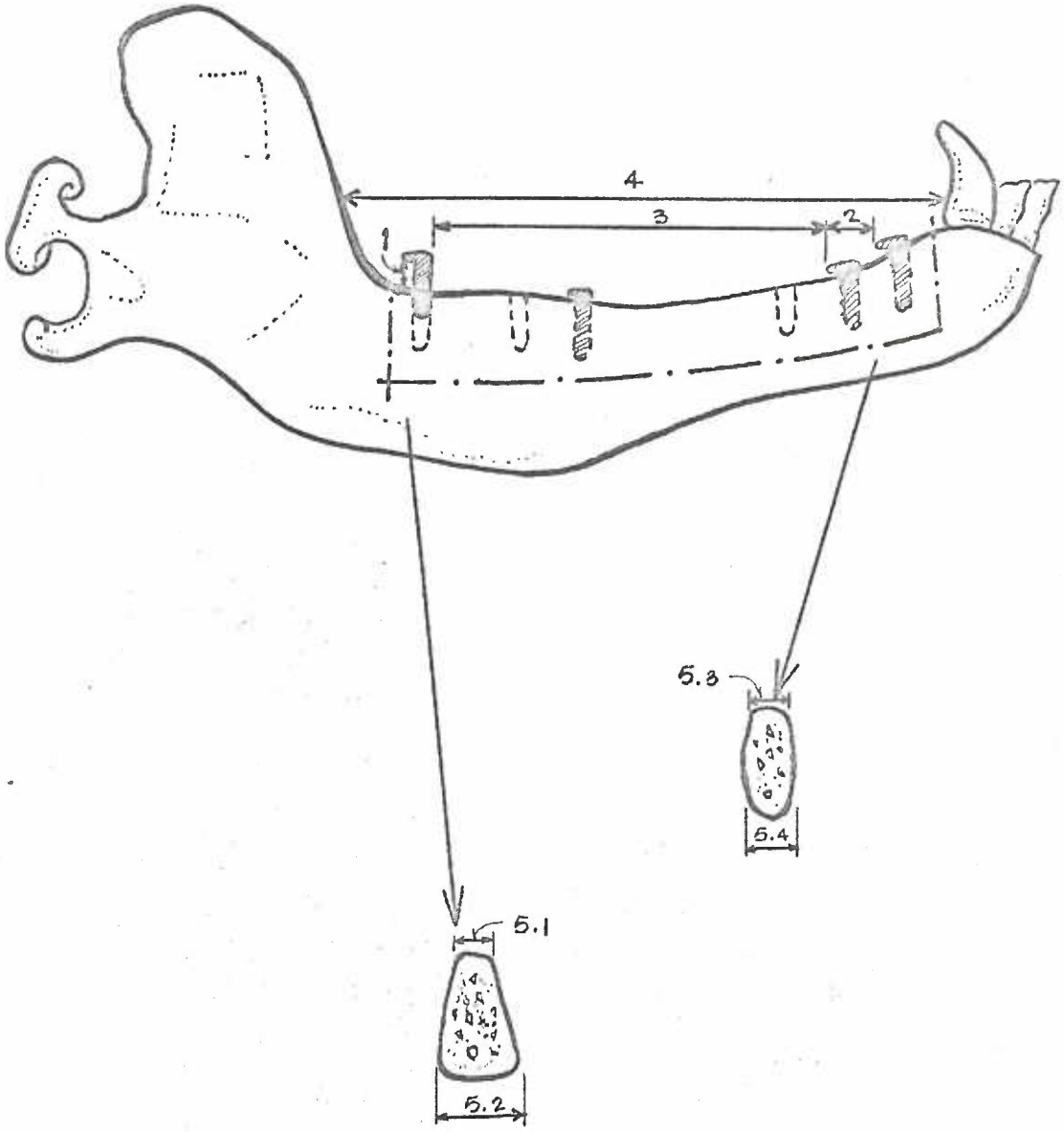
The area examined was identified by the kennel number of each animal and the designation of location such as "distal right molar", "mesial right molar", "distal right premolar", etc. After sacrifice, the distal and mesial implants in each experimental unit were identified as "acrylic" or "Ticonium" according to the sequence which had been allotted to that unit. The correctness of the recorded sequence was verified by the gross examination.

Gross examination

A gross examination was performed on the disarticulated formalin-fixed mandibles. The mucosa was incised and the presence or absence and the type of each implant (Ticonium or acrylic) verified by directly visualizing the implant and touching it with an explorer. In some cases the implants were not found because they had become overgrown by bone; in these instances, the gross examination was completed when removing the implants after decalcification. The actual sequence of the implants was

Figure 5

Measurements on Gross Specimens



(Numbers do not represent measurements. See text pp 42 for explanation of numbers.)

compared with the recorded sequence and found in agreement.

The appearance and quality of the mucosa, the periosteum and cortical plates of bone was described. In addition, the following measurements were taken:

1. Distance between inferior surface of implant lip and alveolar crest.
2. Distance between implants in each experimental unit.
3. Distance between the mesial implant of the molar unit and distal implant of the premolar unit on the same side.
4. Distance from the distal surface of the canine tooth to the anterior border of the ramus in the retromolar angle on right and left sides.
5. Buccolingual diameter of mandibles in cross-section at four equivalent points:
   - 5.1 At the most distal point of the molar unit at the top of the alveolar crest.
   - 5.2 At the most distal point of the molar unit above the mandibular canal.
   - 5.3 At the most mesial point of the premolar unit at the top of the alveolar crest.
   - 5.4 At the most mesial point of the premolar unit above the mandibular canal.

(See diagram, Figure 5, pp 42)

Microscopic examination

The three coded blocks pertaining to an experimental unit were examined together. The examiner did not know which unit she was looking at, nor which of the two implant sites in the unit had contained an acrylic

or a Ticonium implant. Since most of the implants had remained in situ, the examiner could distinguish sham-operated sites from implant sites in spite of the coding.

The sequence in which the units were examined for the first time was determined by their availability. (Those blocks which had decalcified sooner were processed and examined first.) In order to test the consistency of the examiner's interpretation, the examination of microscopic sections was repeated on a random sample of 36 implant sites and the results subjected to statistical evaluation (pp 177).

The essential histologic features were expressed in simple sentences which could be answered with "present" or "yes" (+); "absent" or "no" (-), and "cannot determine" (0). The answers were tabulated for each block. The histologic features were listed as follows:

1. Lymphocytes and plasma cells*
2. Granulocytes*
3. Inflammation minimal
   moderate
   marked
4. Bone formation*
5. Bone formation* slight
   moderate
   marked
6. Evidence of bone resorption*
7. Bone resorption* slight
   moderate
   marked
8. Residual necrotic bone*

9. Soft tissue necrosis*

10. Epithelial downgrowth*

11. Evidence of bone resorption at crest

12. Bone resorption at crest slight

moderate

marked

The features marked with an asterisk refer to areas directly adjacent to the implant.

The criteria for determining these features were as follows:

In general, a feature had to be found only in a single section to be recorded as "present" (or"yes") for that block.

Regarding lymphocytes, plasma cells and granulocytes, the presence of a single cell of each type was sufficient to record the feature as present.

Minimal inflammation was considered to be present when the concentration of inflammatory cells exceeded the concentration which the examiner would expect to find normally in bone marrow and gingiva. (Whenever a block had a single section which had inflammation, the presence of inflammation was recorded for the entire block.) This evaluation was subjective; however, the consistency of the investigator's evaluation was tested statistically (see Appendix, pp 177).

In evaluating bone resorption, a single osteoclast next to bony trabeculae adjacent to the implant constituted evidence of bone resorption. The osteoclast could be facing the implant or could be situated at the side of the trabecula which was distant from the implant, facing the surrounding bone.

The degree of bone resorption was recorded as slight, moderate or marked on the basis of the concentration of osteoclasts and the magnitude

of the area involved.

Under "residual necrotic bone", areas of necrotic bone enclosed in vital bone were recorded.

"Soft tissue necrosis" was recorded when necrotic areas in either the bone marrow or gingiva were found.

The proliferation of epithelium along the surface of an implant was recorded as "epithelial downgrowth".

A single osteoclast was sufficient evidence of bone resorption at the top of the alveolar crest.

In grading bone resorption of the alveolar crest, the number of osteoclasts, the depth and number of excavations in the normally smooth outline of the crest and the distance between bone and epithelium, representive of the amount of bone already resorbed, were considered. (Plates number 17, 18, 19 illustrate the categories of slight, moderate, and marked as used in this study.)

Other features, when found, were described briefly for each block.

After tabulating the above discussed histologic features for each block pertaining to an experimental unit, a comparison on the basis of these features was made within the unit.

In addition to tabulating the main histologic features, composite descriptions were made of each group of similar implants and/or sham-operated sites.

Statistical evaluation of clinical and microscopic findings

The following null hypotheses were tested. It was hoped that upon the rejection of some of them, certain pertinent conclusions about the behavior of the implants could be drawn.

1. Fractured acrylic implants are not different from non-fractured acrylic implants with respect to clinical changes.

2. Acrylic implants are not different from Ticonium implants with respect to clinical change "A", clinical change "B", clinical change "C", etc.
3. Acrylic implants are not different from Ticonium implants with respect to all clinical changes.
4. Molar areas are not different from premolar areas with respect to the occurrence of clinical changes in implant sites.
5. Areas where roots were fractured during extraction are not different from areas where roots were not fractured during extraction with respect to the occurrence of clinical changes in implant sites.
6. Male animals are not different from female animals with respect to the occurrence of clinical changes at implant sites.
7. Dogs with narrow ridges are not different from dogs with broad ridges with respect to the occurrence of clinical changes at implant sites.
8. Fractured acrylic implants are not different from non-fractured acrylic implants with respect to each of the histologic features listed on pp 44.
9. Acrylic implants are not different from Ticonium implants with respect to each of the histologic features listed on pp .
10. The clinical group "Thinning of the Mucosa and Loss of Mucosa" is not different from the clinical group "No Change" with respect to marked crestal bone resorption.
11. Implants associated with clinically observed changes ("Thinning of the Mucosa", "Loss of Mucosa", "Loss of Implant") are not different from implants free of any clinically observed changes

with respect to the histologic finding "Marked crestal bone resorption".

Fisher's exact test (55) was used to test each of these hypotheses except hypotheses 5, 10 and 11, where the chi-square statistic was used (56). The hypotheses were accepted if no significant difference was found between the two test groups and rejected if a significant difference at the 0.05 level was found.

RESULTS

Clinical Findings after Extraction of Teeth

The rate and pattern of healing of extraction wounds was not uniform in all of the dogs. At seven weeks after extraction, the alveoli of dogs 4630 and 4632, which were littermates, were similar in that they were much more radiolucent than the surrounding bone and the lamina dura was partially visible. In dogs 6004 and 6007, which were also littermates, at seven weeks all extraction sites were more radipaque than the surrounding bone, but remnants of the lamina dura could not be distinguished. In dogs 3474, 3475 (littermate to 3474), 6043 and 4598 the alveoli were beginning to fill with bone of the same radiopacity as that of the surrounding bone.

After extraction, in dogs 4630, 4632 (littermates), and 6004 the shape of the alveolar ridge underwent marked changes which could be detected visually and by palpation. The crest of the ridge became sharp, narrow and irregular in these animals, while dogs 6007, 6043 and 4598 had broad, flat ridges. Dogs 3474 and 3475 (littermates) had smooth ridges which were not as wide as those of 6007, 6043 and 4598, but wider than those of 4630, 4632 and 6004. The differences are substantiated by measurements on fixed mandibles (see gross examination, pp 63).

Clinical Findings at the Time of Implantation

At the time implantation was begun, the extraction sites in all dogs had the same radiopacity as the surrounding structures and could not

be distinguished from the surrounding bone.

Clinical Findings Following Implantation and Sham-Site Operation

Except for the loss of implants, healing was uneventful around both types of implants as well as at the sham-operated sites. Eight days after surgery, the incisions had completely closed and epithelialized. Two weeks after surgery the edentulous alveolar ridges containing both types of implants and the sham sites could not be distinguished from normal, edentulous alveolar ridges (Plate 1, pp 110). Only three of the implants could be detected by palpation after their insertion. From three to six weeks after insertion, fourteen implants which were not palpable originally became palpable. These fourteen implants and two of the three implants originally palpable showed one or more of the following specific changes:

1. Thinning of the mucosa
2. Depigmentation
3. Loss of the mucosa.

The changes are listed in Table 6 (pp 51).

No changes suggestive of inflammation such as redness, swelling, presence of exudate or mobility of implants were observed at any of these sixteen implant sites, nor at any of the sham-operated sites.

Thinning of the mucosa and depigmentation

Thinning of the mucosa and depigmentation were observed concurrently. Depigmentation was striking in black-haired dogs with heavily pigmented gingivae (Plate 2, pp 112), and was less apparent in light-haired dogs with less pigmented gingivae. The mucosa was thinner over the top of the implants; consequently, the implants could be palpated. In the case of Ticonium implants the tissues showed greyish translucency.

Table 6

Clinical Course of Implants

Dog Kennel Number	Sites	Implants	Palpable after Placement	Thinning of the mucosa at (No. of weeks after placement)	Loss of mucosa at (No. of weeks after placement)
3474	All	All	No	No	No
3475	Right Molar	Acrylic	No	No	No
		Ticonium	No	No	No
	Right Premolar	Acrylic	No	No	No
		Ticonium	No	Yes (6)	No
	Left Molar	Acrylic	No	No	No
		Ticonium	No	No	No
	Left Premolar	Acrylic	No	Yes (4)	No
		Ticonium	No	Yes (4)	No
4630	Right Molar & Premolar	All	No	No	No
	Left Molar	Acrylic	No	Yes (4)	No
		Ticonium	No	Yes (3)	No
	Left Premolar	Acrylic	No	Yes (3)	No
		Ticonium	No	Yes (4)	No
4632	Right Molar	Acrylic	No	Yes (4)	Yes (8)
		Ticonium	No	No*	No
	Right Premolar	Acrylic	No	Yes (4)	No
		Ticonium	No	Yes (4)	No

Table 6 (Continued)

Clinical Course of Implants

Dog Kennel Number	Sites	Implants	Palpable after Placement	Thinning of the mucosa at (No. of weeks after placement)	Loss of mucosa at (No. of weeks after placement)
4632	Left Molar	Acrylic	No	No	No
		Ticonium	No	No	No*
	Left Premolar	Acrylic	No	Yes (4)	No
		Ticonium	No	Yes (4)	No
6004	Right Molar	Acrylic	No	No	No
		Ticonium	Yes	No	No
	Right Premolar	Acrylic	No	No	No
		Ticonium	No	No	No
	Left Molar	Acrylic	Yes	Yes (4)	Yes (7)
		Ticonium	Yes	Yes (4)	No
	Left Premolar	Acrylic	No	Yes (4)	Yes (8)
		Ticonium	No	Yes (4)	No
6007	All	All	No	No	No
6043	All	All	No	No	No
4598	All	All	No	No	No

Table 7

Clinical Changes Associated with Implants at End of Experiment

		ACRYLIC (Number of Implants)	TICONIUM (Number of Implants)
LOSS OF IMPLANT			
Dog 4632	5 weeks	0	1
	10 weeks	0	1*
	Total	0	2
LOSS OF MUCOSA OVER IMPLANT			
Dog 4632	5 weeks	0	0
	10 weeks	1	0
Dog 6004	5 weeks	0	0
	10 weeks	2	0
		3	0*
THINNING OF MUCOSA OVER IMPLANT			
Dog 3475	5 weeks	1	1
	10 weeks	0	1
Dog 4630	5 weeks	0	0
	10 weeks	2	2
Dog 4632	5 weeks	1	1
	10 weeks	1	1
Dog 6004	5 weeks	0	0
	10 weeks	0	2
	Total	5	8*
TOTAL NUMBER OF IMPLANTS WITH CHANGES		8	10*

*Difference is not statistically significant.

Loss of the mucosa

Three of the acrylic implants with thinning of the overlying mucosa became exposed to the oral environment seven to eight weeks after insertion (Plate No. 3, pp 114). The area of exposure enlarged from barely visible at seven weeks to about 2 mm x 2 mm at ten weeks (at which time the animals were sacrificed).

Loss of implants

Two of the Ticonium implants fell out during their post-operative period before the incisions had closed. The implants were not actually observed during exfoliation, but were absent at the follow-up examination eight days after insertion. At this time and when withdrawing sutures at five days after insertion, there were no clinical signs of inflammation. The shape of the alveolar ridge was sharp and narrow in the area of these implants and they had not been firmly fixed at the time of their placement. (The investigator had recorded this fact at that time.)

Clinical changes related to acrylic and Ticonium implants

Essentially three types of changes were observed as shown in Table 7 (pp 53). These changes were:

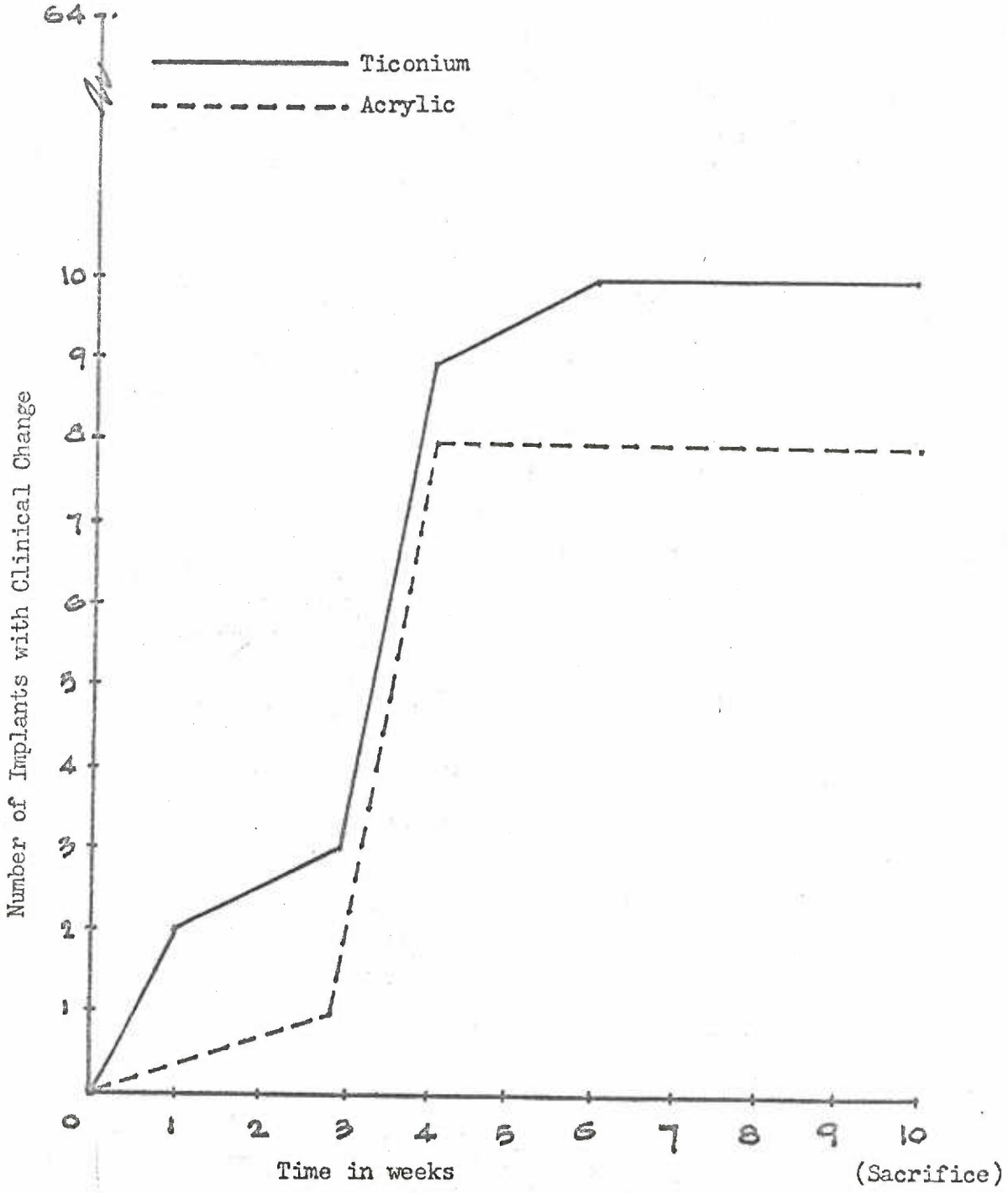
1. Loss of implant
2. Thinning of the mucosa with depigmentation
3. Loss of mucosa.

The difference between acrylic and Ticonium implants with respect to each change is within the limits of experimental error (see pp 165, Statistical Analyses).

It is also apparent that the total number of acrylic implants associated with changes is smaller than the total number of Ticonium implants associated with changes. However, this difference is not statistically

Figure 6

Cumulative Occurrence of Clinical Changes in Relation to Time



significant at the 0.05 level of significance (see Appendix, pp 166, Statistical Analyses). As noted earlier, six of the acrylic implants fractured during insertion. The clinical changes associated with these implants were not statistically different at the 0.05 level of significance from those which did not fracture (see Appendix, pp 165, Statistical Analyses). Therefore fractured acrylic implants were included with intact implants in Table 7 and were considered as one group--"acrylic implants"--when analyzing the difference between acrylic and Ticonium implants.

Relationship of clinical changes to time

Figure 6 shows the cumulative occurrences of all clinical changes in relationship to time. It can be seen that the number of implants associated with clinical changes increases as time goes by with a particularly sharp increase between the third and fourth weeks after implant placement. Between the fourth and sixth weeks the curve for Ticonium implants levels off and becomes completely level between the sixth and tenth weeks, while the curve for acrylic implants stays level from the fourth week on. It should be noted, however, that three of the acrylic implants with only "thinning of the mucosa" at the end of the fourth week had "loss of mucosa" at the end of the eighth week.

Table 8 shows the clinical changes in five and ten week implants for convenience of comparison. Since "thinning of the mucosa" and "loss of mucosa" constitute a continuous process, these two are included here under one heading. Acrylic and Ticonium implants are considered together because it has been previously shown that there is no significant difference between them (see Appendix, pp 165, Statistical Analyses). Note that more implants in the 10-week group than in the 5-week group show this feature.

Table 8

Numbers of Five-and Ten-Week Implants
Associated with Clinical Tissue Changes

	Five-week Implants	Ten-week Implants	Total
ALL CHANGES			
Acrylic	2	6	8
Ticonium	3	7	10
Acrylic and Ticonium	5	13	18
LOSS OF IMPLANT			
Acrylic	0	0	0
Ticonium	1	1	2
Acrylic and Ticonium	1	1	2
THINNING OF THE MUCOSA AND LOSS OF MUCOSA			
Acrylic	2	6	8
Ticonium	2	6	8
Acrylic and Ticonium	4	12	16

Table 9

Clinical Changes Related to Anatomical Site

	Molar Area (Number of Implants)	Premolar Area (Number of Implants)
Loss of Implant		
Acrylic	0	0
Ticonium	2	0
	2	0
Thinning of the Mucosa and Loss of Mucosa over Implant		
Acrylic	3	5
Ticonium	2	6
	5	11
All changes	7	11

Relationship of clinical changes to anatomical site

It was of interest to determine if the anatomical site influenced the tissue response to the implants. Table 9 contrasts the number of implants with clinical changes in molar areas versus premolar areas. The difference between these two anatomical sites with respect to all changes of either of the two processes ("loss of implant" and "thinning of the mucosa with subsequent loss of mucosa") is within the limits of experimental error. In this test, acrylic and Ticonium implants were again considered as one group, because it had been shown that there was no significant difference between them with respect to clinical changes (see Appendix, p 165, Statistical Analyses).

Relationship of clinical changes to specific experimental animals

Table 10 lists the number of implants with changes by dog. It should be noted that most of the changes occurred in certain dogs, while in others there were no clinically manifest tissue changes related to the implants. The dogs with the largest number of changes (4630, 4632, 6004) all have the greyhound genetic background and are females. Dog 6004 was a littermate to 6007 (see Table 3) which was a male and had no changes; however, dog 6004 resembled the pair 4630-4632 phenotypically, while 6007 resembled dogs 6043 and 4598 phenotypically. Also apparent from Table 10 is the fact that there were three implants with changes in the three male animals, while there were fifteen implants with changes in the five female animals. However, the difference between males and females with respect to the number of implants with clinical changes is within the limits of experimental error (see Appendix, p 167, Statistical Analyses).

Table 10

Clinical Changes Related to Specific Experimental Animals

Dog Kennel Number	Genetic Background*	Sex	Number of Implants with Changes
3474	BR/BR	F	0
3475	BR/BR	M	3
4630	R/BG	F	4
4632	R/BG	F	7
4598	BR/BR	F	0
6004	BR SG BR /	F	4
6007	BR	M	0
6043	BR SG BR/RBG	M	0

*B = Basenji R = Retriever S = Samoyed G = Greyhound

Relationship of clinical changes to injury during extraction

As noted earlier, some of the roots were fractured during extraction and some required removal of bone for their extraction. Table 11 (pp 62) shows the anatomical areas in which roots had been fractured during extraction and lists the number of implants with clinical change in each of these areas. From Table 11 it can be seen that there were five out of a total of sixteen implants with clinical changes in the areas where roots had been fractured. The areas of extraction not complicated by root fracture received forty-eight implants, fifteen of which were associated with clinical changes. The difference in number of clinical changes observed in areas with root fracture and areas without root fracture is within the limits of experimental error (see Appendix, p 166, Statistical Analyses).

Radiographic findings following implantation and sham-site operation

No pathological changes around implant or sham sites were observed on x-ray films. However, at five weeks as well as at ten weeks the crest of the alveolar ridge had a diffuse, slightly scallopped outline indicative of bone resorption in all dogs. This finding was present over implant and sham areas as well as in areas containing neither implant nor sham sites. Bone around implants with clinical changes ("loss of mucosa" and "thinning of the mucosa") had the same appearance as bone around implants without clinical changes (see Plates 4 and 5). The exfoliation sites of the two Ticonium implants which fell out had the same appearance as their corresponding sham sites.

Gross Findings

Gross findings related to the implants

When examining the gross, formalin fixed specimens, the top of the

Table 11

Relationship of Clinical Changes to Injury during Extraction

Dog Kennel Number	Side	Area	Fractured Root	Required Bone Removal for Extraction	Clinical Changes (Number of Implants)
3475	Left	Premolar	Yes	No	0
4630	Right	Premolar	Yes	Yes	0
4632	Left	Premolar	Yes	No	2
	Right	Molar	Yes	Yes	1
4598	Right	Premolar	Yes	Yes	0
	Left	Premolar	Yes	No	0
6004	Right	Premolar	Yes	Yes	0
	Left	Premolar	Yes	No	2
Total					5

acrylic implants could be seen. These portions were transparent and of the same appearance as at the time of their preparation. After decalcification, however, the acrylic implants appeared opaque. The Ticonium implants retained their original appearance and were untarnished even after decalcification.

Gross findings related to the tissues

The gross findings were in agreement with the clinical findings in that no pathological changes besides "loss of mucosa" and "thinning of the mucosa" were observed.

The tissues, particularly in the gingivae, were firmly adherent to the implants and were at times torn when removing the implants.

The periosteum was normal and the cortical plates were intact and normal.

Measurements on gross specimens

(The following measurements are illustrated in Figure 6, pp 42).

1. Distance between inferior surface of implant lip and alveolar crest.

   This distance was not measurable in any dog in any unit; in other words, none of the implants were extruded from their sockets.

2. Distance between adjacent implants within one experimental unit.

   The measurements varied from 0.3 to 0.6 cms, with the mode being 0.4 cms.

3. Distance between two experimental units on the same side (distance between mesial implant of the molar unit and distal implant of the premolar unit on the same side).

   These varied from 1.3 to 2 cms, the mode being 1.6 cms.

Table 12

Width of Mandibles (in cms) and Ratio of Width at Crest to Length of Mandible

Dog Kennel Number	Width at Crest				Ratio of Width to Length				Average
	Molar		Premolar		Molar		Premolar		
	Right	Left	Right	Left	Right	Left	Right	Left	
3474	0.3	0.3	0.4	0.4	0.039	0.040	0.053	0.055	0.0470
3475	0.4	0.4	0.4	0.4	0.049	0.048	0.049	0.048	0.0485
4598	0.5	0.5	0.5	0.7	0.068	0.067	0.082	0.080	0.0742
6043	0.5	0.5	0.6	0.6	0.054	0.055	0.064	0.066	0.0597
6007	0.5	0.5	0.7	0.5	0.060	0.060	0.084	0.059	0.0657
6004	0.2	0.1	0.2	0.1	0.024	0.012	0.024	0.012	0.0180
4630	0.2	0.2	0.1	0.1	0.022	0.023	0.012	0.011	0.0170
4632	0.1	<0.1	0.1	0.1	<0.010	0.010	0.010	<0.010	<0.0100

4. Length of the hemimandibles (distance from the distal surface of the canine tooth to the anterior border of the ramus in the retromolar angle on right and left sides).

   The length of the mandibles varied from 7.6 in dog 3474 to 9.3 in dog 6043.

5. Width of the mandibles (buccolingual diameter of mandibles in cross-section at four equivalent points (see diagram, Figure 6).

   5.1 From 0.1 to 0.5 at the most distal point of the molar unit at the top of the alveolar crest.

   5.2 From 0.6 to 1.0 at the most distal point of the molar unit above the mandibular canal.

   5.3 From 0.1 to 0.7 at the most mesial point of the premolar unit above the mandibular canal.

The more relevant measurements for each dog are given in Table 12.

Relationship of alveolar ridge shapes to clinical changes

On the basis of mandibular width at crest (Table 12) and the ratio of mandibular width at crest to length of mandibles, the dogs could be divided into two categories:

1. Dogs with flat wide ridges (3474, 3475, 4598, 6043, 6007).
2. Dogs with narrow, sharp ridges (6004, 4630, 4632).

In Table 13, the number of implants associated with clinical changes for dogs falling into each of these categories is given. The difference in number of implants associated with clinical changes between dogs with narrow, sharp alveolar ridges (15 out of 24) and dogs with wide, flat ridges (3 out of 40) is highly significant when evaluated statistically.

Table 13

Relationship of Alveolar Ridge Shapes to

Clinically Observed Changes

	Number of Implants with Clinical Changes	Total Number of Implants
Dogs with broad, flat ridges		
6007	0	8
6043	0	8
4598	0	8
3475	3	8
3474	0	8
Total	3	40
Dogs with narrow, sharp ridges		
6004	4	8
4630	4	8
4632	7	8
Total	15	24

Table 14

Division of Implant and Sham Sites According to Inflammation

	Ten week			Five week		
	Acrylic	Ticonium	Sham	Acrylic	Ticonium	Sham
Inflammation Chronic	1 Minimal or none	2 Minimal or none	3 Minimal or none	4 Minimal or none	5 Minimal or none	6 Minimal or none
	7 Moderate	8 Moderate		9 Moderate	10 Moderate	
Acute	11 Moderate					

Microscopic Observations

Microscopic descriptions

On the basis of inflammatory reactions, implant and sham sites could be divided into eleven groups which are numbered and tabulated in Table 18:

1. 10-week acrylic implant sites with minimal chronic inflammation or no inflammation.
2. 10-week Ticonium implant sites with minimal chronic inflammation or no inflammation.
3. 10-week sham sites with minimal chronic inflammation or no inflammation.
4. 5-week acrylic implant sites with minimal chronic inflammation or no inflammation.
5. 5-week Ticonium implant sites with minimal chronic inflammation or no inflammation.
6. 5-week shame sites with minimal chronic or no inflammation.
7. 10-week acrylic implant sites with moderate chronic inflammation.
8. 10-week Ticonium implant sites with moderate chronic inflammation.
9. 5-week acrylic implant sites with moderate chronic inflammation.
10. 5-week Ticonium implant sites with moderate chronic inflammation.
11. 10-week acrylic implant sites with moderate acute inflammation.

Since several of these groups presented the same microscopic appearance, composite descriptions were made of each similar series of implant or sham sites.

Ten week implants with minimal chronic or no inflammation (Group 1 and 2)

The description proceeds from the surface epithelium to the apical area of the implant. Where the epithelium was not disrupted by post-mortem extraction of the implant it appeared intact, usually with multiple, well-developed rete pegs. Occasionally, the rete pegs decreased in depth and number and the epithelium became flattened. This was observed also in areas of the gingiva which contained no implants. The basal layer of the epithelium varied from moderate to heavy melanin pigmentation. In the lamina propria of the mucosa, an occasional dense focus of inflammatory cells, chiefly lymphocytes and plasma cells, could be found distant from the implants.

The top of the implants, including the lip portions situated in the gingiva, were covered by a thick layer of fibrous connective tissue, which consisted of thick bundles of collagen fibers running parallel to the surface of the implant. The bundles of fibers followed the contour of the implant (Plate No. 10, p 128). This layer was distinct from bundles of collagen in the submucosa, which were randomly arranged.

In most cases, crestal bone resorption was a prominent feature. The severity of this process was graded as:

1. slight, with a few shallow Howship's lacunae and an occasional osteoclast (Plate 17 , p 142).
2. moderate, with a jagged crestal outline and few osteoclasts (Plate 18 , p 144).
3. marked, with many osteoclasts, having either a jagged crestal outline or large deep excavations. In the latter instance, large portions of vital bone seemed to be separated from the crest (Plate 19 , p 146).

Crestal bone resorption could be of such an extent that only about half the length of the implant remained surrounded by bone (Plate 20, p 148).

Often the highest portion of the crest was next to the implant. The crest either sloped down away from the implant in both directions in the plane of the section or was at the same level next to the implant as it was at places distant from the implant. In a few instances (recorded in the tabulation) young trabeculae of bone formed along the surface of the implant and extended coronally above the alveolar crest as a thin bony plate (See Plate 7, p 122).

The sham-operated sites were either level or concave compared to the outline of the adjacent alveolar crest. There was no predictable pattern of bone resorption mesial or distal to the implant or sham sites. The only apparent tendency was for the crest to be somewhat higher next to the implant.

The intraosseous shaft of the implant was surrounded by bone with mature histologic characteristics which could be distinguished from the bone originally present in the area.

At times, the implant lip was lying directly on bone without causing apparent bone resorption; at other times there was a layer of dense fibrous connective tissue between the inferior side of the implant lip and the top of the alveolar crest which was undergoing resorption.

The implant sites were lined by a very fine connective tissue membrane estimated to vary from less than 5 to about 10 microns in thickness (Plate 9 , p 126). Occasionally, this membrane was continuous with a wide band of loose connective tissue estimated from 80 to 100 microns. The thin membrane was most prominent in areas where it

separated a marrow space from the implant space. Adjacent to compact bone the connectissue membrane was hard to observe because it was flattened against the bony surface. The membrane often contained dark, elongated, flattened nuclei resembling fibrocytes, and at times larger nuclei resembling osteoblasts.

In this connective tissue membrane and in the marrow spaces adjacent to the implant, there were sparsely distributed perivascular inflammatory cells (Plate No. 23, p. 154). These were lymphocytes, plasma cells, macrophages and an occasional neutrophil. Special staining (Giemsa) for eosinophils and mast cells was negative. Special staining for bacteria with Brown and Brenn stain proved also negative. At all sites there were areas of perivascular hemorrhage.

The major portion of the implant shaft was surrounded by newly formed bone; in most cases, the trabeculae were arranged with their long axis parallel to the long axis of the implant and resembled the lamina dura surrounding the roots of teeth (Plate No. 6, p 120).

The maturity of the bone adjacent to the implant site appeared the same as that seen in the 10-week sham sites.

In a number of sites there were deep purple staining cellular amorphous areas most often completely enclosed in vital bone (Plate 28, p 164). These were interpreted and tabulated as residual necrotic bone. In each implant site where residual necrotic bone was present, new, vital bone had formed between the implant surface and the necrotic bone. An occasional purple staining mass was found in the marrow space and interpreted as dystrophic calcification. Such areas were not associated with bone resorption.

An unexpected finding in this series was the reaction of the

tissues to those acrylic implants which fractured. Those which had fractured in such a manner that the top of the implant was level with or deep to the alveolar crest were partially or totally overgrown by bone.

One implant had fractured and both portions remained in situ. A bridge of tissue had grown through the break of continuity in the implant (Plate No. 22, p 152). The bridge of tissue had two layers; one consisted of young mature bone, the other of cell rich connective tissue. These cells were arranged in a palisading fashion and were continuous with the periosteum.

Five-week implants (acrylic and Ticonium) with minimal chronic inflammation or no inflammation (Groups No. 4 and 5)

This group differed from the ten-week implants in that the major portion of the implant shaft was surrounded by dense fibrous connective tissue. The remainder of the features were the same as in the ten-week implants with minimal chronic or no inflammation. The bundles of fibers were arranged parallel to each other and parallel to the long axis of the implant; the nuclei had the same orientation.

The dense connective tissue layer varied in width. Most often it was as wide as the periodontal membrane of the dog. (Portions of the canine roots were included in the premolar experimental unit and the width of the periodontal membrane could be observed.) Within the same section, it would narrow to a thin band consisting of a few bundles of collagen only. Youthful, small osseous trabeculae were formed directly in this layer, at times replacing it in the entire length of an implant shaft in one section. In the next section, dense connective tissue layer would reappear again, with a different proportion of bone to dense

connective tissue occupying the area next to the implant.

A dense fibrous connective tissue layer of youthful bone surrounded the shaft of the implant. This was followed in some sections by a loose connective tissue layer and youthful bone, or directly by youthful bone and at times by mature bone.

The new bony trabeculae within the dense connective tissue layer and adjacent to it were considered less mature than those at the ten-week implant and sham sites, but were equivalent in maturity to the bony trabeculae at the five-week sham sites.

In a few instances, there were aggregations of giant cells and lymphocytes in the gingiva distant to the implant. The giant cells contained a birefringent foreign body.

Implants (acrylic and Ticonium 5-and 10-week) with moderate chronic inflammation (Groups 7, 8, 9 and 10)

The only difference between this group and the five-and ten-week groups with minimal or no inflammation was the presence of moderate chronic inflammation. There were dense, focal areas of inflammation consisting chiefly of lymphocytes and plasma cells. These foci were found next to the implant and in the gingiva only. (Plate No.25, pp 158)

In the rest of the implant area, there was only minimal or no inflammation.

Ten-week implants (acrylic) with moderate acute inflammation (Group 11)

This group, consisting of three implant sites, differed from the ten-week implant sites with minimal chronic or no inflammation in two ways only:

1. Adjacent to the implant there was a band-like inflammatory

infiltrate consisting of neutrophils, macrophages, lymphocytes and plasma cells in decreasing order of frequency (Plate No. 26, p 160). In the adjacent marrow spaces scattered cells of the same types were observed. Special staining for eosinophils and mast cells (Giemsa) as well as for bacteria (Brown and Brenn) were negative.

2. The surface epithelium proliferated toward the apex along the lateral sides of the implant. Near the surface a broad layer of epithelium was present, which became thinner as it reached deeper structures. In the middle third of the implant site the epithelium was densely infiltrated by inflammatory cells and only isolated islands of epithelial cells were seen next to the implant (Plates No. 26, 27, pp 160, 162).

   In the apical third, no epithelium was found. In the two other implants in this group, epithelial downgrowth was limited to the gingival third of the implant site and so was the moderate, acute type of inflammation. In the lower half of the implant, where no epithelium was present, there was only minimal chronic inflammation of the same type as in the other lo-week implant sites with minimal chronic inflammation.

   In spite of the presence of inflammation between implant and bony surface, the latter did not show prominent signs of bone resorption. Only an occasional Howship's lacuna or osteoclast was observed. However, this slight degree of bone resorption was comparable to that seen at the other group of implant sites which had minimal chronic or no inflammation. A similar degree of resorption was also seen at sham-operated sites as well as

in unoperated areas of bone.

All other microscopic features were the same as in the ten-week implant areas with minimal or no inflammation.

Ten-week sham sites (Group 3)

In all except two instances, the sham sites could be distinguished from the surrounding bone. The ease with which this distinction could be made varied, some sham sites being more difficult to identify than others. Nevertheless, the following features could be identified at the sham sites after ten weeks:

The line of the cut (when preparing the socket) could at times be observed as a sharp break of continuity in the bone. Sometimes there was a thin, deep purple staining line.

The direction of fibers and lamellae in the bone at the sham site showed an abrupt, 90 degree change from those in the surrounding bone.

The age of the bone at the sham sites was different from that of the surrounding bone. More bone fibers and osteocytes per unit area could be observed.

An occasional osteoclast and a few, perivascular inflammatory cells in the marrow spaces at the site were also seen.

Residual necrotic bone was present in the same degree as in the 10-week implant sites.

Crestal bone resorption was essentially the same as at the 10-week implant sites except that the sham areas tended to be level or concave when compared to the outline of the adjacent alveolar crest.

Occasional accumulations of foreign body giant cells, containing a birefringent foreign body, were found in the gingiva away from the

sham sites. Occasional foci of dense inflammation in the gingiva, away from the sham sites, were also seen. These consisted mainly of lymphocytes and plasma cells.

Five-week sham sites, Group 6 (Plate No. 15, pp 138)

In contrast to ten-week sham sites, the five-week sham sites could be distinguished from the surrounding bone at first glance.

They had a central portion of youthful, very vascular loose connective tissue with areas of fresh hemorrhage as well as abundant hemosiderin pigment. The lateral areas of the sham sites had young, small osseous trabeculae directed at various angles to each other. The trabeculae were surrounded by a row of plump osteoblast and at times had a light pink osteoid halo. It seemed that the defect created in the bone was filling in from the lateral sides as well as the deepest portions simultaneously.

Within the central soft tissue portion as well as the marrow spaces, minimal perivascular inflammation, of the same type and degree as observed at the implant sites, was present.

Occasional groups of dense, chronic inflammatory cells and foreign body giant cells were observed in the gingiva distant from the sham sites.

Tabulated microscopic features

As mentioned earlier in Materials and Methods (pp 44) certain specific histologic features were tabulated.

Tables 15-18 list the number of acrylic, Ticonium and sham sites which contained each of these tabulated histologic features. Fractured acrylic implants were included with non-fractured acrylic implants because statistically no significant difference was found between them with

Table 15

Microscopic Observations:

(Five and Ten-Week Implants)

	ACRYLIC (Number of Implants)	TICONIUM (Number of Implants)	SHAM (Number of Sites)
Lymphocytes and/or plasma cells			
Present	27	24	22
Absent	4	1	7
Cannot tell	1	7	3
Granulocytes			
Present	20	11	11
Absent	5	11	7
Cannot tell	7	10	14
Inflammation interpreted as:			
Minimal	22	17	21
Moderate	5	4	0
Marked	0	0	0
No inflammation	5	11	11

Table 16

Microscopic Observations

Bone Formation and Resorption at Implant or Sham Sites

(Five-and Ten-Week Implants)

	ACRYLIC (Number of Implants)	TICONIUM (Number of Implants)	SHAM (Number of Sites)
Bone formation			
Present	32	32	32
Absent	0	0	0
Cannot tell	0	0	0
Bone formation is			
Slight	0	0	0
Moderate	0	0	0
Marked	32	32	32
Evidence of bone resorption			
Present	14	11	13
Absent	16	18	16
Cannot tell	2	3	3
Bone resorption interpreted as			
Slight (remodeling)	14	11	13
Moderate	0	0	0
Marked	0	0	0

Table 17

Microscopic Observations

Miscellaneous Features Present at Implant or Sham Sites

(Five-and Ten-Week Implants)

	ACRYLIC (Number of Implants)	TICONIUM (Number of Implants)	SHAM (Number of Sites)
Residual necrotic bone			
Present	17	19	16
Absent	15	13	16
Cannot tell	0	0	0
Soft tissue necrosis			
Present	1	2	0
Absent	31	30	32
Cannot tell	0	0	0
Epithelial downgrowth			
Present	4	0	0
Absent	28	30	32
Cannot tell	0	2	0

Table 18

Microscopic Observations

Tissue Changes at the Alveolar Crest

(Five-and Ten-Week Implants)

	ACRYLIC (Number of Implants)	TICONIUM (Number of Implants)	SHAM (Number of Sites)
Evidence of bone resorption			
Present	28	30	30
Absent	4	2	2
Cannot tell	0	0	0
Bone resorption at crest interpreted as:			
Slight	8	12	7
Moderate	6	3	7
Marked	14	15	16
Bone formation at crest			
(Recorded when present only)	4	4	5
Bone formation next to implant exceeding height of crest			
(Recorded when present only)	4	3	-

respect to any of the tabulated histologic features.

In addition to the features listed in Tables 15-18, the presence of focal inflammation in the gingiva away from the implant or sham sites was recorded in two blocks containing acrylic, three blocks with Ticonium and three blocks with sham sites.

Consistency of the investigator's interpretation

The consistency of the investigator's interpretation of the various histologic features was acceptable (See Appendix, p 186, Statistical Analyses).

Results of statistical evaluation of microscopic findings

There was no significant difference between acrylic and Ticonium implants with respect to any of the tabulated histologic features at the 0.05 level of significance (See Appendix, p 171, Statistical Analyses).

Comparison of clinical and microscopic findings

Table 19 lists the number of implant sites (acrylic and Ticonium combined) in each clinical category which show a certain histologic feature.

The following facts contained in this table are emphasized:

The group "loss of implant" has no more microscopically observed tissue changes than the "no clinical change" group.

The group "thinning of the mucosa" is similar to the "no clinical change" group in most of its microscopic characteristics, but differs in two aspects:

1. Epithelial downgrowth is present at one site in the "thinning of the mucosa" group but absent at all sites in the "no clinical change" group.
2. Ten out of thirteen implant sites (77%) show marked crestal

bone resorption in the "thinning of the mucosa" group, while only fourteen out of forty-six (30%) implant sites in the "no clinical change" group show this feature.

The group "loss of mucosa" differs from the "no clinical change" group as follows:

1. All implant sites in the category "loss of mucosa" have epithelial downgrowth, while none of the implant sites in the category "no clinical change" have this feature.
2. All implant sites in this group ("loss of mucosa") have marked crestal bone resorption, while only 30% of implant sites in the "no clinical change" group have marked crestal bone resorption. This group ("loss of mucosa") differs from the "thinning of the mucosa" group in respect to epithelial downgrowth and soft tissue necrosis. These features will be discussed further on pages 90, 91, and 92.

Table 19

Comparison of Clinical Findings and Tabulated Histologic Features

Histologic Feature	Loss of Implant (Number of implant sites)	Thinning of Mucosa (Number of implant sites)	Loss of Mucosa (Number of implant sites)	No Change (Number of implant sites)
Lymphocytes and/or Plasma Cells*				
Present	0	8	3	40
Absent	0	1	0	4
Cannot tell	2	4	0	2
Granulocytes*				
Present	0	4	3	24
Absent	0	1	0	15
Cannot tell	2	8	0	7
Inflammation* Interpreted as				
Minimal	0	6	0	33
Moderate	0	2	3	4
Marked	0	0	0	0
No inflammation	2	5	0	9
Bone Formation*				
Present	5	13	3	46
Absent	0	0	0	0
Cannot tell	0	0	0	0

Table 19 (Continued)

Comparison of Clinical Findings and Tabulated Histologic Features

Histologic Feature	Loss of Implant (Number of implant sites)	Thinning of Mucosa (Number of implant sites)	Loss of Mucosa (Number of implant sites)	No Change (Number of implant sites)
Bone Formation*				
Slight				
Moderate				
Marked	2	13	3	46
Bone Resorption*				
Present	1	6	1	16
Absent	1	7	2	25
Cannot tell	0	0	0	5
Bone Resorption*				
Slight	1	6	1	16
Moderate	0	0	0	0
Marked	0	0	0	0
Residual Necrotic Bone*				
Present	2	8	2	24
Absent	0	5	1	22
Cannot tell	0	0	0	0
Soft Tissue Necrosis*				
Present	0	0	1	0
Absent	2	13	2	46
Cannot tell	0	0	0	0

Table 19 (Continued)

Comparison of Clinical Findings and Tabulated Histologic Features

Histologic Feature	Loss of Implant (Number of implant sites)	Thinning of Mucosa (Number of implant sites)	Loss of Mucosa (Number of implant sites)	No Change (Number of implant sites)
Epithelial Downgrowth*				
Present	0	1	3	1
Absent	2	9	0	46
Cannot tell	0	3	0	0
Bone Resorption at Crest				
Present	2	13	3	40
Absent	0	0	0	6
Cannot tell	0	0	0	0
Bone Resorption at Crest				
Slight	0	2	0	18
Moderate	0	1	0	8
Marked	2	10	3	14
Bone Formation at Crest (Recorded when present only)	0	3	0	5
Bone Formation next to Implant Exceeding Height of Crest (Recorded when present only)	0	3	0	4

* At implant site

DISCUSSION

Implant materials used

Ticonium was chosen as the control implant material because it is a chrome-cobalt alloy and is therefore known to be well-accepted by the tissues. In addition, the prosthetic laboratory of the University of Oregon Dental School is franchised to work with this particular brand of alloy, thus permitting ready access to the required facilities. A commonly available brand of self-curing transparent denture base acrylic (Walther's), which had been used by this investigator, was selected for the present experiment. The selection and method of using the self-curing acrylic requires some comment:

The self-curing type of acrylic appears to be more controversial as an implant material than heat-cured acrylic, according to the literature. In Pasqualini's experiment (38), three out of four implants made of the self-curing variety of acrylic exfoliated while only one out of four of the heat-curing variety was lost, though another author (31) claimed good results with the self-curing type of acrylic.

Adverse reactions are generally attributed to free residual monomer, which is believed to be toxic. One would expect more residual monomer and hence more pronounced deleterious effects with the self-curing type.

One of the most important and salient features of the present study was the fact that acrylic seemed to be as well-accepted by the tissues as Ticonium. The results may have been related to the processing of

the acrylic. In this study, the acrylic was subject to heat during the preparation as well as during the sterilization of the implants. It was hoped that the sterilizing procedure would coincidentally reduce the amount of monomer in the implant.

The acceptance of the acrylic by the tissues in this study is in agreement with the findings of Flohr (30) and Hodosh et al. (32, 33, 34, 35), but in disagreement with the findings of Pasqualini (38) and Hegedus and Inke (37). Neither Flohr nor Hodosh specify the type of acrylic used, but Hodosh does state that his implants were subject to heat during fifteen minutes. Hegedus and Inke (37), in one of their methods, cemented their implants using a mixture of uncured acrylic with despeciated bone; with respect to their other method (precured implants only), they do not indicate how their acrylic was processed. Neither does Pasqualini mention how the acrylic was processed. The method of these authors (Pasqualini and Hegedus and Inke) may have been different from the method used in this study. In addition, from Pasqualini's report it appears, though not clearly stated, that all implants of one kind of material were placed in the same dog. Factors pertaining to that particular animal may have influenced his results. It should be recalled that in a preliminary experiment by this investigator, all implants placed in one dog during a period of illness exfoliated, whereas other implants, placed in the same dog during periods free of illness, remained in situ.

When the present study is compared with the reports in the literature, it appears that heat treatment of the implants to reduce the amount of free monomer is an important factor in the tissue reaction to the implant. Because the time required to process self-curing acrylic is

less than for heat-cured acrylic, the use of self-curing acrylic would be more advantageous in a clinical situation where speed is essential.

Duration of study

The present investigation was a short-term study which showed that acrylic did not produce toxic, allergic or other untoward reactions. Long-term studies should be undertaken to rule out or confirm the carcinogenic potential of this material.

The specific periods of observation of five and ten weeks were chosen in accordance with the healing rates recorded in the literature. Healing around both acrylic and Ticonium implants in the present study proceeded at essentially the same rate as it did around the Vitallium implants used by Seidenberg and Lord (16). In both studies, the five-week implants had a wide band of connective tissue, with the cells and fibers oriented parallel to the implant surface and following the implant's curvature. Young bony trabeculae were present in the fibrous tissue as well as peripherally to it. The ten-week implants in both studies were lined by a thin connective tissue membrane and surrounded by more mature bone. It should also be emphasized that the rate of healing in the present study seemed to be the same at sham and implant sites. Acrylic and Ticonium did not produce a delay in healing at the five-and ten-week stages of this experiment. This was not the case with other plastics, however. Polyurethane polymer implanted as an immobilizing agent in experimentally fractured mandibles in dogs delayed the normal process of healing as observed at three and four weeks (48).

Clinical and microscopic observations

There was no statistically significant difference between acrylic and Ticonium implants with respect to any of the clinical and microscopic

features observed. The most important observations were as follows:

After tooth extraction, the wounds healed well but the alveolar ridges took on two different shapes:

1. sharp and narrow
2. blunt and broad

The shape of the healed ridge played an important role in all the changes which were observed clinically after implantation. These changes were "loss of implant", "thinning of the mucosa" and "loss of mucosa". Considering all three types of changes together, dogs with sharp and narrow ridges had significantly more clinical changes associated with implants than dogs with blunt and broad ridges.

"Thinning of the mucosa" and "loss of mucosa" are considered as part of a continuing process because the mucosa was lost only over implants which previously were covered by thin mucosa and these changes took place gradually as seen by weekly clinical examination. In this study, "loss of implant" is entirely unrelated to the former two changes. The implants were lost within eight days after placement, whereas "thinning of the mucosa" started three to four weeks after implant placement and was followed by "loss of mucosa" seven to eight weeks after implantation. None of the implants which were associated with thinning and loss of the overlying mucosa exfoliated during the ten-week period of the study.

In the literature (1, 17, 30, 32, 38) loss of the implant is usually considered as a sign of rejection by the tissues. In the present experiment, "loss of implant" cannot be interpreted as implant rejection for several reasons:

1. Only two out of sixty-four implants exfoliated. The majority

of implants (97%) were retained.

2. Both implants which exfoliated were made of Ticonium, a type of chrome-cobalt alloy known to be well accepted.
3. The two implants which fell out were not as firmly fixed initially as were the remaining implants because of insufficient bony support. Both exfoliations occurred in the dog with the narrowest ridge (Dog 4632, width of ridge at crest 0.1 and less than 0.1 cms).
4. Exfoliation took place in the initial period of healing, as mentioned before, when proper fixation is critical.
5. Microscopically, the two exfoliation sites could not be distinguished from equivalent sham sites; healing at these exfoliation sites was as advanced at at the corresponding sham sites.

"Thinning of the mucosa" was observed at 25% of all implant sites and was accompanied by depigmentation in dark-haired dogs. "Loss of mucosa" and subsequent exposure of the implant to the oral environment followed the phenomena of thinning and depigmentation in three cases (approximately 5%). Although all three cases happened to be acrylic implants, it is thought that this was fortuitous rather than being related to the material per se for the following reasons:

1. The difference between acrylic and Ticonium implants with respect to "loss of mucosa" was within the limits of experimental error.
2. "Loss of mucosa" was clearly the continuation of a process initially manifest by "thinning of the mucosa", and thinning

of the mucosa affected Ticonium implants in equal measure[1].

The sequence of events which led to these clinical changes (thinning and loss of mucosa) is thought to be as follows:

1. After extraction of teeth, the alveolar crest begins to resorb.
2. Bone resorption produces the two types of alveolar ridges found in this study, namely sharp ridges and blunt ridges.
3. Crestal bone resorption continues, is enhanced, or sets in de novo after the surgery associated with implantation procedures.
4. As the height of the alveolar crest diminishes, the implants, which cannot be resorbed together with the surrounding bone, start impinging on the overlying mucosa.
5. As crestal bone resorption progresses, the level of the implant and the level of the bony crest become more dissimilar umtil finally the implant perforates the overlying mucosa. Both loss and thinning of the mucosa may be caused by mechanical pressure of the receding tissue on the implant rather than by properties of the material.

The above hypothesis is supported by the following facts:

1. It is known from clinical observations that resorption of the alveolar ridge takes place after the extraction of teeth.
2. Without bone resorption, the marked change in ridge shape observed could not have taken place.
3. The preparation of a mucoperiosteal flap alone is sufficient to initiate crestal bone resorption (57).

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[1] In fact, more Ticonium implants than acrylic implants were associated with thinning of the mucosa, but the difference was not statistically significant.

4. Crestal bone resorption was observed on radiographs prior to as well as after implant surgery (see Plate 4, pp 116).
5. The effects of bone resorption become more marked as time goes by. The number of clinical changes ("thinning of the mucosa" and "loss of mucosa") also increased with time.
6. More clinical changes were found in dogs with sharp ridges than dogs with blunt ridges (this difference was statistically significant at the 0.02 level).
7. Microscopically, more implant sites in the categories "loss of mucosa" and "thinning of the mucosa" had marked crestal bone resorption than implants in the "no clinical change" group. This difference was highly significant statistically.

It seems that crestal bone resorption was the main factor responsible for the clinically observed tissue changes.

Will crestal bone resorption eventually lead to exfoliation of implants, even if the implant material itself is inert? This question can only be answered satisfactorily by future studies of longer duration. In several cases, crestal bone resorption was of such magnitude that the implants had lost about half of their bony support. There is hope, however, that bone resorption, with time, may diminish and the level of the alveolar crest stabilize. If one accepts the hypothesis that the clinical changes "loss of mucosa" and "thinning of the mucosa" are a result of crestal bone resorption, then the curve relating these changes to time (see pp 55) may be indirectly a reflection of crestal bone resorption related to time. According to this curve, it seems that the rate of crestal bone resorption may reach a peak sometime after the surgical insult, which is expressed in the sudden rise of the

number of implants with clinical changes between the third and fourth weeks. Since the curve for clinical changes at implant sites becomes level from the eighth week on, one might assume that crestal bone resorption also levels off after a certain amount of time following the initial insult. This would be in agreement with clinical observations on edentulous full denture patients, in whom the most marked changes of ridge shape take place soon after tooth extraction. However, the findings in the present study cannot provide a definitive answer to this problem.

Would crestal bone resorption take place in equal degree following removal of teeth if there had been no implants or sham sites? It is known from the literature (57) that the elevation of a flap alone causes some crestal bone resorption. Whether this process is aggravated by implant and sham operations could be studied by using separate areas containing implants alone, sham sites alone, implants and sham sites and areas with neither implant nor sham sites, where the only insults were previous tooth extraction and elevation of a mucoperiosteal flap.

Does the presence of implants increase or decrease crestal bone resorption? Compared to sham sites, implants seem to decrease rather than increase crestal bone resorption, and maintain the level of the alveolar crest. New bone formation, exceeding the height of the crest, took place next to implants only. The level of the crest in the vicinity of implants was higher than or as high as implant-free areas, whereas the level of the crest at sham sites was as high as or lower than the level at implant-free and sham-free areas.

Could crestal bone resorption be influenced by genetic factors? An interesting possibility for future evaluation is the finding that

only certain dogs developed sharp, narrow ridges. Two of these dogs were littermates (4630, 4632); the third dog (6004) had a similar genetic background, but its littermate (6007) had a blunt and broad ridge. However, the dog with the narrow ridge (6004) did not resemble its littermate (6007) phenotypically. Instead, it resembled the pair 4630, 4632, which had sharp and narrow ridges, in respect to other phenotypic characteristics, namely color of hair, shape of muzzle and limbs. It can also be seen from this study that dogs of a certain genetic combination had blunt ridges, which were more favorable to implantation. Selective breeding of such dogs for future implant studies might be desirable.

Another important finding in the present study is the lack of bone resorption in the area surrounding the shaft of the implants. There was no significant bone resorption of the socket wall either on the side facing the implant, nor on the side away from the implant ("undermining resorption") (see Plates 8 and 9). The "minimal bone resorption" occasionally recorded can be interpreted as normal remodeling activity since it was observed to the same degree at sham sites as well as in areas containing neither implant nor sham sites. Since bone resorption adjacent to the implant is thought to be a feature of rejection leading to implant exfoliation, the absence of resorption and the presence of bone formation suggest tissue acceptance and a potential for retention of the implants. All implant sites in this experiment had marked bone formation. In a preliminary experiment by the investigator, in which implants were exposed to the oral environment in a miniature swine, no new bone formation was observed around the implant, but bone resorption and inflammation were marked. As will be recalled, these implants

exfoliated immediately upon removal of the splint. This finding did not agree with those of Hodosh (32, 33, 34, 35). Thus, complete embedding of the implant is another factor that influences the result of implantation.

In the present experiment, bone formation took place over the coronal surface of those acrylic implants whose upper portion had accidentally fractured, thus covering the implants. This finding is similar to those of Fogarty and Howes (39). Connective tissue and bone also grew between the fractured halves of an acrylic implant, in a manner similar to the tissue growth reportedly recently by Hodosh, who cut channels through the implant (35).

Inflammation, in this experiment, was subjectively evaluated to exist in a range from "none" to "moderate" and was found to be of three types:

1. Minimal, predominantly chronic.
2. Moderate, predominantly chronic.
3. Moderate, predominantly acute.

Most implant sites which had inflammation at all had the minimal, predominantly chronic type. One cannot lend particular importance to this type of inflammation when evaluating the reaction to implants themselves because:

1. This type of inflammation was present at sham sites as well as implant sites.
2. Perfusion may have been a factor in the presence of white blood cells in the tissues, particularly since these cells usually appeared around dilated vessels and were accompanied by erythrocytes.

3. The tendency of the investigator was to overcall rather than undercall inflammation, since the presence of minimal chronic inflammation in a single section was considered sufficient to tabulate the entire implant site as having chronic minimal inflammation.
4. Clinical findings were inversely related to the microscopic findings of minimal chronic inflammation. No inflammation was observed clinically. In those implants which had other clinical changes ("loss of implant", "loss of mucosa" and "thinning of the mucosa") minimal chronic inflammation was present in a smaller proportion than in implants in the category "no clinical change" (see Table 19, pp 83).

The presence of moderate chronic inflammation cannot be interpreted as a reaction exclusively caused by the implants for these reasons:

1. Few implant sites (approximately 14%) showed this type of inflammation.
2. When present, it was limited to the gingiva and was focal in nature.
3. Similar foci of moderate, chronic inflammation were found in the gingiva in areas without implants in approximately 12% of all cases.

Moderate acute inflammation was present only in the three cases of acrylic implants exposed to the oral environment. This reaction was always associated with epithelial downgrowth. Inflammation seemed to start in the gingiva, since in two of the three implants it was present in the gingival third only. In the third implant, which had been exposed for one week longer than the other two, the middle third, but not

the apical third, was involved. It is thought, therefore, that this type of inflammation was caused by exposure to the oral environment rather than by the implants themselves.

Neither "moderate chronic" nor "moderate acute" inflammation was manifest by clinical signs of inflammation, such as redness, swelling, etc.

Another microscopic feature which had no clinical expression was residual necrotic bone. This finding cannot be regarded as an effect of the implants either, because it was present at sham sites and implant sites in about equal proportion. Since it was not found at implant and sham-free areas, it is thought to be related to the surgical insult. (Note, however, that none of the differences between implant and sham sites were evaluated statistically. In spite of the coding, the investigator could distinguish implant sites from sham sites and thus may have been subject to bias.)

The following microscopic and clinical features then seem to be related:

1. "Epithelial downgrowth" and exposure to the oral environment ("loss of mucosa").

   All of the implant sites which fell into the clinical category "loss of the mucosa" had epithelial downgrowth.

2. "Acute moderate inflammation" and exposure to the oral environment ("loss of mucosa")

   As mentioned before, moderate acute type of inflammation was seen only in the clinical category "loss of mucosa".

3. "Crestal bone resorption" and "thinning and loss of the mucosa"

   All implant sites in the "loss of mucosa" category had marked

crestal bone resorption. Significantly more implant sites in the "thinning of the mucosa" group than in the "no clinical change" group had marked crestal bone resorption.

CONCLUSIONS

Under the conditions of this experiment there was no evidence to indicate that the tissue reaction to acrylic implants differs from the tissue reaction to Ticonium implants. Both types of implants were well accepted.

Certain histologic features were found which augmented and were related to certain clinical observations. These were:

1. Thinning of the mucosa, accompanied by depigmentation and loss of mucosal continuity, observed clinically, were related to marked crestal bone resorption as seen microscopically.
2. In the few cases in which there was loss of mucosal continuity, as observed clinically, epithelial downgrowth along the surface of the implant was seen microscopically.
3. In the few cases of loss of mucosal continuity, as observed clinically, this also seemed to be related to moderate acute inflammation as seen microscopically.

Crestal bone resorption appears to be a potential hazard to the retention of implants. However, acrylic and Ticonium implants seemed to have a tendency to maintain the height of the alveolar crest when compared to implant-free areas. Crestal bone resorption and the clinically observed changes were significantly higher in dogs with sharp and narrow edentulous ridges than in dogs with blunt and broad edentulous ridges.

SUMMARY

The purpose of this investigation was:

1. To study the tissue reactions to acrylic implants when embedded in the jaws of dogs, by comparing them to the tissue reactions to chrome-cobalt type (Ticonium) implants, which are known to be well accepted.
2. To determine, on a preliminary basis, if histologic features can be found which will augment and be related to clinical features when acrylic and Ticonium implants are used.

Thirty-two experimental units were placed into the edentulous mandibles of eight dogs, four in each dog. Each experimental unit consisted of an acrylic implant, a Ticonium implant, and a sham-operated site containing no implant. At the time of sacrifice, each animal had two units which were in place for ten weeks and two units which were in place for five weeks. Since the Ticonium and acrylic implants were of the same design and were placed in adjacent anatomical sites in the same animal, using the same surgical technique, any differences could be attributed to the nature of the acrylic per se. The sham-operated sites served to show the effects of the surgical procedure.

The tissue reaction to the implants was evaluated clinically and microscopically, without the investigator knowing which type of implant site was being examined. The numbers of implant and sham sites showing certain defined histologic features were recorded in addition to the customary microscopic descriptions. Both clinical and microscopic

findings were evaluated by a statistical method; the consistency of the investigator's interpretation of histologic features was also tested statistically and found acceptable.

The clinical findings were as follows:

The majority of implants (97%) were retained and most implant sites (approximately 72%) had no clinical changes at all. (The clinically observed changes were "loss of implant", "thinning of the mucosa with depigmentation" and "loss of mucosa".)

Two out of thirty-two Ticonium implants were lost within eight days of placement due, presumably, to inadequate bony support.

Five out of thirty-two acrylic implants and eight out of thirty-two Ticonium implants were associated with thinning of the mucosa, and three out of thirty-two acrylic implants were associated with loss of mucosa overlying the implant.

The difference between acrylic and Ticonium implants with respect to each of these three clinical changes alone as well as to all clinical changes together was not statistically significant at the 0.05 level.

The relationship of clinical changes to various parameters of the experiment was explored. The positive findings were:

The number of implants associated with clinical changes was significantly greater in dogs with sharp, narrow ridges as opposed to dogs with broad, flat ridges.

Marked crestal bone resorption was significantly (0.01 level) greater in the group with clinical changes as opposed to the group without clinical changes.

The main microscopic findings were as follows:

All implants were in a bony socket, which included young, recently

formed trabeculae close to the implant. The ten-week implants were lined by a thin connective tissue membrane, while the five-week implants were surrounded by a thicker layer of dense connective tissue which varied in width. All remaining features were similar. There was minimal chronic inflammation or no inflammation at most implant and sham sites. Six implant sites had moderate focal chronic inflammation limited to the gingiva. Foci of moderate chronic inflammation were also found in the gingiva unrelated to implant and sham sites in eight cases. Moderate acute inflammation was present only in the three exposed implants. Crestal bone resorption graded as slight, moderate, or marked, was present in implant and sham areas as well as in areas containing neither implant nor sham sites. The alveolar crest immediately adjacent to the implants was higher than or level with the surrounding bone.

There was no statistically significant difference at the 0.05 level between acrylic and Ticonium implants with respect to:

Presence and degree of inflammation.

Presence and degree of bone resorption around implant as well as at the alveolar crest.

Presence and degree of bone formation next to the implant.

Presence of residual necrotic bone, soft tissue necrosis, and epithelial downgrowth.

It was found that the following clinical and microscopic features were related to each other:

1. Thinning and loss of mucosa to marked crestal bone resorption.
2. Loss of mucosa to epithelial downgrowth along the surface of the implant.

3. Loss of mucosa to moderate acute type of inflammation adjacent to the implant.

The meaning and importance of microscopic findings and their relationship was discussed. New questions based on the findings of the present study were posed and some future avenues of study were indicated.

The conclusions were that:

1. Under the conditions of this experiment, there was no evidence to indicate that the tissue reaction to acrylic implants was different from that to Ticonium implants, and
2. Certain histologic features were found which augmented and were related to certain clinical features in both acrylic and Ticonium implants.

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APPENDIX I

Plates

Plate 1

Implant Sites Without Clinical Change

Figure 8. Edentulous mandibular ridge containing acrylic and Ticonium implants. The alveolar ridge has the same appearance as a normally healed edentulous ridge without implants. There are no clinically observed tissue changes. (Dog 6007, right molar and premolar units, ten weeks). Molar unit, mandibular ridge (m). Premolar unit, mandibular ridge (p). Tongue (t).

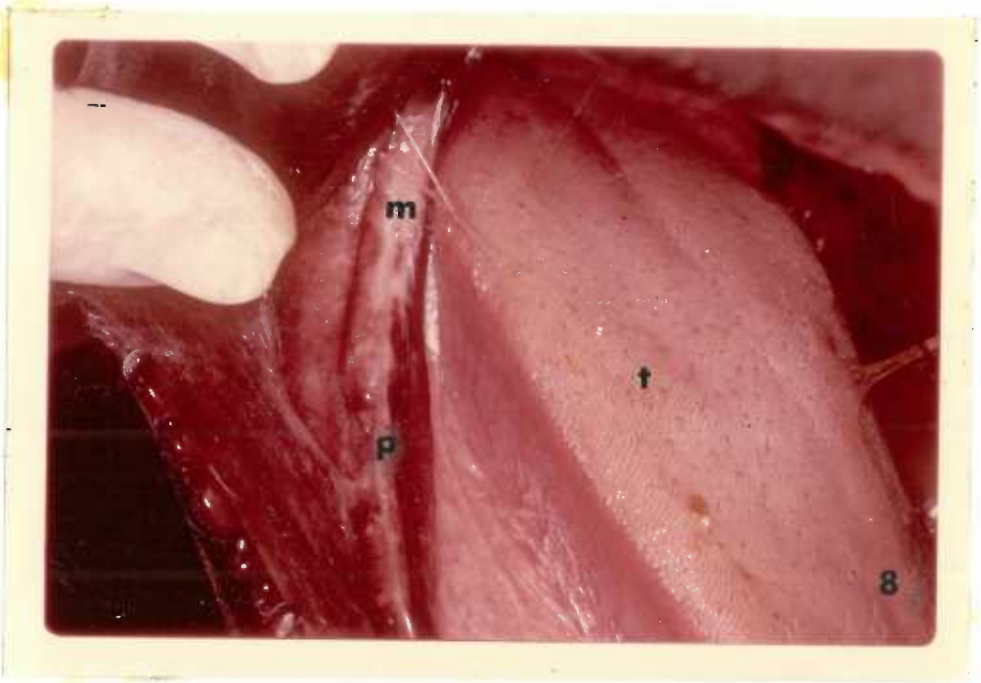
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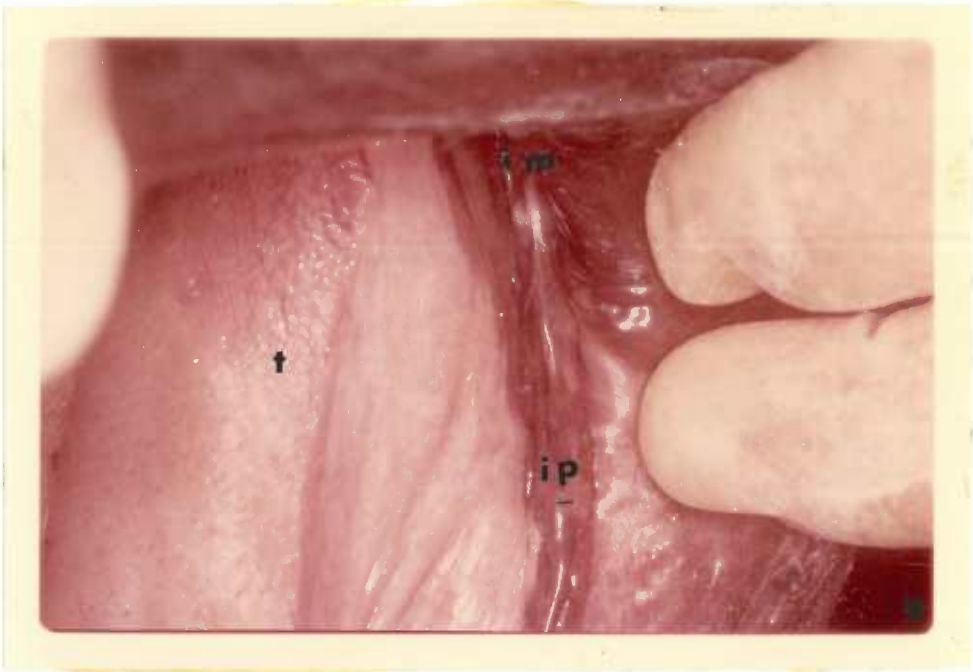
Plate 2

Clinical Changes: "Thinning of the Mucosa" Followed by "Loss of Mucosa"

Figure 9. Acrylic implant in molar unit (im) associated with thinning of the mucosa and accompanied by depigmentation and acrylic implant in premolar unit (ip) with thinning of the mucosa only, 4 weeks after implantation (Depigmentation developed later). Tongue (t). (Dog 6004, left portion of molar and premolar units.)

Figure 10. Implants shown in the preceding figure at 10 weeks after implantation. A portion of mucosa over the implants has been lost and the implants are exposed to the oral environment. Acrylic implant in molar unit (im); acrylic implant in premolar unit (ip); tongue (t).



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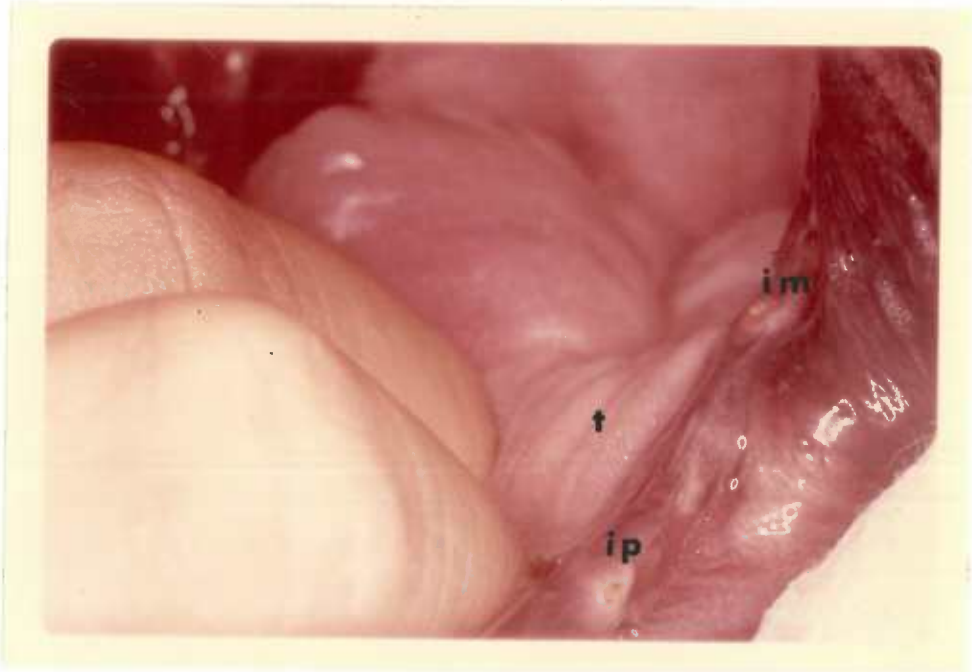

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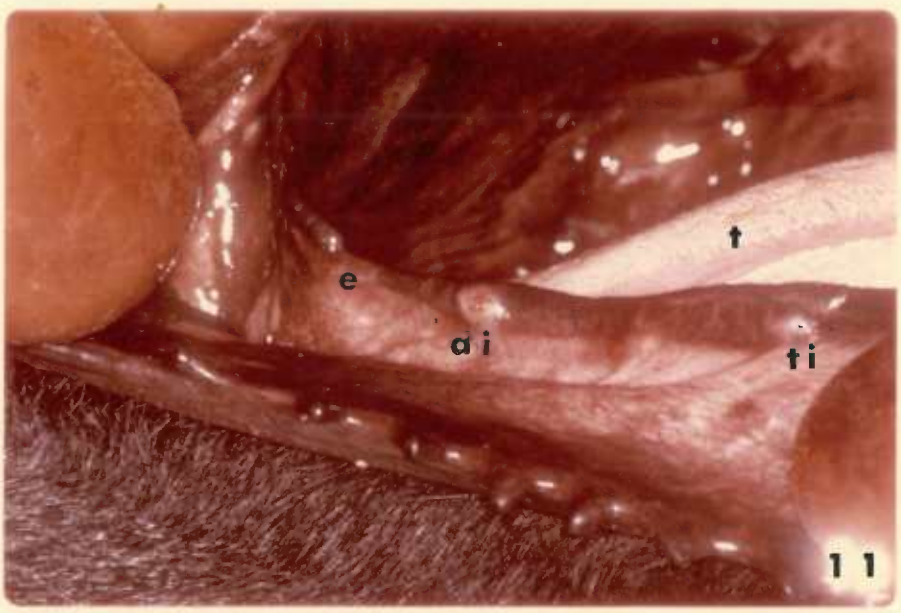
Plate 3

Clinical Changes: "Loss of Implant", "Thining of the Mucosa" and "Loss of Mucosa"

Figure 11. Site of exfoliated Ticonium implant (e) and acrylic implant (ai) with loss of mucosa (molar unit). Ticonium implant (ti) with thinning of the mucosa, premolar unit. Tongue (t). Dog 4632, right, ten weeks after implantation)

Figure 12. Ticonium implant (ti) and acrylic implant (ai), both covered by thin and depigmented mucosa. (Premolar unit, left, 5½ weeks after implantation)
Floor of the mouth (f); tongue (t); left canine tooth (c); opposing ridge (r) with suture marks (s) three days after implant surgery. (Dog 4630, right and left mandible).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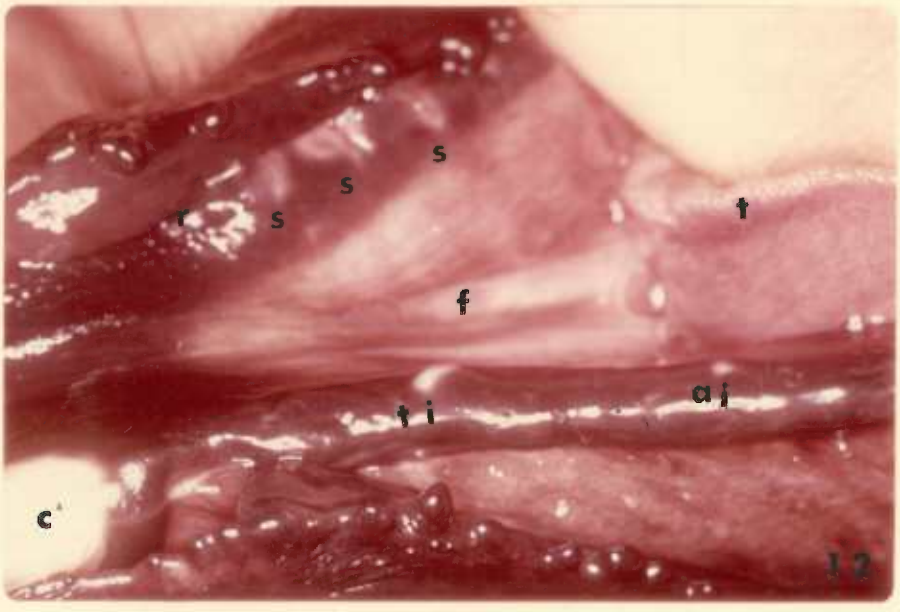
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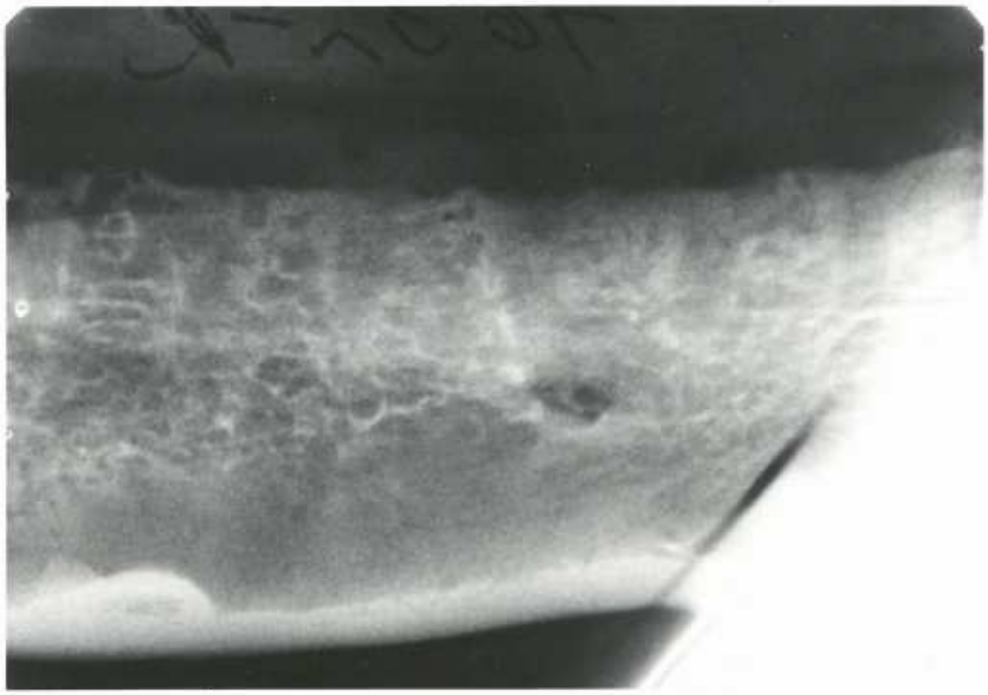
Plate 4

Radiographs before Implantation and Five Weeks after Implantation

Figure 13. Area of premolar unit prior to implant surgery (10 weeks after extraction of teeth). Note irregular crestal outline indicating bone resorption. (Dog 4632, right mandible)

Figure 14. Same area five weeks after implantation. Ticonium implant (t), sham site (s), acrylic implant (a), with bridge of tissue (b) growing through break of continuity in implant. Both implants had "thinning of the mucosa" as seen clinically. Note irregular crestal outline indicating bone resorption. (Dog 4632, right mandible).



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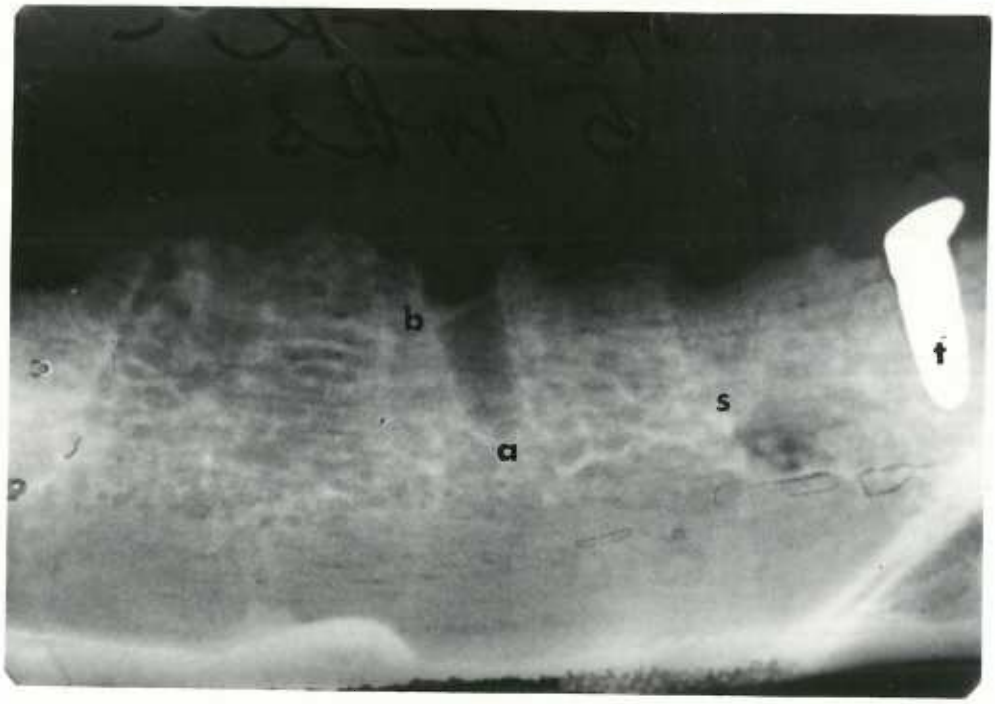
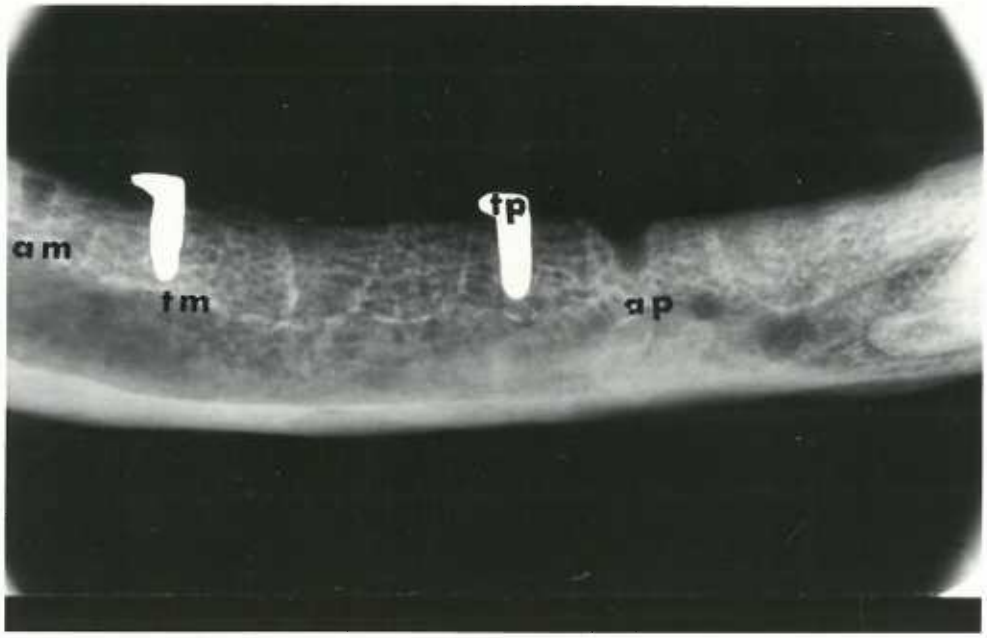


Plate 5

Radiographs of Implants at Ten Weeks

Figure 15. Ticonium implant (tp) and acrylic implant (ap) in premolar area; Ticonium implant (tm) and acrylic implant (am) in molar area. The sham sites cannot be distinguished from the surrounding bone. Note bone resorption at alveolar crest. (Dog 6004, right mandible)

Figure 16. Ticonium implant (tp) and acrylic implant (ap) in premolar area; Ticonium implant (tm) and acrylic implant (am) in molar area. All of these implants were free of clinically detectable changes. The sham sites cannot be distinguished from the surrounding bone. Note bone resorption at alveolar crest. (Dog 6007, right mandible)



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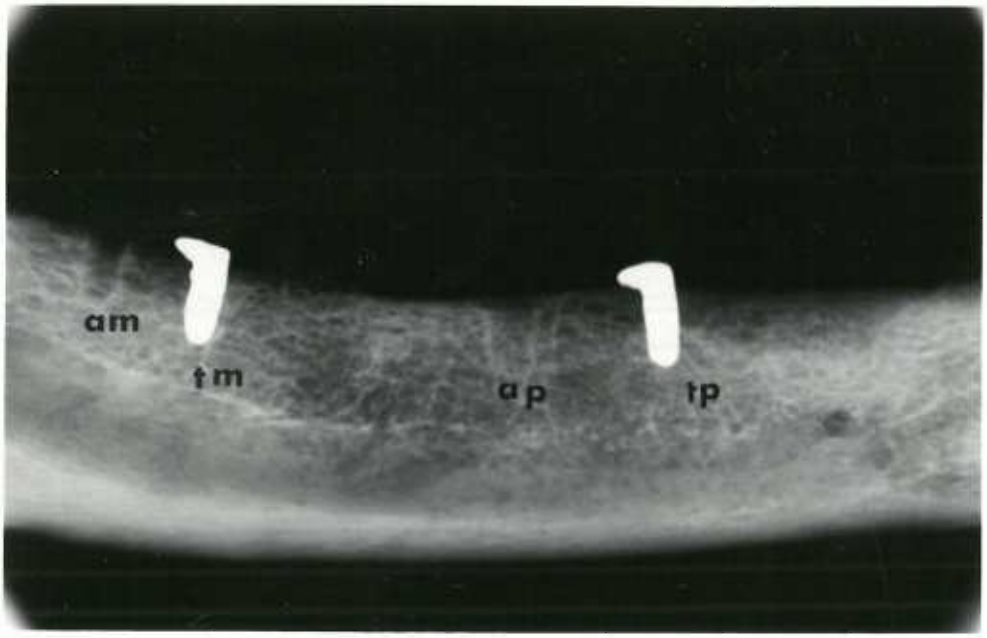

Plate 6

Ten-week Acrylic and Ticonium Implants

Figure 17. Ten-week acrylic implant (ai) covered by normal mucosa. Stratified squamous epithelium (e) with well-developed rete pegs. Not bone formation (b) next to implant exceeding level of alveolar crest (c) which has resorbed. Lamina dura type bone (l) forms wall of implant socket. (No. 85 - 60, x 37.5)

Figure 18. Ten-week Ticonium implant (ti) covered by normal mucosa. Stratified squamous epithelium (e) with well-developed rete pegs. Note alveolar crest (c) next to implant at original height and sloping downward away from implant. Lamina dura type bone (l) forms wall of implant socket. (No. 75 - 80 x 37.5)

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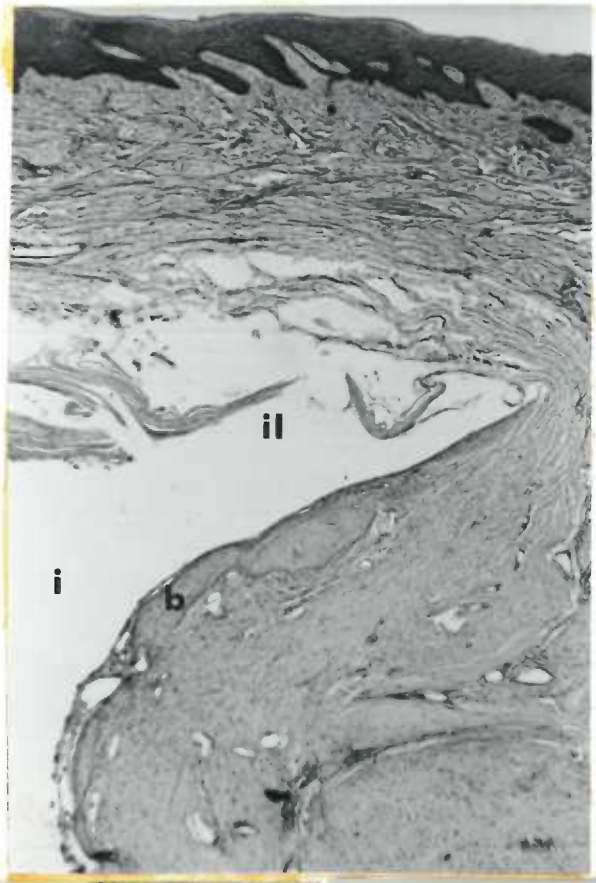
Plate 7

Bone Formation Adjacent to Implant Exceeding Height of Alveolar Crest

Figure 19. Detail of Figure 17 at higher magnification. Note bony trabeculae (b) next to implant shaft (i) and implant lip (il) exceeding height of crest (crest not included in field). (No. 85 - 60, x 131.25)

Figure 20. Detail of Figure 19 at higher magnification. Note bony trabeculae following outline of implant exceeding the height of the alveolar crest (c) which is being resorbed. (i) implant space. (No. 85 - 60, x 131.25)

Figure 21. Detail of Figure 20 at higher magnification. Note bony trabeculae (b) with numerous osteocytes and osteoblastic border facing implant, (i), which is lined by a thin connective tissue membrane (m). The blood vessels (v) are artifactually dilated. (No. 85 - 60, x 450)



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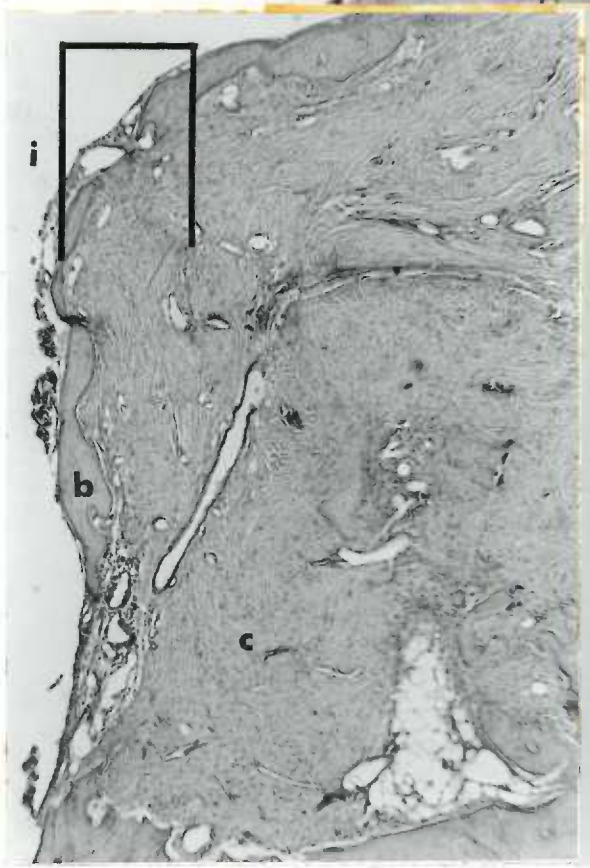

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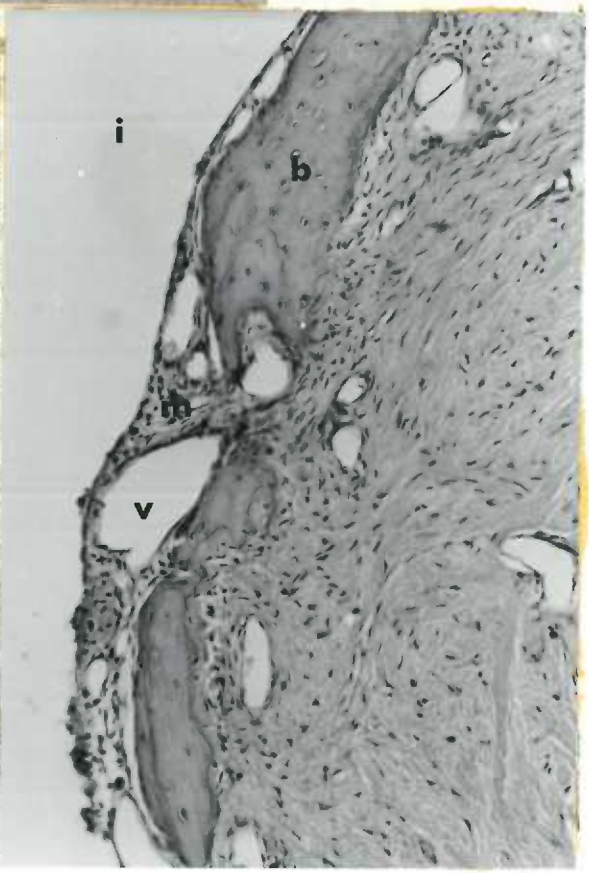


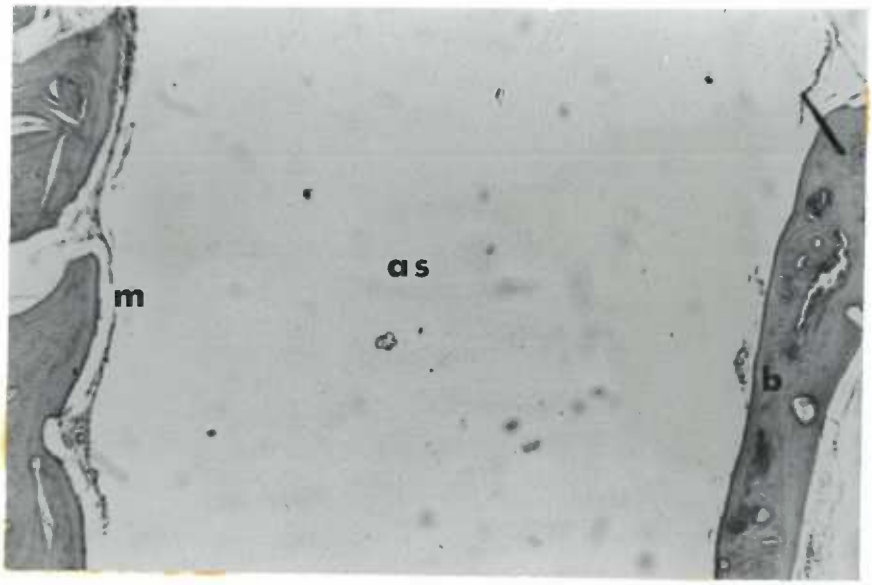
21

Plate 8

Ten-week Acrylic Implant Shaft and Surrounding Tissues

Figure 22. Enlargement of Figure 17. Mature lamina dura type bone (b) forms the implant socket's wall and the lining connective tissue membrane (m) is thin and appears only in some places. Note absence of inflammation. (mr) marrow space; (as) acrylic implant shaft. (No. 85-60, x 131.25)

Figure 22a. Enlargement of Figure 17. Apical end of acrylic implant shaft (as). (m) thin connective tissue membrant; (mr) marrow spaces.



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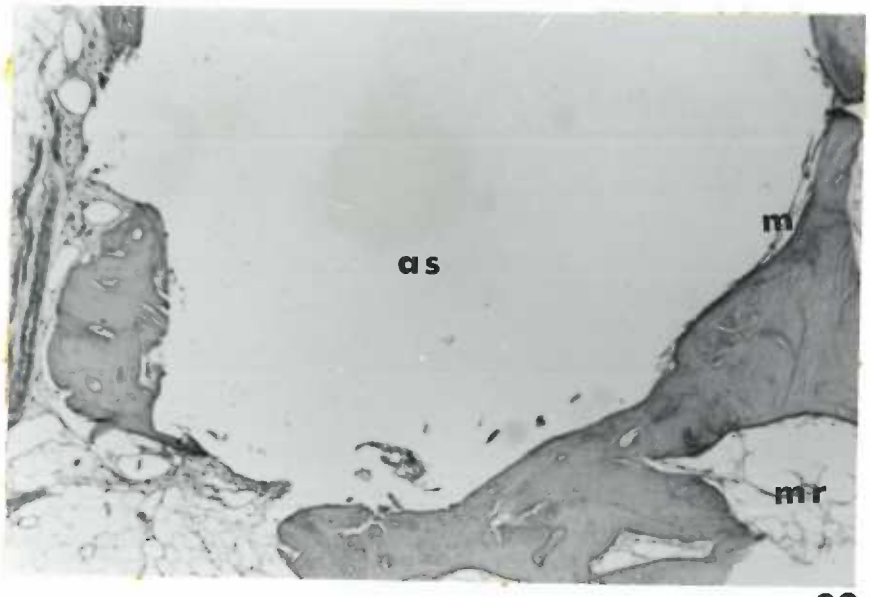

22 a

Plate 9

Composite Figure of Ten-week Ticonium Implant Shaft and Surrounding Tissues

Figure 23. Enlargement of Figure 18. Mature lamina dura type bone (b) forms the implant socket wall. The socket is lined by a thin connective tissue membrane (note absence of inflammation) (m). Implant lip (l); top of implant (t); implant shaft (s); marrow space (mr). (No. 75-80, x 131.25)

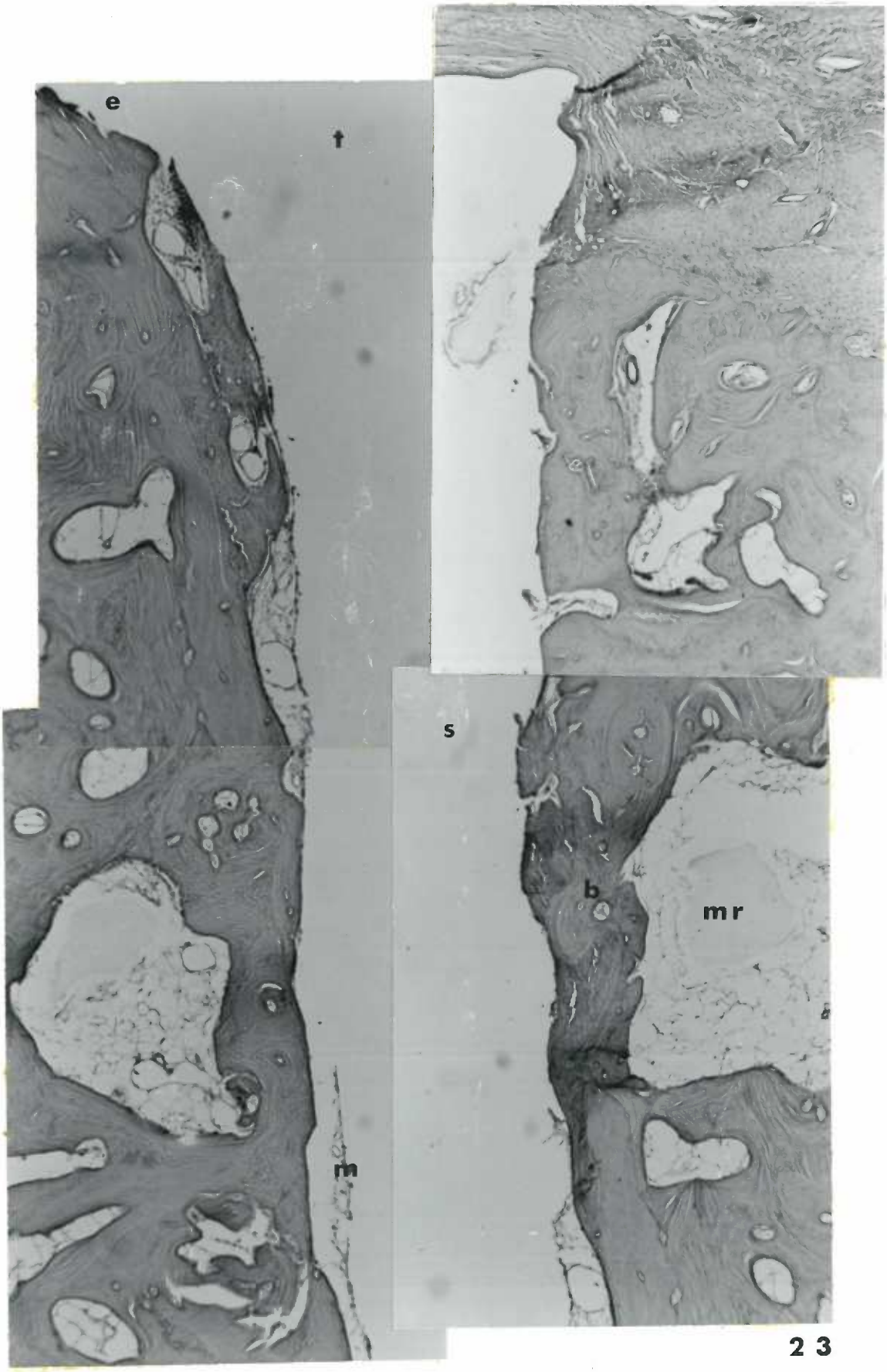

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Plate 10

Composite Figure of Ten-week Ticonium Implant Lip and Surrounding Tissues

Figure 23a. Implant lip (l) surrounded by parallel bundles of dense connective tissue fibers (f) which follow the implant's curvature. The implant lip is resting on the bony crest (b) which is not being absorbed in area adjacent to implant. Note crest sloping downward away from implant. (No. 75-80, x 131.25)

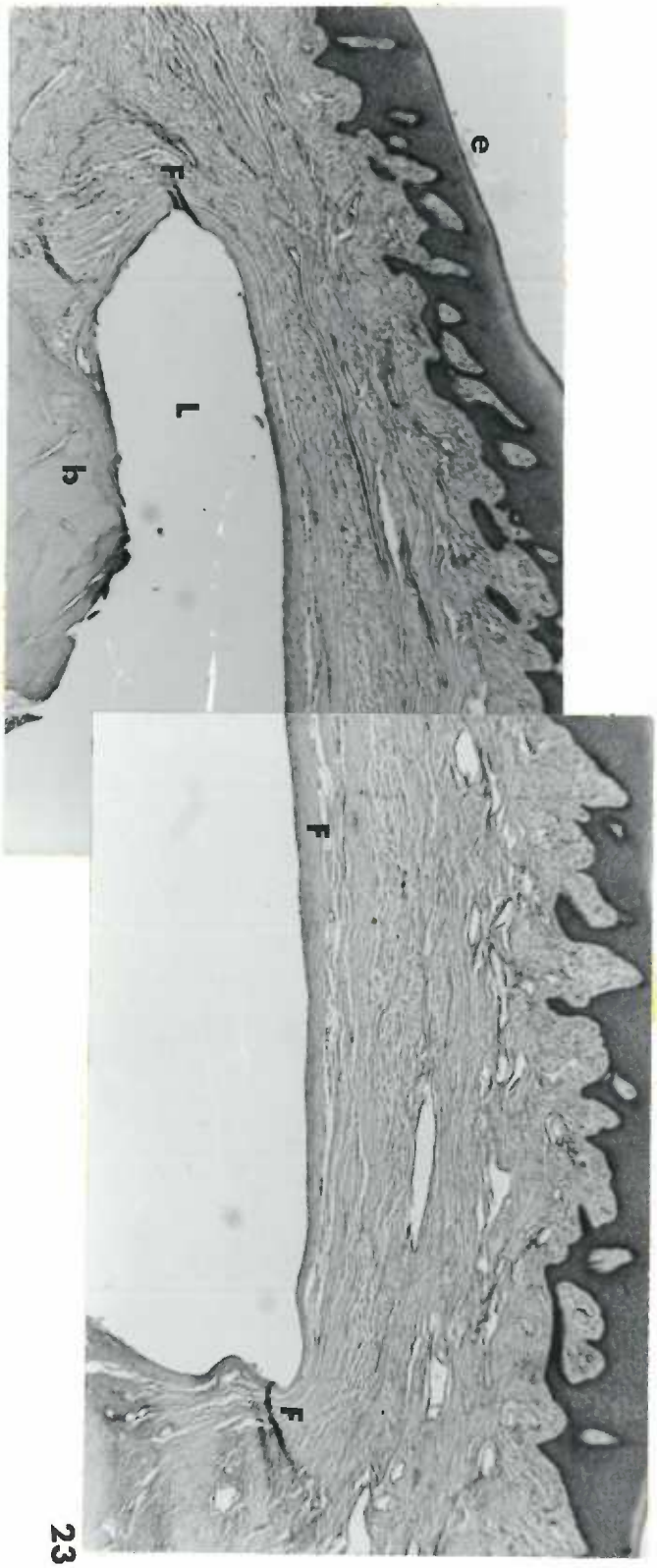

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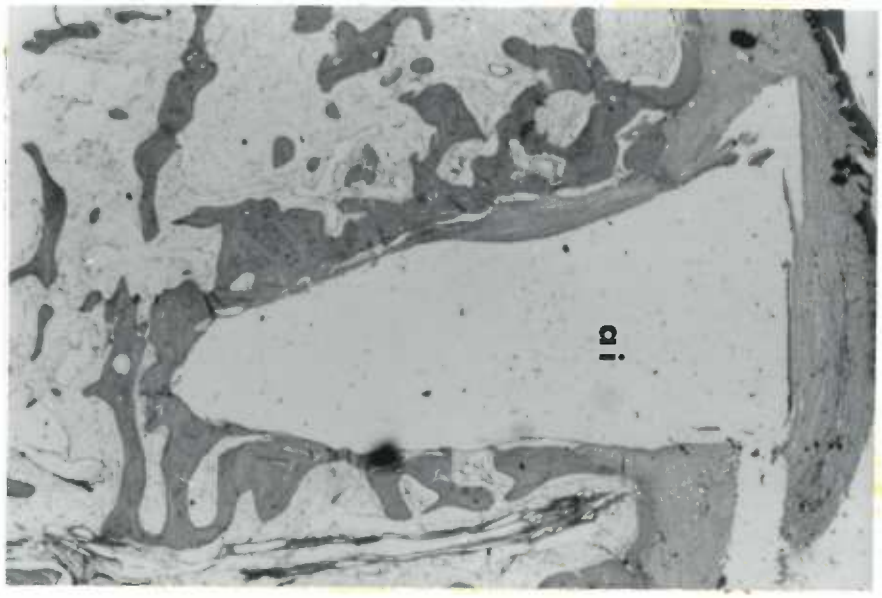
Plate 11

Five-week Acrylic and Ticonium Implants and Surrounding Tissues

Figure 24. Five-week acrylic implant (ai). On one side, the implant is surrounded by thick layers of dense and loos fibrous connective tissue (ct) and on the other side, it is surrounded by bone (b). (No. B-20, x 36)

Figure 25. Five-week Ticonium implant (ti). The implant is surrounded by thick layers of dense and loose fibrous connective tissue (ct) as well as by bone (b). (No. 56-80, x 131.25)



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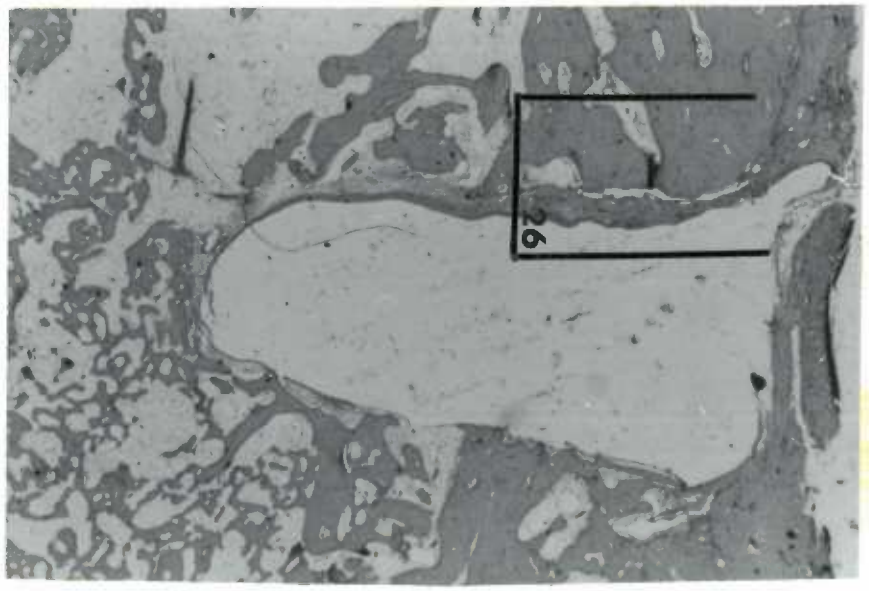

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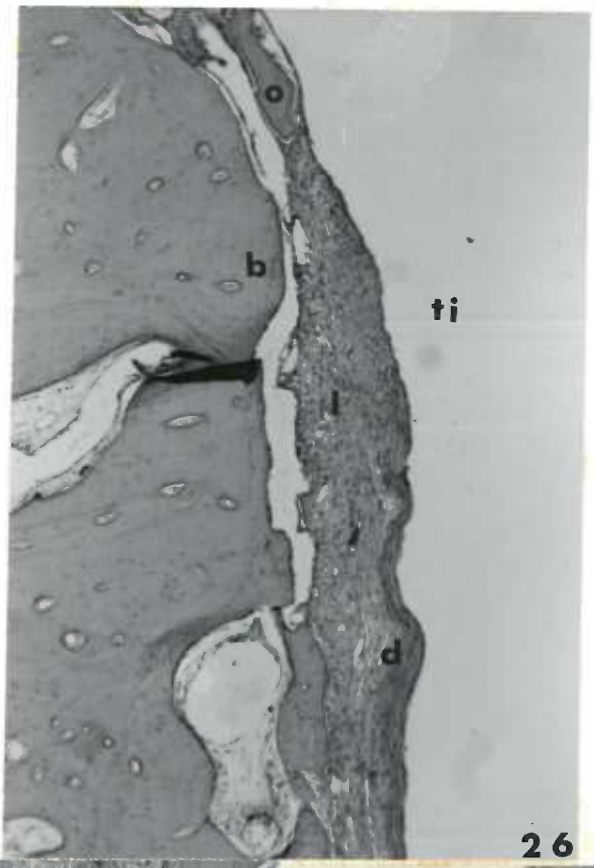
Plate 12

Tissues Surrounding Five-week Implants

Figure 26. Enlargement of Figure 25. Ticonium implant space (ti) lined by dense connective tissue (d) followed by loose connective tissue (l) and bone (b). Young osseous trabecula (o) forming in connective tissue layer next to implant. (No. 56-80, x 131.25)

Figure 27. Detail of acrylic implant shown in Figure 24. The implant space (ai) is lined by a layer of dense connective tissue (d) followed by loose connective tissue (l) and bone (b). A young osseous trabeculae (o) is forming next to implant within the dense connective tissue layer. (No. 13 - 40, x 131.25)

Figure 28. Higher magnification of an area in Figure 27. Acrylic implant space (ai) lined by a layer of dense connective tissue (d). The fibers and nuclei are oriented parallel to the long axis of the implant. Loose, more vascular connective tissue (l) toward surrounding bone, which is not included in the picture. (No. 13 - 40, x 937.5)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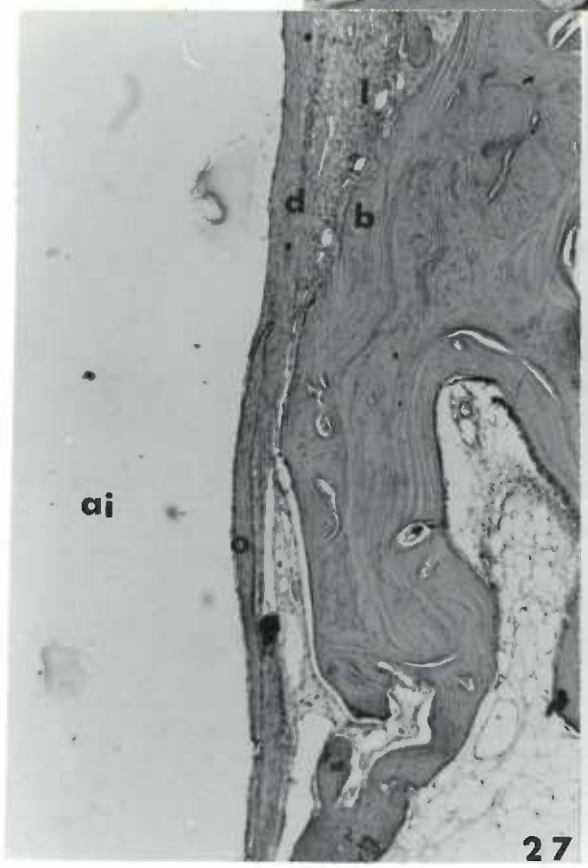
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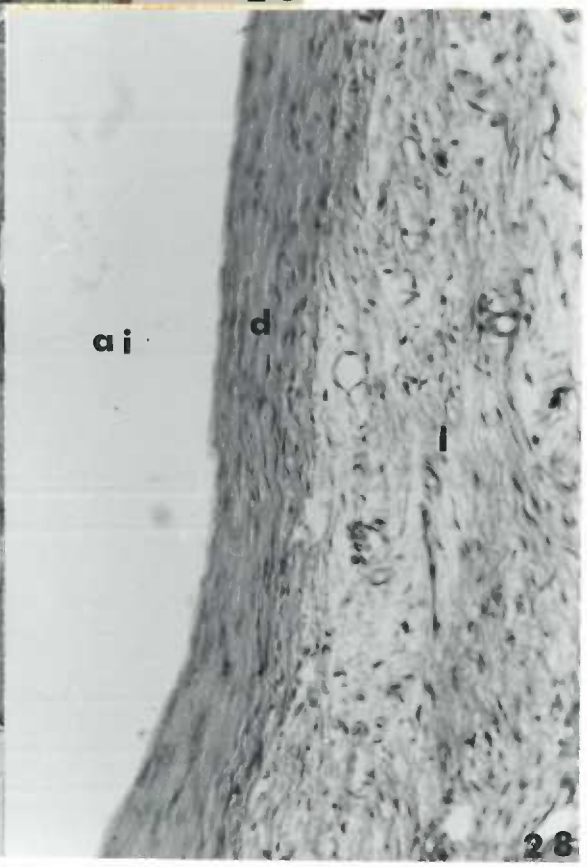
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Plate 13

Tissues Surrounding Five-week Implants

Figure 29. Composite figure of lower half of five-week Ticonium implant (ti) shown in Figure 25. The dense connective tissue layer (d) immediately adjacent to the implant is changing into a thin collagenous band (h) and in another area the bulk of the connective tissue is replaced by newly formed osseous trabeculae (o). A thin membrane (m) comparable to that seen in the ten-week implants separates the newly formed bone from the implant surface. (No. 56-80, x 131.25)

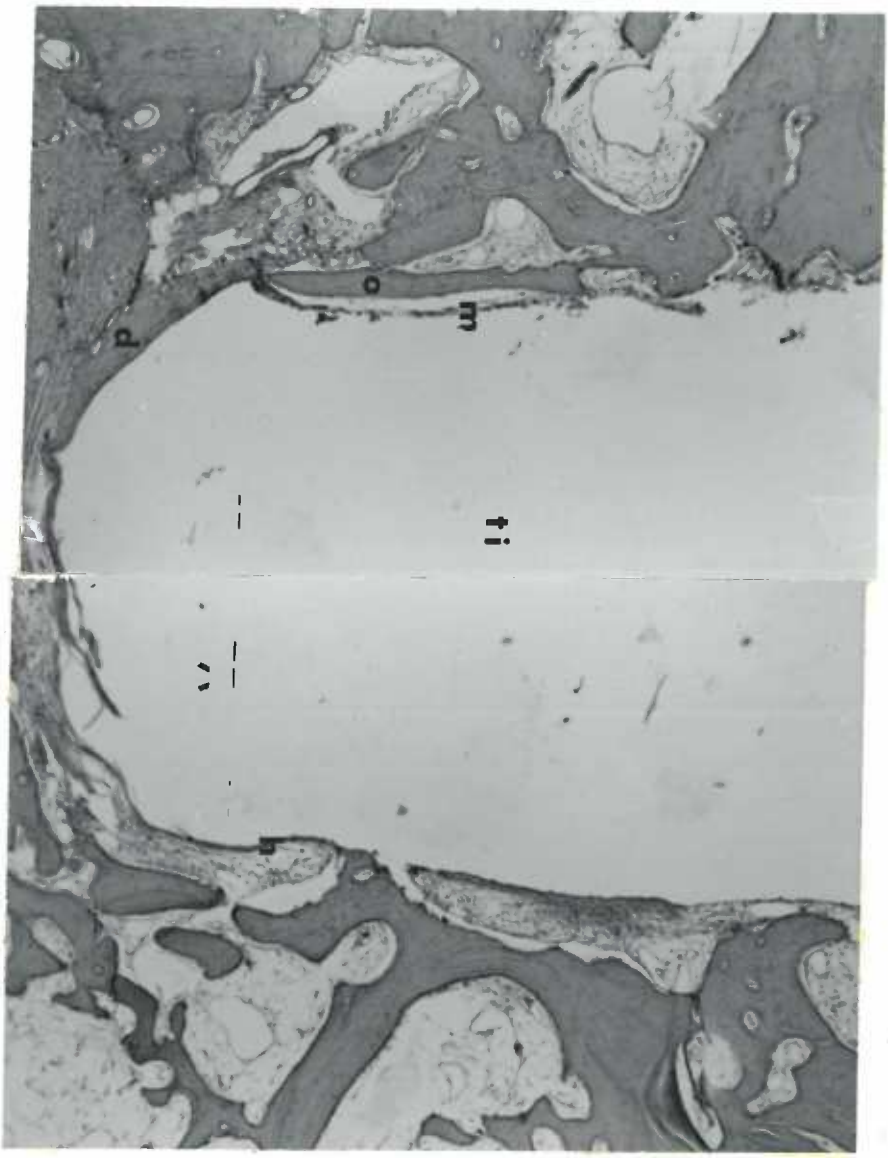

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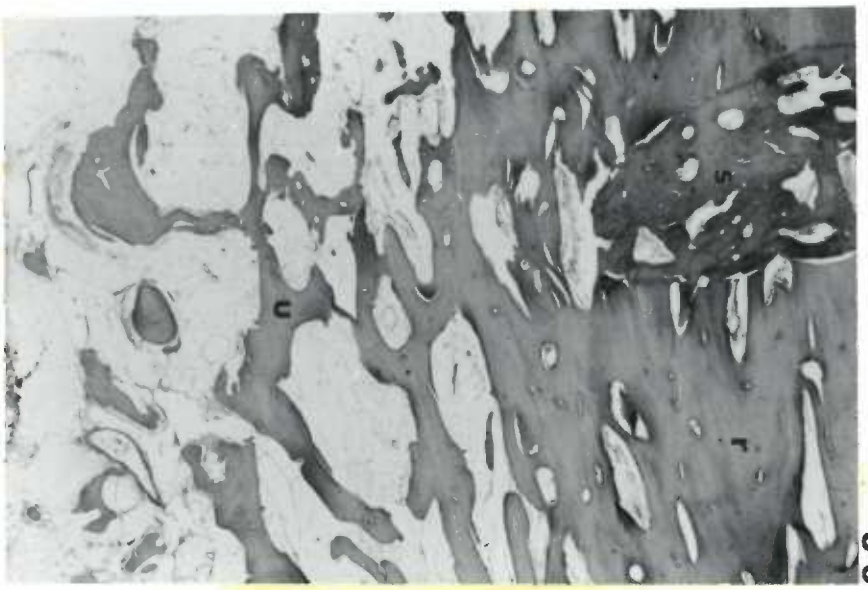
Plate 14

Ten-and Five-week Sham Sites

Figure 30. Ten-week sham operated site (s). The surrounding area includes cortical (r) and cancellous bone (b). The section does not go through the center of the sham area, but is near lingual end. (No. 48-100, x 37.5)

Figure 31. Five-week sham operated site (s) in area including cortical and cancellous bone. The level of the alveolar crest (c) is lower above the sham site than away from it. (No. 81-60, x 37.5)



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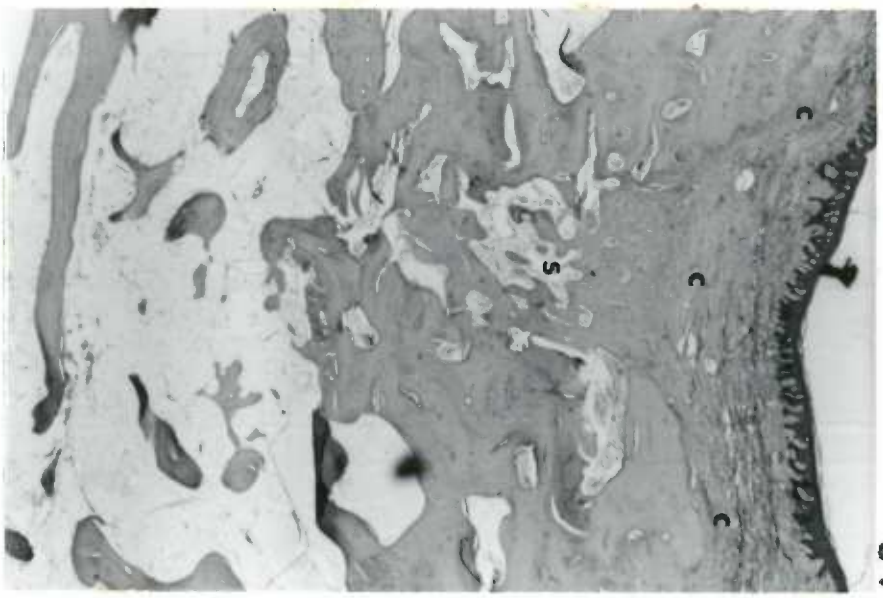

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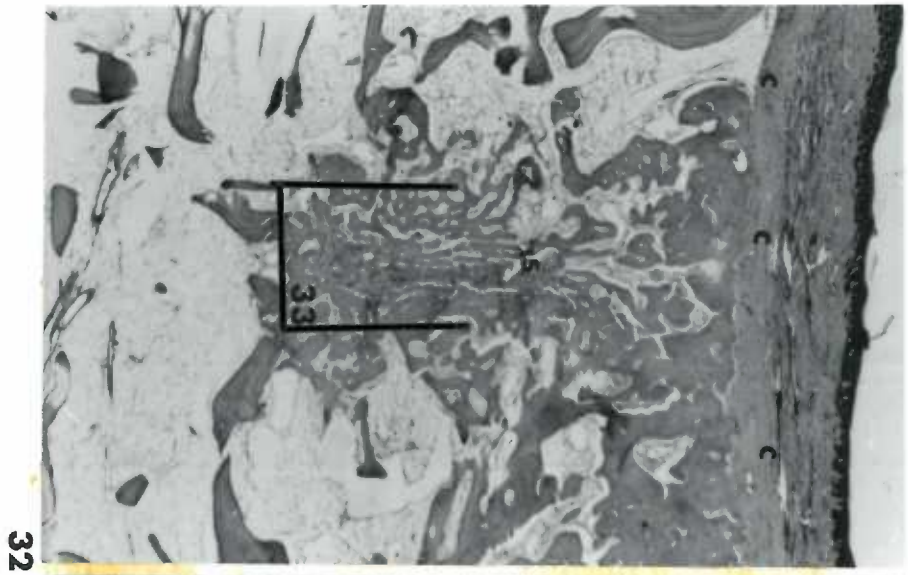
Plate 15

Five-week Sham Sites

Figure 32. Five-week sham site (s). The osseous trabeculae are smaller and more densely distributed than those in the surrounding area. The alveolar crest (c) above the sham site is approximately at the same level as the alveolar crest in the neighboring areas. (No. 73-100, x 37.5)

Figure 33. Detail of 5-week sham site. There are many youthful osseous trabeculae (b) at the lateral sides and apical end of the socket; the center of the socket is filled by youthful fibrous connective tissue (f). (No. 73 - 100, x 131.25)

Figure 34. Detail of five-week sham site. Bony trabeculae (b) lined by osteoblasts (o) form the lateral sides of the socket. The center of the sham-operated site consists of youtful fibrous connective tissue (f) which contains erythrocytes, hemosiderin pigment, and occasional inflammatory cells (i). (No. 73-100, x 450)



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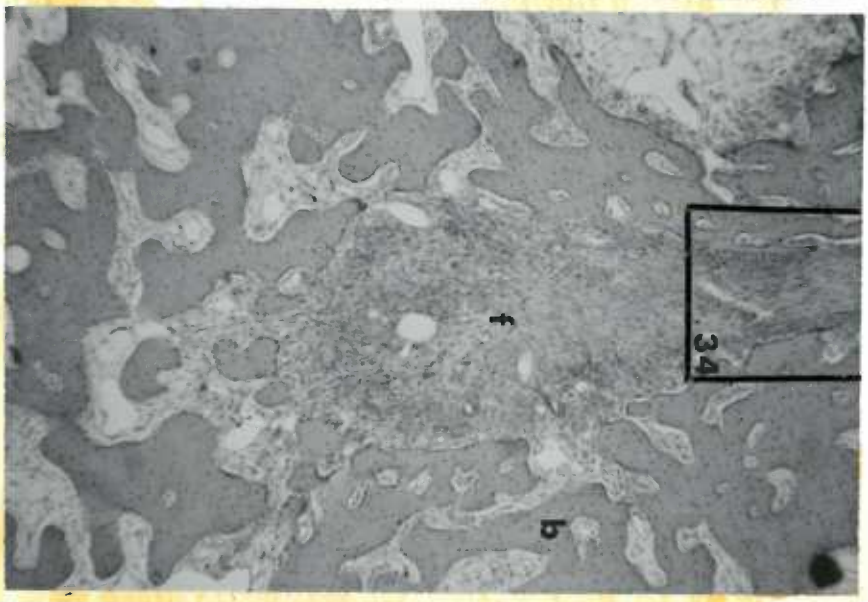

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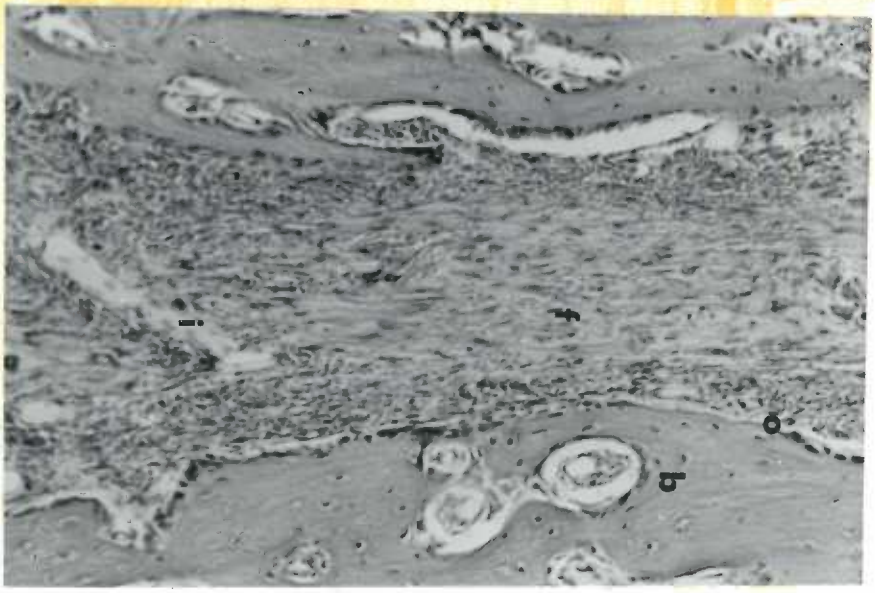

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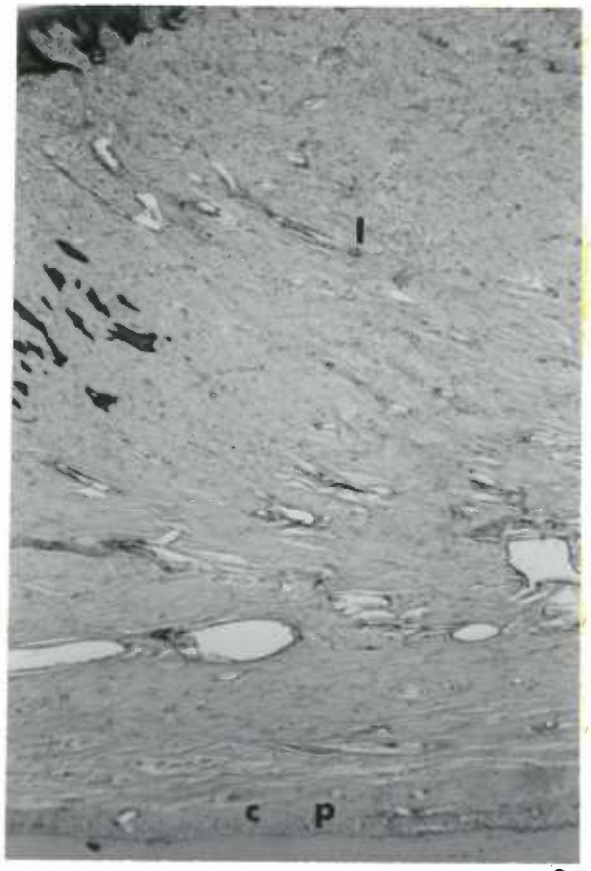
Plate 16

Normal Alveolar Crest

Figure 35. The alveolar crest (c) is smooth and covered by periosteum (p). (l) lamina propria. (No. 75-80, x 131.25)

Figure 36. Detail of Figure 35 at higher magnification. The alveolar crest (c) is smooth, covered by periosteum (p) and lined by a row of osteoblasts (o). (l) lamina propria. (No. 75-80, x 450)



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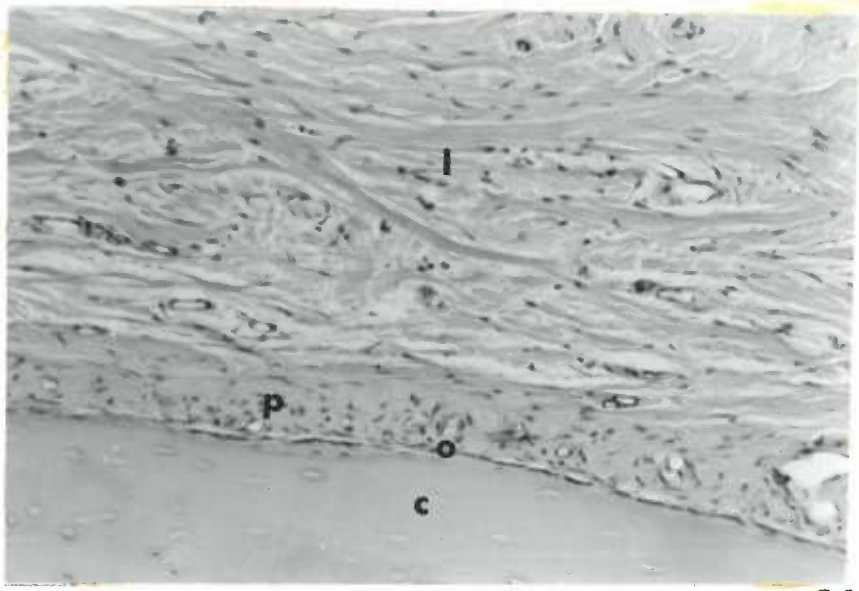

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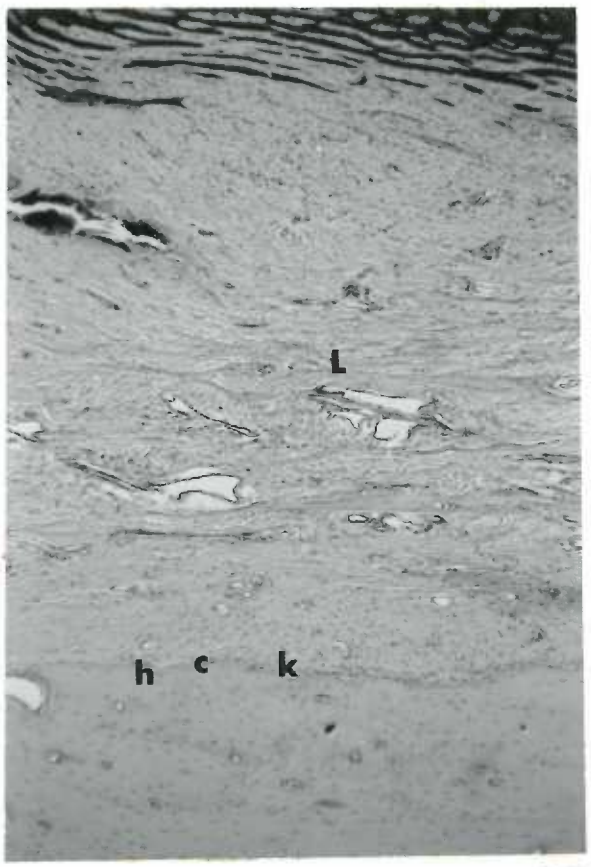
Plate 17

Slight Crestal Bone Resorption

Figure 37. Smooth crestal outline (c) with a few Howship's lacunae (h) and osteoclasts (k). (e) epithelium; (l) lamina propria. (No. 75-80, x 131.25)

Figure 38. Detail of Figure 35 at higher magnification. Alveolar crest (c) with osteoclast (k) and Howship's lacunae (h); (l) lamina propria; (p) periosteum. (No. 75-80, x 450)



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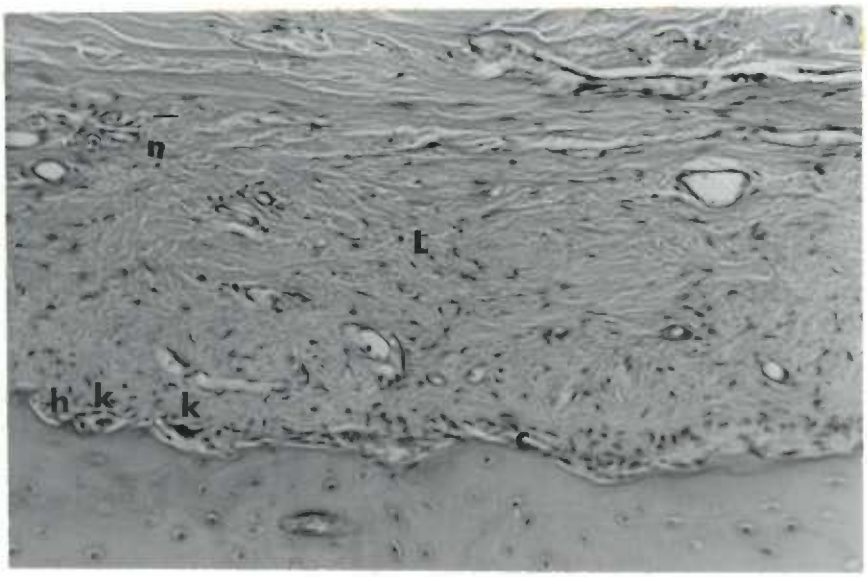

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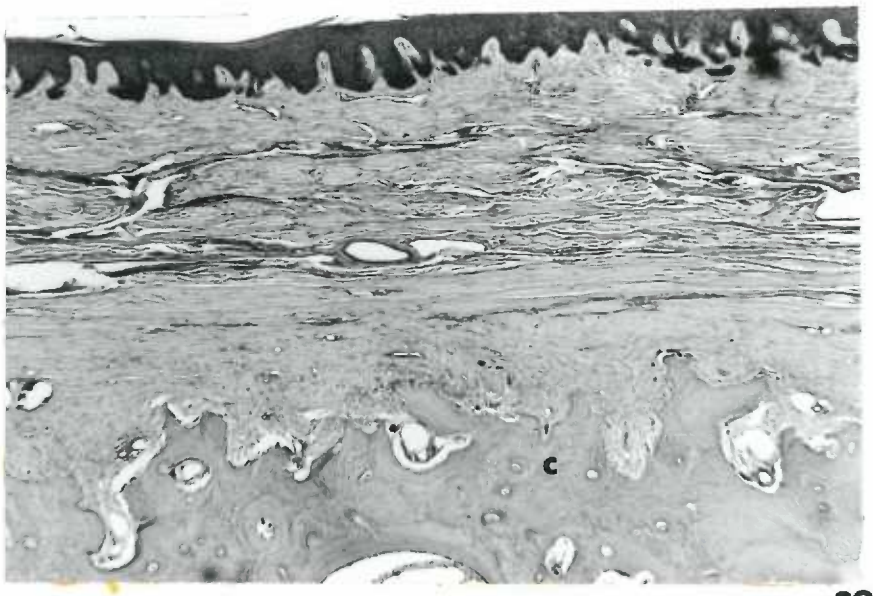
Plate 18

Moderate Crestal Bone Resorption

Figure 39. The alveolar crest (c) has a jagged outline. The distance between the epithelium and the alveolar crest is of approximately normal extent. (No. 73-100, x 131.25)

Figure 40. Detail of Figure 39 at higher magnification. Portions of bone (r) are separated from the alveolar crest (c). There are numerous osteoclasts (k) in Howship's lacunae (h). (No. 73-100, x 450)



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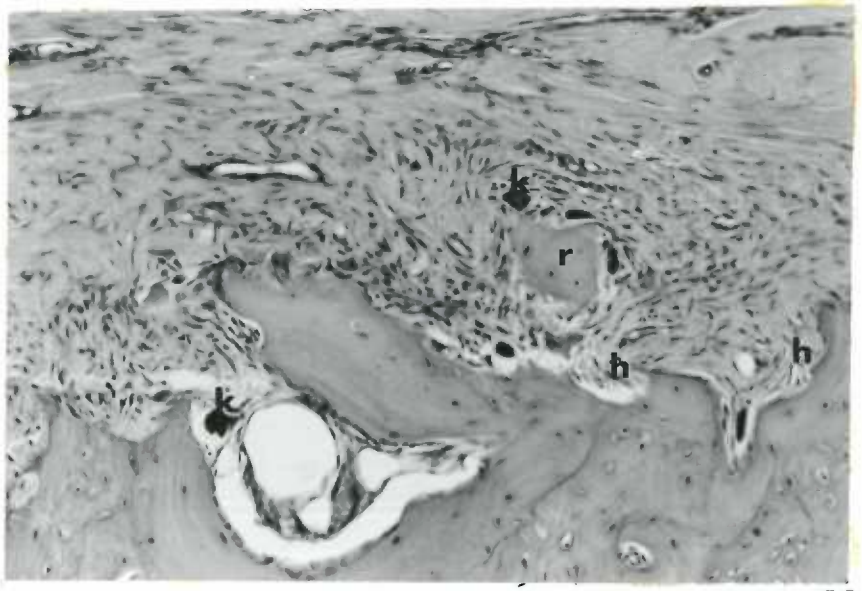

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Plate 19

Marked Crestal Bone Resorption

Figure 41. The alveolar crest (c) is sloping downward away from the implant (i). There are deep and large excavations (d) in the normally smooth crestal outline. The distance between the surface epithelium and the top of the crest is increased. (No. 62-80, x 37.5)

Figure 42. Detail of Figure 41. (l) lamina propria; (r) portion of bone being resorbed; (c) alveolar crest with numerous osteoclasts (k) and Howship's lacunae (h). (62-80, x 131.5)

Figure 43. Detail of Figure 42 at higher magnification. (r) portion of bone being resorbed; (c) alveolar crest; (k) osteoclasts; (h) Howship's lacunae. (No. 62-80, x 450)

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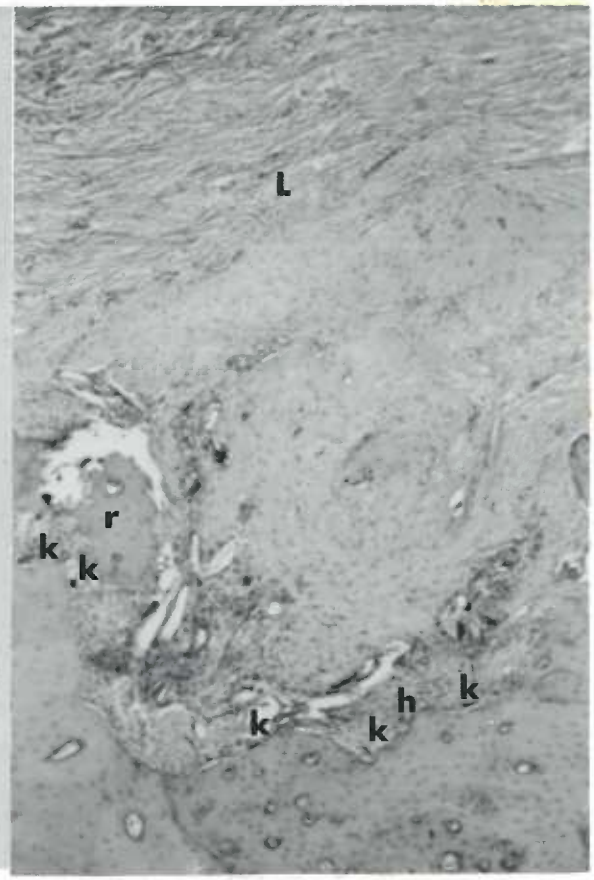

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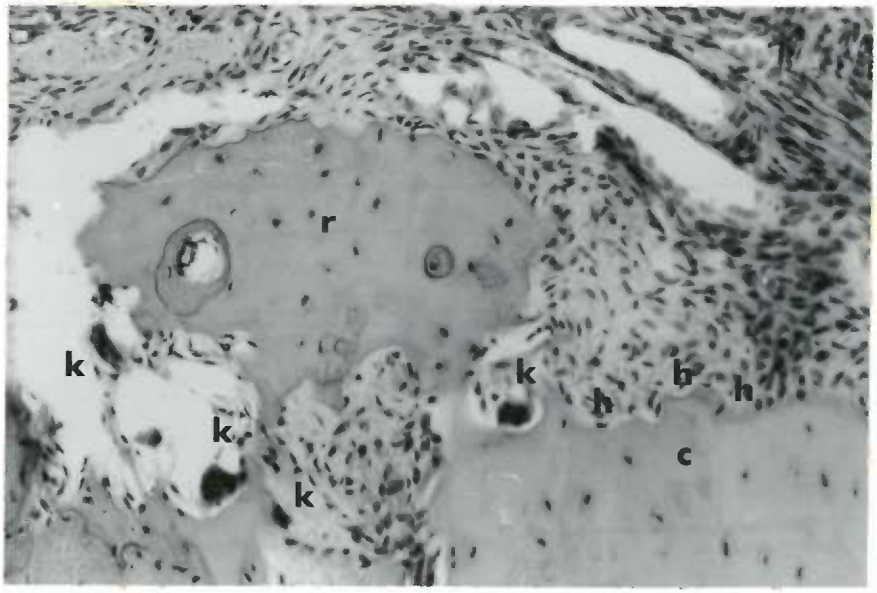

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Plate 20

Extent of Marked Crestal Bone Resorption

Figure 44. Some implants, as the acrylic implant (ai) in this figure, have lost about half of their supporting bone by crestal bone resorption. The level of the alveolar crest (c) away from the implant is at about halfway between the coronal and the apical ends of the implant. However, the bony plate (b) next to the implant is considerably higher than the alveolar crest. (e) epithelium; (n) area darkened by diffusion of India ink employed to mark distobuccal side of blocks. (No. 85-100, x 37.5)

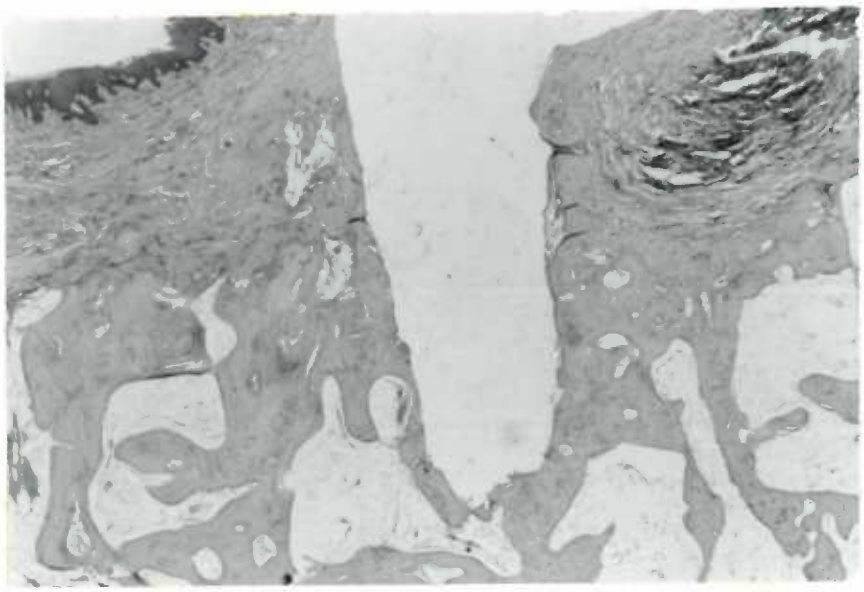

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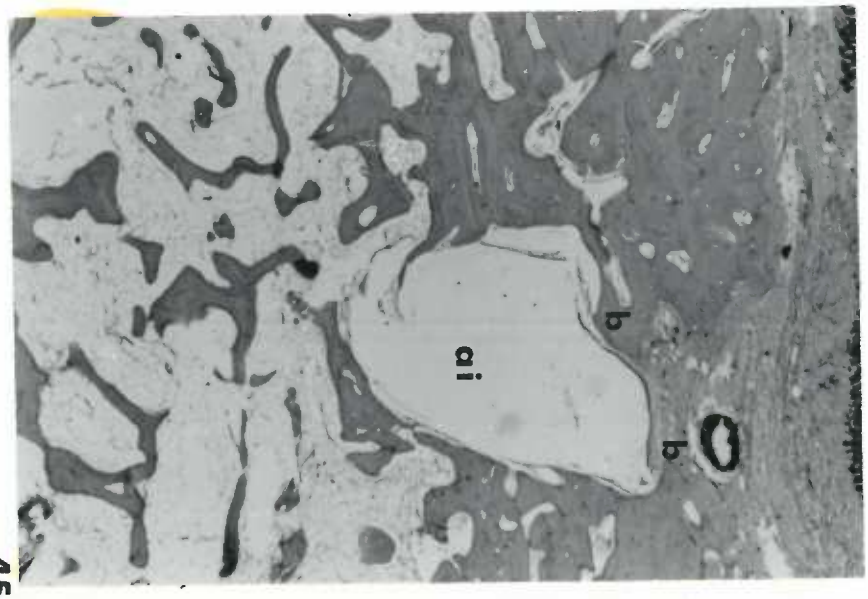
Plate 21

Bone Formation over Top of Broken Implant

Figure 45. Bone (b) has grown coronally above broken acrylic implant (ai). (No. 8-40, x 37.5)

Figure 46. Bone (b) growing above coronal portion of acrylic implant (ai). Implant lined by thin connective tissue membrane (m). (No. 8-60, x 131.25)

Figure 47. Detail of Figure 45 at higher magnification. Bone growing actively (b) over coronal portion of broken acrylic implant (ai). (m) connective tissue membrane lining implant. (No. 8-60, x 450).



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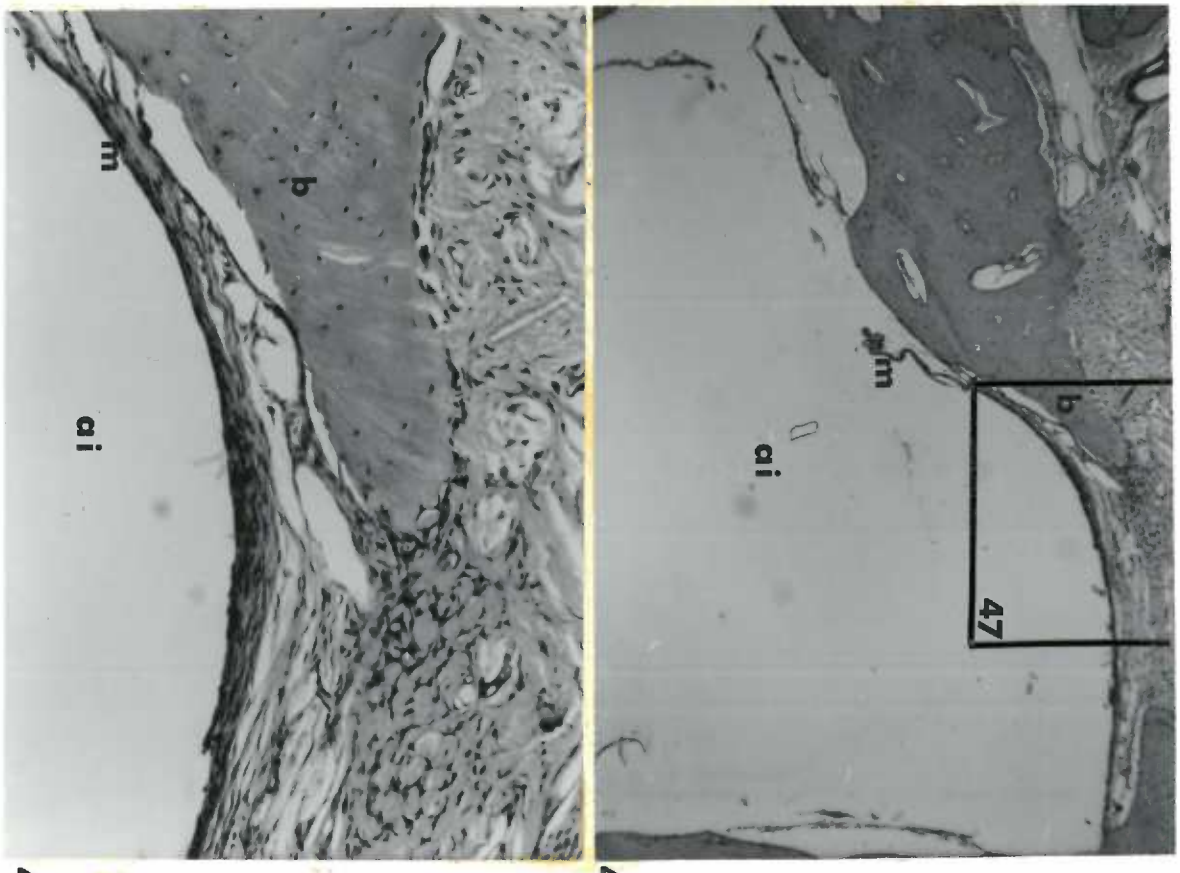

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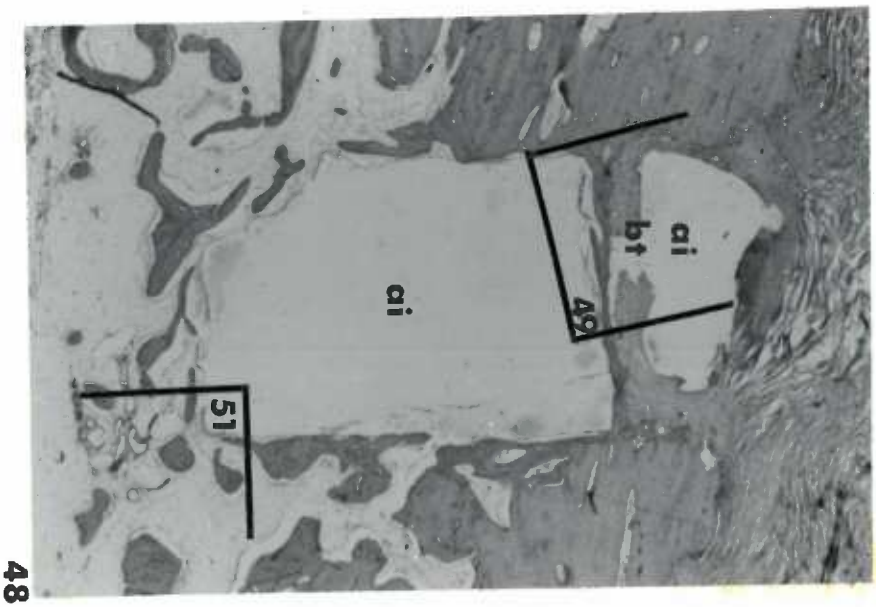
Plate 22

Bone Formation Between Broken Halves of an Acrylic Implant

Figure 48. The broken halves of a ten-week acrylic implant (ai) are separated by a bridge of tissue (bt). (No. 62-80, x 37.5)

Figure 49. Detail of Figure 48. The bridge of tissue between the two broken halves of this ten-week acrylic implant (ai) consists of bone (b) and connective tissue resembling and continuous with periosteum (p). The soft tissue was torn during removal of the implant. (No. 62-80, x 131.25)

Figure 50. Detail of Figure 49 at higher magnification. (ai) acrylic implant; (p) periosteal portion of tissue bridge; (b) bony portion of tissue bridge showing resorption (r) on coronal surface and osteoblasts (o) on deep surface facing the implant. (No. 62-80, x 450)



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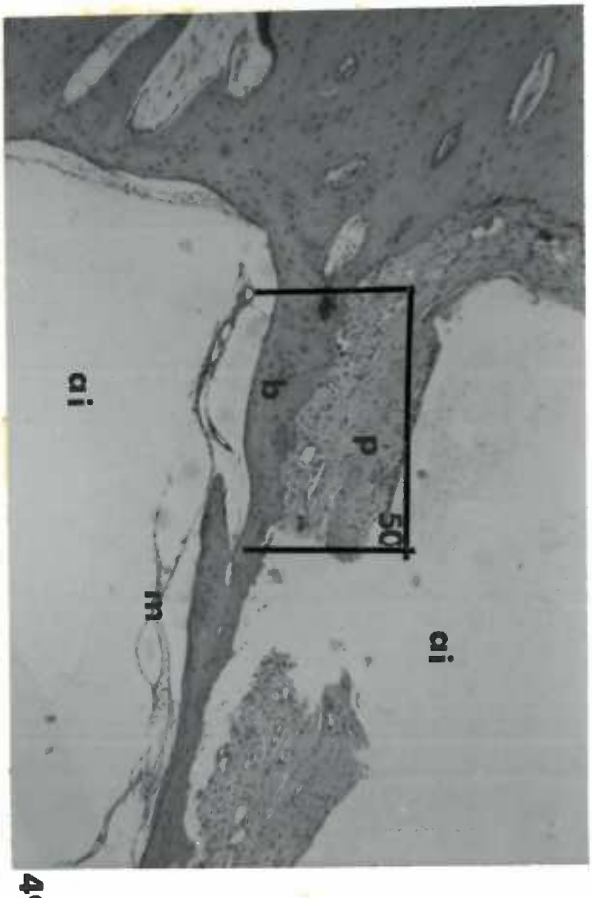

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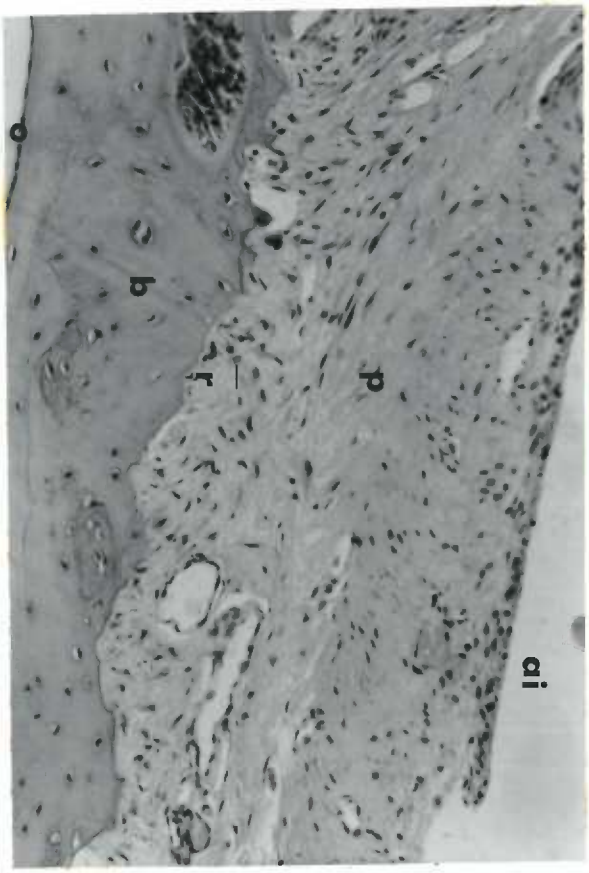

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Plate 23

Minimal Chronic Inflammation at Implant Site

Figure 51. Detail of Figure 48 showing the type of inflammation designated as minimal chronic. (ai) acrylic implant; (b) bony trabeculae; (v) artifactually dilated blood vessels. (No. 62-80, x 450)

Figure 52. Detail of Figure 51 at higher magnification. (b) bony trabecula lined by osteoblasts. (v) artifactually dilated blood vessels; (i) inflammatory cells; (m) thin connective tissue membrane lining implant space (ai). (No. 62-80, x 937.5)

Figure 53. Detail of Figure 51 at higher magnification. The inflammatory cells surround dilated blood vessels (v) and are mingled with erythrocytes (e). (m) connective tissue membrane lining implant space; (l) lymphocytes; (g) macrophages; (b) bone. (No. 62-80, x 1500)

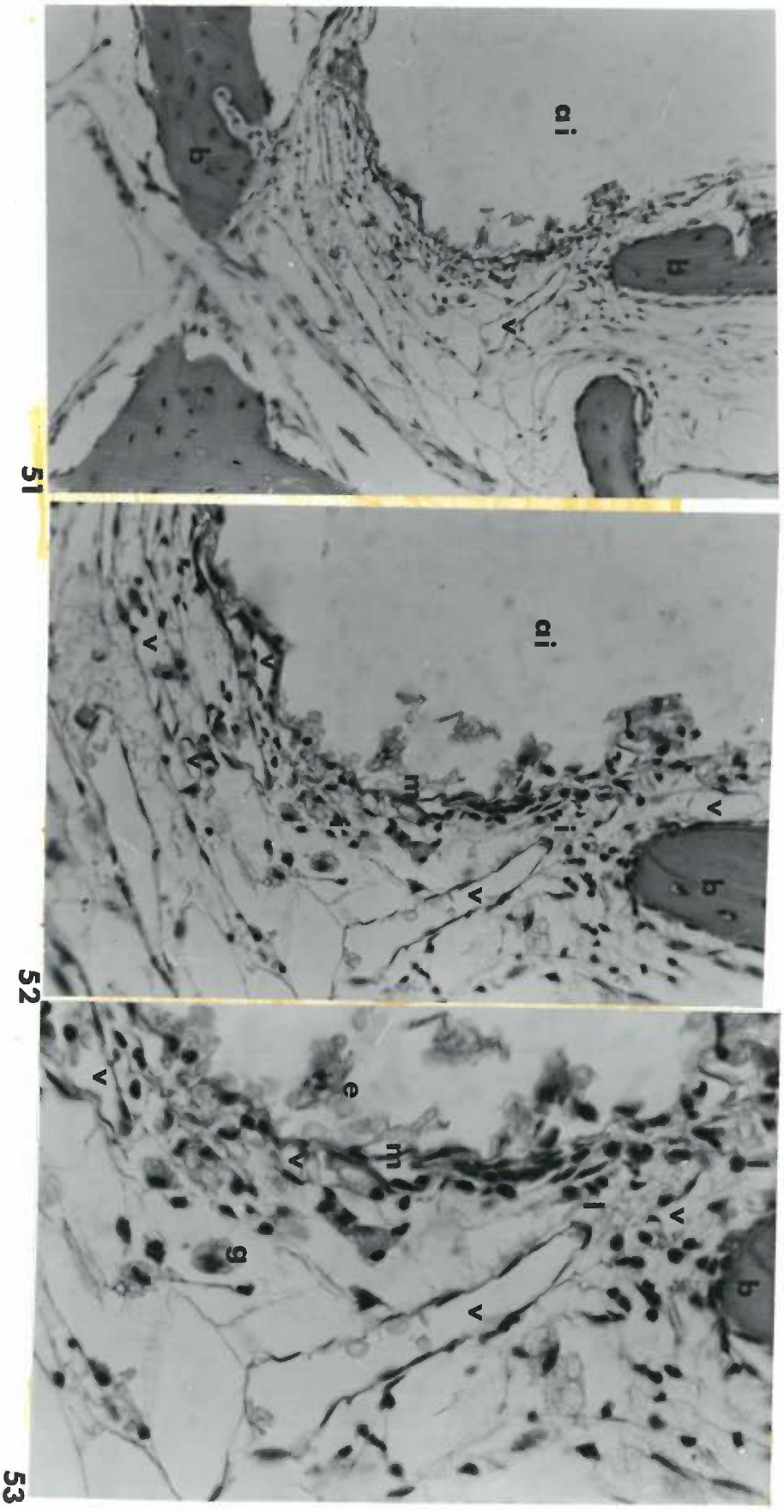
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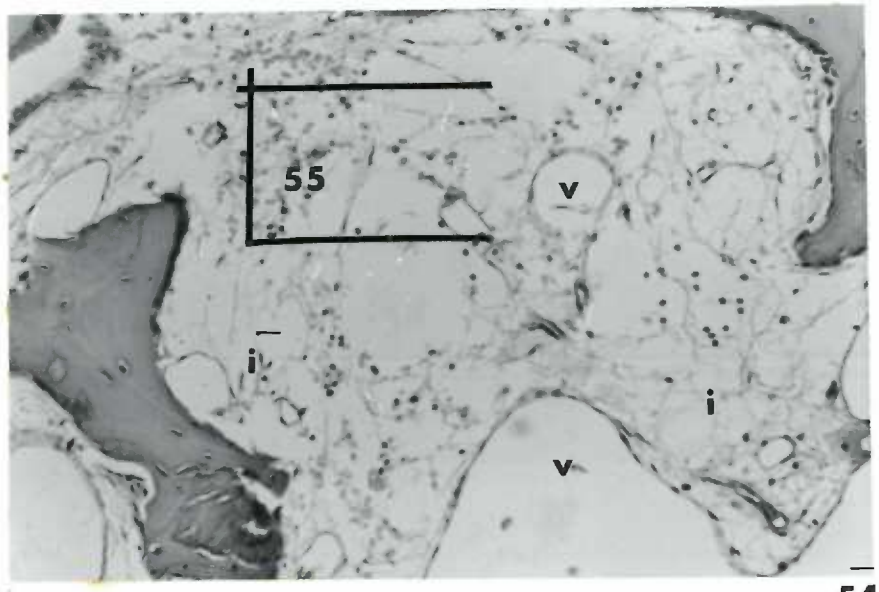
Plate 24

Minimal Chronic Inflammation at Sham-Operated Site

Figure 54. Detail of a sham-operated site showing the type of inflammation designated as minimal chronic. (v) artifactually dilated blood vessels; (i) inflammatory cells. (No. 67-240, x 450)

Figure 55. Detail of Figure 54 at higher magnification. (v) blood vessel; (n) neutrophil; (e) erythrocytes; (l) lymphocyte. (No. 67-240, x 1500)



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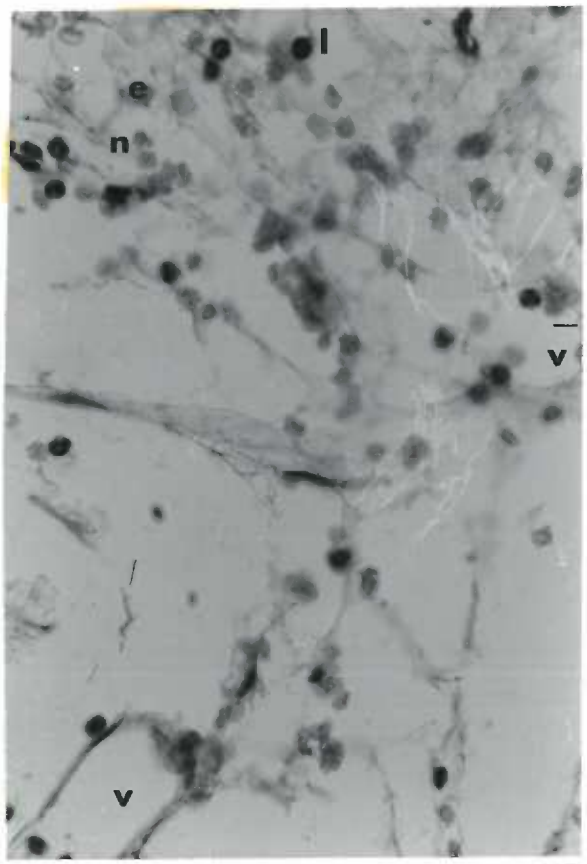

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Plate 25

Moderate Chronic Inflammation

Figure 56. Focus of inflammation designated as moderate chronic in the gingiva; this focus in an area containing neither implant nor sham sites. (e) epithelium; (l) lamina propria; (i) focus of inflammation; (c) alveolar crest. (No. 51-1, x 37.5)

Figure 57. Focus of moderate chronic inflammation shown in preceding figure in another section of the same block. (i) inflammatory cells; (l) lamina propria; (c) alveolar crest. (No 51-20, x 450)

Figure 58. Detail of Figure 57 at higher magnification. Lymphocytes and plasma cells are the predominant cell type. (v) blood vessels. (No. 51-20, x 1500)


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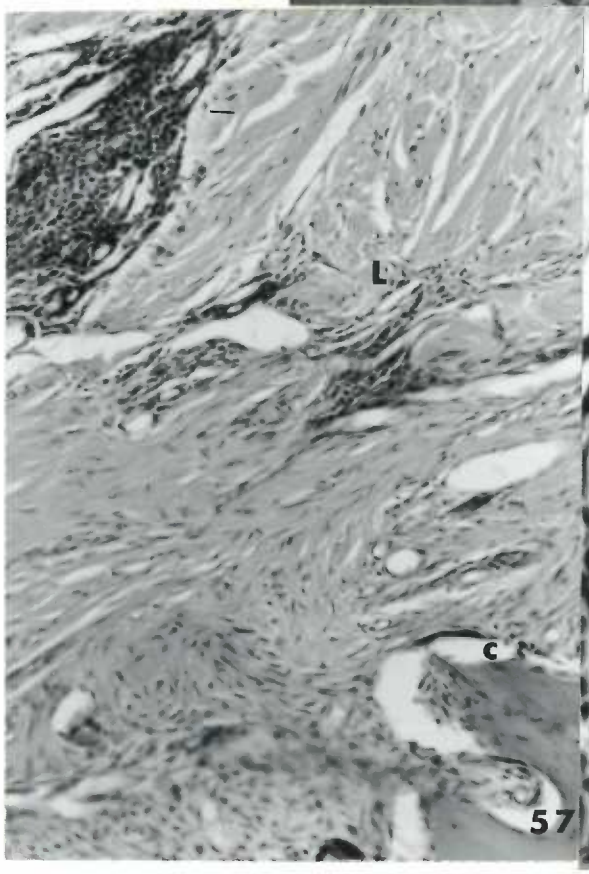
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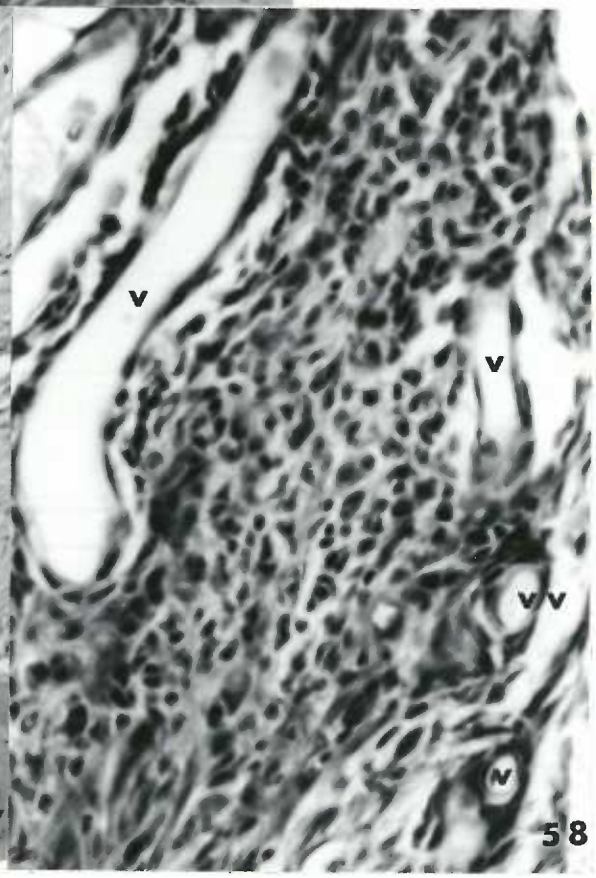
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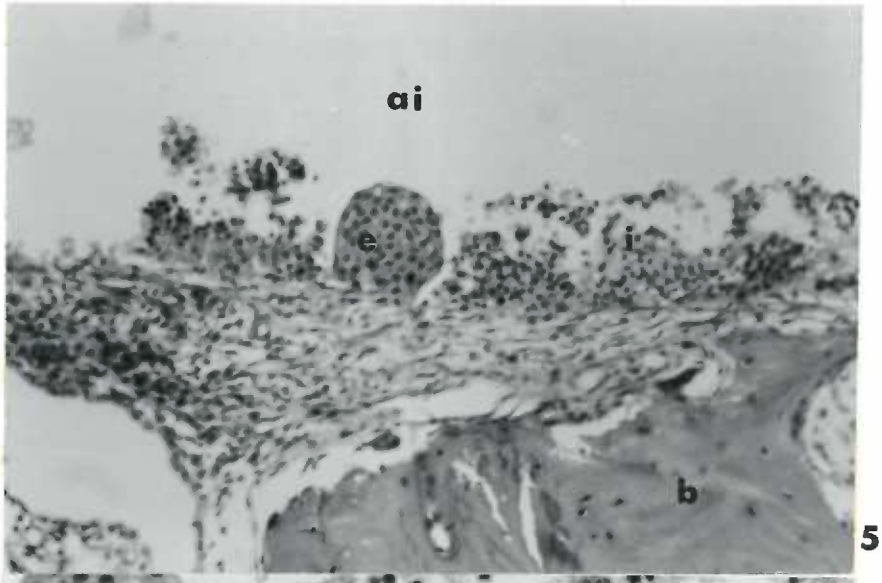
Plate 26

Moderate Acute Inflammation and Epithelial Downgrowth

Figure 59. Band-like inflammatory infiltrate (i) and stratified squamous epithelium (e) adjacent to acrylic implant shaft (ai); (b) bone. (No. 17-80, x 450)

Figure 60. Detail of Figure 59 at higher magnification. The inflammatory infiltrate (i) is localized and consists chiefly of neutrophils.. (e) epithelium; (b) bone. (No. 17-80, x 937.50)

Figure 61. Detail of Figure 59 at higher magnification. (e) epithelium; (n) neutrophils; (l) lymphocytes; (r) erythrocyte. (No. 17-80, x 1500)



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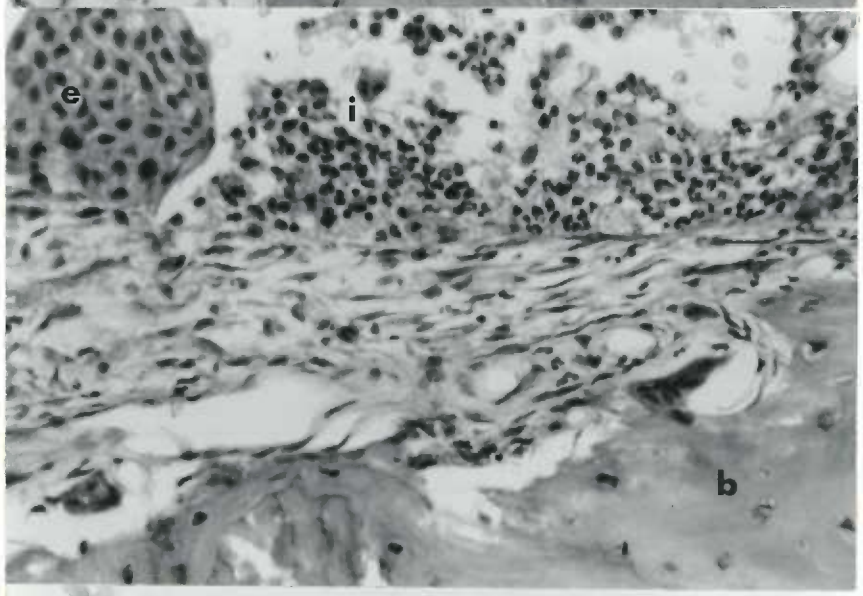

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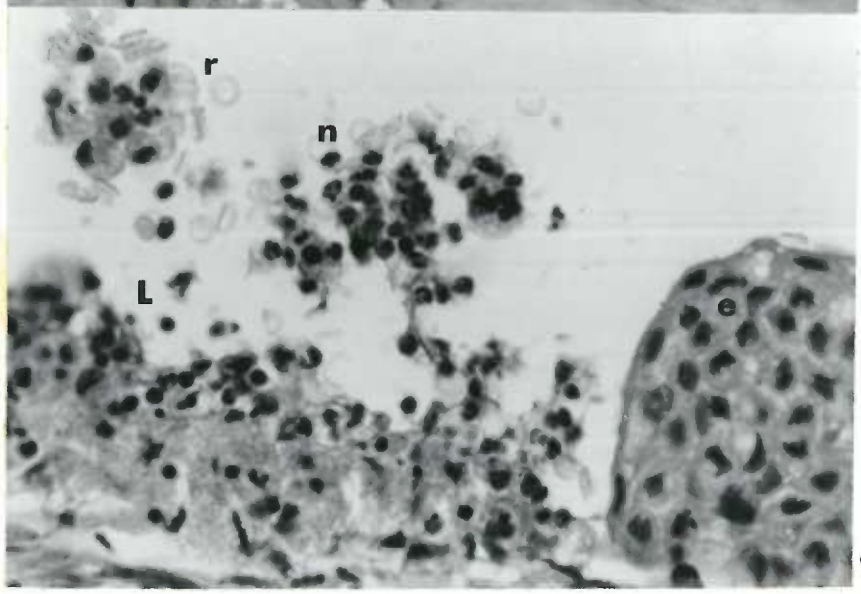

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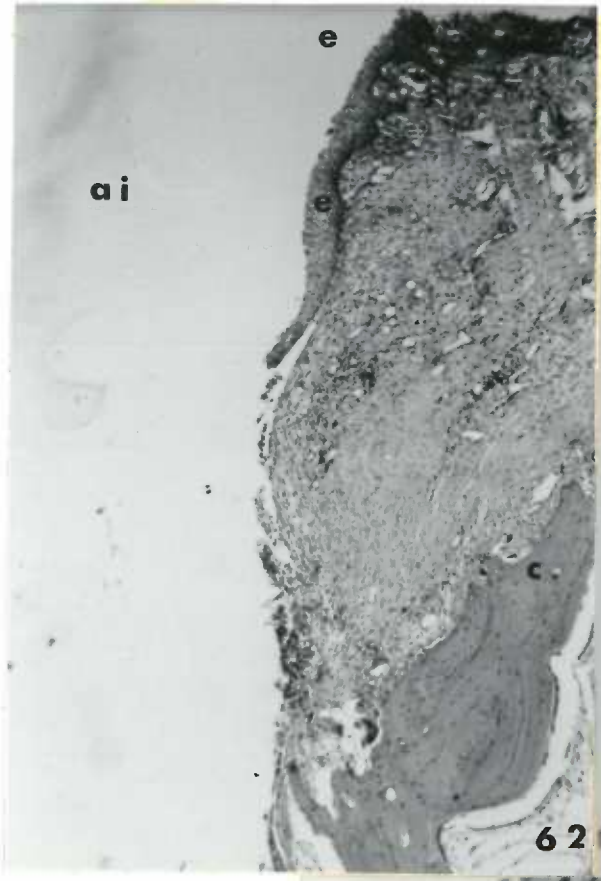
Plate 27

Epithelial Downgrowth and Moderate Acute Inflammation

Figure 62. Surface epithelium (e) has grown under the lip (l) of the implant and extends along the acrylic implant (ai) shaft. (c) alveolar crest showing resorption. (No. 17-80, x 131.25)

Figure 63. Detail of Figure 62 at higher magnification. (ai) acrylic implant. The epithelium (e) and the lamina propria (l) are both infiltrated by inflammatory cells (i). (No. 17-80, x 450)

Figure 64. Detail of Figure 62 at higher magnification. (ai) acrylic implant; (e) epithelium; (n) neutrophil. (No. 17-80, x 937.5)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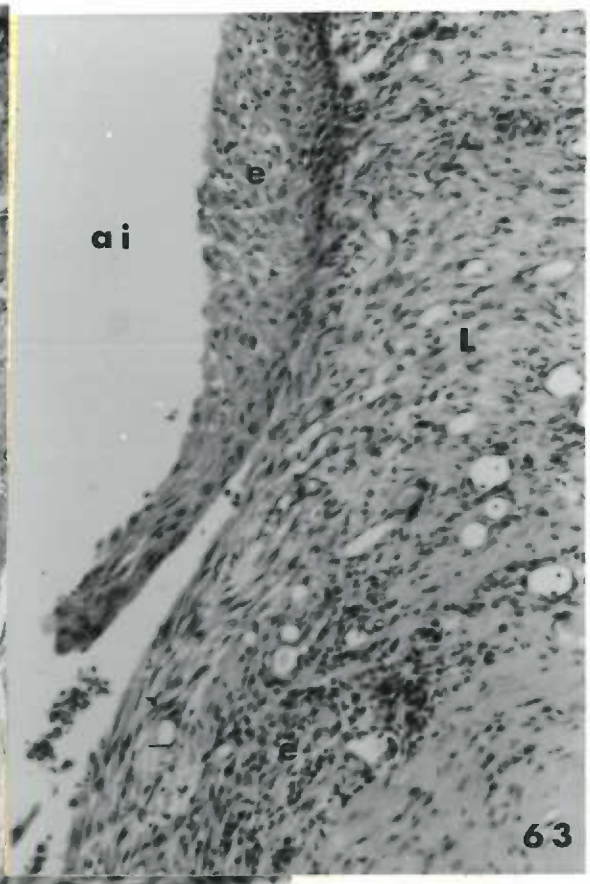
62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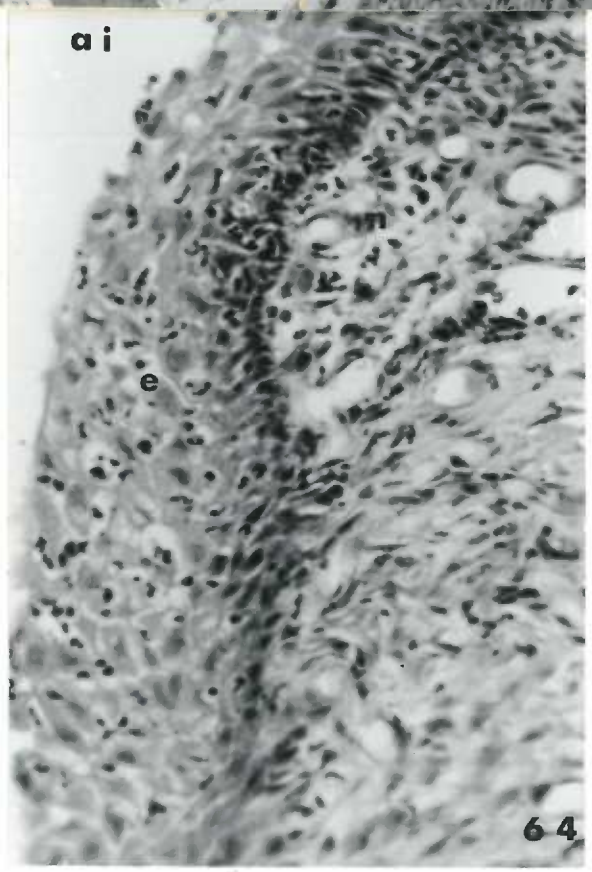
ai
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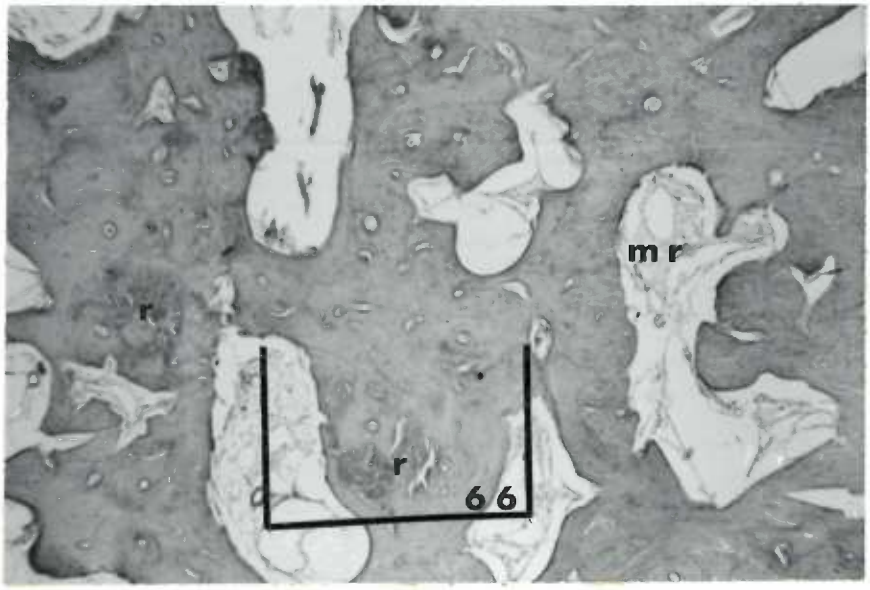
64

Plate 28

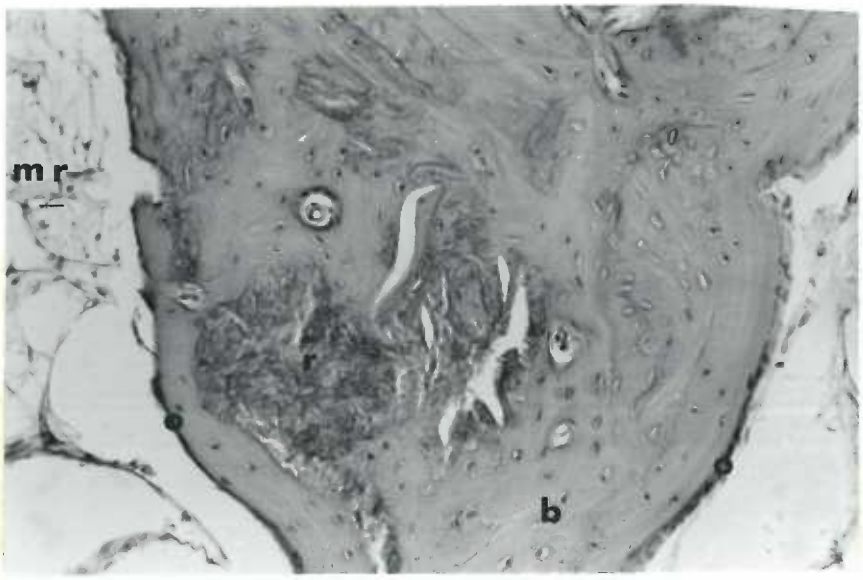
Residual Necrotic Bone

Figure 65. Detail of a ten-week sham site with areas of residual necrotic bone (r) enclosed in vital bone (b). (mr) marrow space. (No. 58-80, x 131.25)

Figure 66. Detail of Figure 65 at higher magnification. (r) residual necrotic bone enclosed in vital bone (b), bordered by osteoblasts (o); (mr) marrow space. (No. 58-80, x 450)



65



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APPENDIX II

Statistical Analyses

Numbers in the 2 x 2 tables are the number of implant sites.

Hypothesis No. 1

Fractured acrylic implants are not different from non-fractured acrylic implants with respect to clinical changes.

	Change	No change
Fractured acrylic implants	1	5
Non-fractured acrylic implants	7	19
	8	24

The difference is not significant.

Hypothesis No. 2

2.1 Acrylic implants are not different from Ticonium implants with respect to "loss of implant".

	Acrylic	Ticonium
Implants lost	0	2
Implants not lost	32	30
	32	32

The difference is not significant

2.2 Acrylic implants are not different from Ticonium implants with respect to "thinning of the mucosa".

	Acrylic	Ticonium
Thinning of the mucosa present	5	8
Thinning of the mucosa absent	24	24
	29	32

The difference is not significant.

2.3 Acrylic implants are not different from Ticonium implants with respect to "loss of mucosa"

	Acrylic	Ticonium
"Loss of mucosa" present	3	0
"Loss of mucosa" absent	29	32
	32	32

The difference is not significant.

Hypothesis No. 3

Acrylic implants are not different from Ticonium implants with respect to all clinical changes.

	Acrylic	Ticonium
Change	8	10
No change	24	22
	32	32

The difference is not significant.

Hypothesis No. 4

Molar areas are not different from premolar areas with respect to the occurrence of clinical changes in implant sites.

	Molar areas	Premolar areas
Change	7	11
No change	25	21
	32	32

The difference is not significant.

Hypothesis No. 5

Areas where roots were fractured during extraction are not different from areas where roots were not fractured during extraction with respect to the occurrence of clinical changes in implant sites.

	Areas with root fracture	Areas without root fracture	Σ
Change	5	13	18
No change	11	35	46
	16	48	64

$$\chi^2 = \frac{[\,|(5)(35) - (13)(11)| - 32\,]^2\, 64}{(16)(48)(18)(46)} = 0$$

The difference is not significant.

Hypothesis No. 6

Male animals are not different from female animals with respect to the occurrence of clinical changes at implant sites.

	Males	Females
Change	3	15
No change	21	25
	24	40

There is significant difference at the 0.05 level.

Hypothesis No. 7

Dogs with narrow ridges are not different from dogs with broad ridges with respect to the occurrence of clinical changes at implant sites.

	Dogs with flat ridges	Dogs with narrow ridges
Change	3	15
No change	37	9
	40	24

The difference is significant at the 0.02 level.

Hypothesis No. 8

Fractured acrylic implants are not different from non-fractured acrylic implants with respect to each of the histologic features listed on pp 44.

8.1 Presence of lymphocytes and plasma cells at implant site

	Fractured	Not fractured
Present	6	21
Absent	0	3
	6	24

The difference is not significant.

	Fractured	Not fractured
Can tell	6	24
Cannot tell	0	2
	8	26

The difference is not significant.

8.2 Presence of granulocytes at implant site.

	Fractured	Not fractured
Present	4	16
Absent	0	8
	4	24

The difference is not significant.

	Fractured	Not fractured
Can tell	4	24
Cannot tell	2	2
	6	26

The difference is not significant.

8.3 Degree of inflammation at implant site (none, minimal, moderate, marked)

	Fractured	Not fractured
Minimal	5	17
Not minimal	1	9
	6	26

The difference is not significant.

8.4 Evidence of bone resorption at the implant site.

	Fractured	Not fractured	
Present	2	12	14
Absent	3	13	16

The difference is not significant.

	Fractured	Not fractured
Can tell	5	25
Cannot tell	1	1
	6	26

The difference is not significant.

8.5 Degree of bone resorption at implant site

	Fractured	Not fractured
Minimal	2	12
Not minimal	4	14
	6	26

The difference is not significant

8.6 Presence of residual necrotic bone.

	Fractured	Not fractured
Present	3	16
Absent	3	10
	6	26

The difference is not significant.

8.7 Soft tissue necrosis at implant site.

	Fractured	Not fractured
Present	0	1
Absent	6	25
	6	26

The difference is not significant.

8.8 Epithelial downgrowth at implant site.

	Fractured	Not fractured
Present	0	4
Absent	6	20
	6	24

The difference is not significant.

8.9 Evidence of bone resorption at crest.

	Fractured	Not fractured
Present	4	24
Absent	2	2
	6	26

The difference is not significant.

8.10 Degree of bone resorption at crest.

	Fractured	Not fractured
Slight	1	6
Not slight	5	20
	6	26

The difference is not significant.

The hypothesis is accepted with respect to all ten tissue reactions. Since the fractured implants are not significantly different from non-fractured implants, they will be included with non-fractured implants for further tests.

Hypothesis No. 9

Acrylic implants are not different from Ticonium implants with respect to each of the histologic features listed on pp .

9.1 Presence of lymphocytes and plasma cells at implant sites.

	Acrylic	Ticonium
Present	27	24
Absent	4	1
	31	25

The difference is not significant.

	Acrylic	Ticonium
Can tell	31	25
Cannot tell	1	7
	32	32

The difference is not significant at 0.05.

9.2 Presence of granulocytes at implant sites.

	Acrylic	Ticonium
Present	20	11
Absent	5	11
	25	22

The difference is not significant.

	Acrylic	Ticonium
Can tell	25	22
Cannot tell	7	10
	32	32

The difference is not significant.

9.3 Degree of inflammation at implant sites.

	Acrylic	Ticonium
Minimal	22	17
Not minimal	10	15
	32	32

The difference is not significant.

	Acrylic	Ticonium
Moderate	5	4
Not moderate	27	28
	32	32

The difference is not significant.

	Acrylic	Ticonium
No inflammation	5	11
Inflammation	27	21
	32	32

The difference is not significant.

9.4 Evidence of bone resorption at implant site.

	Acrylic	Ticonium
Present	14	11
Absent	16	18
	30	29

The difference is not significant.

	Acrylic	Ticonium
Can tell	30	29
Cannot tell	2	3
	32	32

The difference is not significant.

9.5 Degree of bone resorption at implant site.

	Acrylic	Ticonium
Slight	14	11
Not slight	0	0
	14	11

The difference is not significant.

9.6 Presence of residual necrotic bone at implant site.

	Acrylic	Ticonium
Present	17	19
Absent	15	13
	32	32

The difference is not significant.

9.7 Soft tissue necrosis at implant sites.

	Acrylic	Ticonium
Present	1	0
Absent	31	32
	32	32

The difference is not significant.

9.8 Epithelial downgrowth at implant site

	Acrylic	Ticonium
Present	4	0
Absent	28	30
	32	30

The difference is not significant.

	Acrylic	Ticonium
Can tell	32	30
Cannot tell	0	2
	32	32

The difference is not significant.

9.9 Evidence of bone resorption at crest

	Acrylic	Ticonium
Present	28	30
Absent	4	2
	32	32

The difference is not significant.

9.10 Degree of bone resorption at crest

	Acrylic	Ticonium
Slight	8	12
Not slight	20	18
	28	30

The difference is not significant.

	Acrylic	Ticonium
Moderate	6	3
Not moderate	22	27
	28	30

The difference is not significant.

	Acrylic	Ticonium
Marked	14	15
Not marked	14	15
	28	30

The difference is not significant.

The null hypothesis is accepted with respect to all of the above listed tissue reactions.

Hypothesis No. 10

Implants in the clinical category "thinning of the mucosa and loss of mucosa" are not different from implants in the clinical category "no change" with respect to the histologic finding "marked crestal bone resorption".

	Thinning and loss of mucosa	No clinical change	Σ
Marked crestal bone resorption present	10	14	24
Absent	3	32	35
	13	46	59

$$\chi^2 = \frac{[\,|(10)(32) - (3)(14)| - 29.5\,]^2\ 59}{(13)(46)(24)(35)} = 7.25311$$

χ^2_{99} with 1 degree of freedom = 6.63

The difference is highly significant.

Hypothesis No. 11

Implants associated with clinically observed changes ("thinning of the mucosa", "loss of mucosa", "loss of implant") are not different from implants free of any clinically observed changes with respect to the histologic finding "marked crestal bone resorption".

	Clinical change	No clinical change	Σ
Marked crestal bone resorption present	12	14	26
Absent	3	32	35
	15	46	61

$$\chi^2 = \frac{[\,|(12)(32) - (14)(3)| - \frac{61}{2}\,]^2\ 61}{(15)(46)(26)(35)} = 9.42660$$

χ^2_{99} with one degree of freedom = 6.63

The difference is highly significant.

APPENDIX II (CONTINUED)

Statistical evaluation of microscopic examination

Recognizing the fact that histologic interpretation relies heavily on subjective individual judgment, the reliatility of the examiner's judgment was tested as follows:

After all implant and sham sites had been examined, a random sample of 36 sites was chosen from the total of 64 implant sites and the examination repeated for each independent histologic item.

(The proportion of matched answers) minus (the proportion of unmatched answers) was chosen as the measure of the consistency of the examiner's interpretation. (Example of matched answer: "Yes" in the first examination and "Yes" in the second examination. Example of unmatched answer: "Yes" in the first examination and "No" in the second examination.)

The results are shown as follows:

		Examination II		
		Yes	No	Cannot determine
Examination I	Yes	a	b	c
	No	d	e	f
	Cannot determine	g	h	i

$$a + b + c + d + e + f + g + h + i = N$$

Then $\frac{a + e + i}{N}$ = proportion of matched answers; and

$$\frac{b + c + d + f + g + h}{N} = \text{proportion of unmatched answers.}$$

Since we have a dichotomous population of answers (matched versus unmatched)

$$\frac{a + e + i}{N} = P \text{ and } \frac{b + c + d + f + g + h}{N} = 1 - P.$$

The (number of matched answers) minus (the number of unmatched answers) becomes $P - (1 - P) = 2P - 1 = y$.

The null hypothesis is postulated as: "The examiner is guessing" or $P = 0.5$ and $2P - 1 = 0$ and $\alpha = .05$ was chosen to test this hypothesis. The critical values for the rejection of the hypothesis are $1.96\ \sigma\ y$. The variance of P, $\sigma_P^2 = PQ/N$ and the variance of the newly defined variable $y = 2P - 1$ becomes $4(PQ)/N$ and the standard deviation of this variable

$$\sigma_y = \sqrt{\frac{4\ PQ}{N}}$$

$$\sigma_y = \sqrt{\frac{4 \times 0.5 \times 0.5}{N}} = \sqrt{\frac{1}{N}} = \frac{1}{\sqrt{N}}$$

In this case $N = 36$; $\frac{1}{\sqrt{36}} = \frac{1}{6}$

$$0 + [\ (1/6)\ 1.96] = .327$$

The difference between matched and unmatched answers:

$$\frac{a + c + i}{N} - \frac{b + c + d + f + g + h}{N} \geq .327$$ to reject the null hypothesis; or

$$2P - 1 = .327$$

$$2P = 1 + .327$$

$$P = \frac{1.327}{2} = .663.$$

In other words, P must be of the magnitude .663 or greater before one can begin to place some degree of reliance on the characteristic as an effective criterion. The proportion "P" (matched answers over total number of answers) is determined by the examiner's consistency, by the clarity of the criteria used to determine histologic features, and finally by the clarity of the histologic features themselves. Therefore, those histologic features which have higher P values are more dependable and are better criteria to further evaluate the tissue response to acrylic and Ticonium implants than histologic features with lower P values.

Statistical Analyses (Continued)

Evaluation of Microscopic Examination

Presence of lymphocytes and plasma cells at implant/sham site

		Examination II		
		Yes	Cannot tell	No
Examination I	Yes	28	0	0
	Cannot tell	2	4	2
	No	0	0	0

$$P = \frac{32}{36} = 0.888$$

Presence of granulocytes at implant/sham site

		Examination II		
		Yes	Cannot tell	No
Examination I	Yes	11	1	1
	Cannot tell	3	16	2
	No	0	1	1

$$P = \frac{28}{36} = 0.778$$

Degree of inflammation (Inflammation interpreted as minimal at implant/sham site)

		Examination II		
		Yes	Cannot tell	No
Examination I	Yes	22	0	0
	Cannot tell	1	6	3
	No	1	0	3

$$P = \frac{31}{36} = 0.861$$

Bone formation at implant/sham site

		Examination II		
		Yes	Cannot tell	No
	Yes	36	0	0
Examination I	Cannot tell	0	0	0
	No	0	0	0

P = 1.00

Bone formation interpreted as minimal

		Examination II		
		Yes	Cannot tell	No
	Yes	0	0	0
Examination I	Cannot tell	0	0	0
	No	0	0	36

P = 1.00

Evidence of bone resorption at implant/sham site

		Examination II		
		Yes	Cannot tell	No
	Yes	10	0	5
Examination I	Cannot tell	0	0	2
	No	2	0	17

$$P = \frac{27}{36} = 0.750$$

Bone resorption interpreted as minimal at implant/sham site

		Examination II		
		Yes	Cannot tell	No
	Yes	10	0	6
Examination I	Cannot tell	0	0	1
	No	1	0	18

$$P = \frac{28}{36} = 0.778$$

Residual necrotic bone at implant/sham site

		Examination II		
		Yes	Cannot tell	No
	Yes	22	0	1
Examination I	Cannot tell	0	0	0
	No	1	0	11

$$P = \frac{33}{36} = 0.917$$

Soft tissue necrosis at implant/sham site

		Examination II		
		Yes	Cannot tell	No
	Yes	0	0	0
Examination I	Cannot tell	0	0	0
	No	0	0	36

$P = 1.00$

Epithelial downgrowth

		Examination II		
		Yes	Cannot tell	No
	Yes	1	0	0
Examination I	Cannot tell	0	2	0
	No	0	0	33

P = 1.00

Evidence of bone resorption at crest

		Examination II		
		Yes	Cannot tell	No
	Yes	30	1	0
Examination I	Cannot tell	0	2	0
	No	0	3	0

$$P = \frac{35}{36} = 0.972$$

Degree of bone resorption at crest: bone resorption interpreted as minimal

		Examination II		
		Yes	Cannot tell	No
	Yes	10	0	2
Examination I	Cannot tell	0	3	0
	No	0	0	21

$$P = \frac{34}{36} = 0.944$$

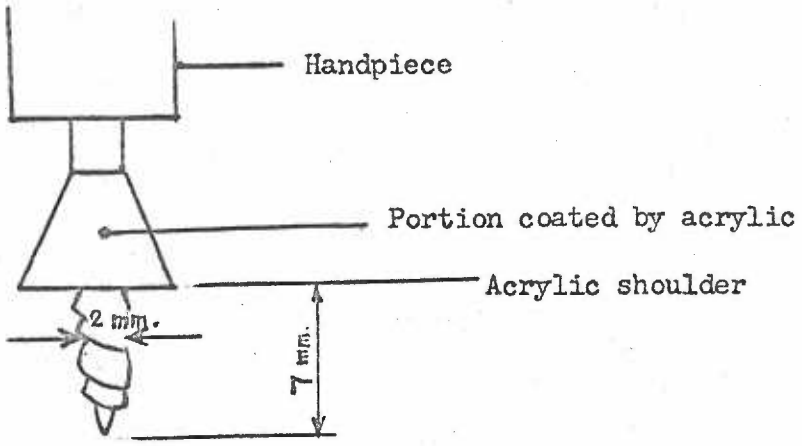
APPENDIX III

Preparation of Implants

Ticonium implants

The upper cutting portion of a Clev-Dent #12 surgical bur was coated with self-curing acrylic, leaving a lower portion of 7 mm working length as shown in Figure 7.

Figure 7



A 7 mm socket was drilled with this bur into the dry mandible of a dog. After painting the socket with Slikdie, it was filled with hard blue wax (Kerr). The "lip" portion of the implant was modeled of the same wax. A heated pin was inserted into the wax, the pattern corrected after cooling, and the wax pattern withdrawn. This first model of the

implant was successively duplicated in acrylic using a denture flask until 16 acrylic implants were obtained. These implants were sprued, invested and the acrylic burnt out. The implants were then cast in surgical grade Ticonium No. 25 on an automatic Ticomatic caster by the technicians of the prosthetic laboratory of the University of Oregon Dental School. The implants were bench-cooled, sandblasted and treated with Tylectro polishing solutions. Then the sprues were cut off with diamond disks and finished by the author with a #2 stainless steel bur. (Polishing procedures customary for other Ticonium appliances were not carried out because these would have increased the possibility of contamination of the implant with other materials.) These Ticonium implants were replicated again in acrylic in a denture flask and a second batch and third batch of Ticonium implants cast and finished in the same manner. The 40 implants selected were thus of a standard size and shape, but had a minute visible difference, the magnitude of which was less than one millimeter.

Acrylic implants

Each acrylic implant was the direct replica of a Ticonium implant. A Ticonium implant and its corresponding acrylic replica were kept together to be implanted into the same experimental unit. To avoid mismatching, a few Ticonium implants were replicated at a time, as follows:

A thin coat of "E-Z" foil was painted on the Ticonium implant. After drying, the implant was enflasked into a Hanau upper denture flask. After the plaster had set, the flask was opened and the implant carefully removed. This procedure was easy due to the non-retentive shape of the implant. The resulting mold was painted with a thin coat of "E-Z" foil. After this separating medium had set, self-curing

transparent denture base acrylic (brand: Walther's; Batch No. 2) was packed into the mold. The rims of the flask were checked and the two halves of the flask carefully joined. Two flasks were placed into a Hanau hand press and the press tightened until metal-to-metal contact had been obtained. The screw was then backed off one-half turn to activate the springs. The press with the flasks was submerged into water at 140° F for thirty minutes. Then the press and flasks were opened, the implant carefully removed and the excess material cut off with a #2 stainless steel bur.

Preparation of implants for surgery

Each pair of corresponding Ticonium and acrylic implants was soaked in water for thirty minutes in a plastic container, then brushed with a stiff brush. The Ticonium implant was grasped with stainless steel forceps interposing a piece of gauze between the two metallic surfaces, the acrylic implant with stainless steel forceps only. The implants were washed in running tap water for three minutes, then in running distilled, deionized water for one minute. They were then dropped into a Tomac Glassene paper syringe envelope; the envelope was sealed and stored until surgery. Prior to surgery, envelopes containing the implants were placed on the instrument tray, wrapped and autoclaved together with the surgical instruments at 216 pounds pressure for thirty minutes.

APPENDIX IV

Formulas of Fixative and Decalcifying Solutions

FORMULA OF FIXATIVE SOLUTION

Sodium Chloride	36 grams
Disodium Hydrogen Phosphate (Na_2HPO_4)	40 grams
Sodium Dihydrogen Phosphate (NaH_2PO_4)	14 grams
Sodium Nitrite ($NaNO_2$)	40 grams

Dissolve in 3,000 mls water.

Add 400 ml concentrated formalin.

Shake to mix.

Adjust to pH 7.2 with Na_2HPO_4.

Dilute to 4,000 ml with water.

Formula of Decalcifying Solution

Sodium Formate	34 grams
Water	500 cc
Formic Acid	175 cc
Water	325 cc

Dissolve Sodium Formate in hot water and add to mixture of formic acid and water.