

CHAPTER VI.QUALITATIVE AND QUANTITATIVE CHANGES IN THE BLOOD, PRIOR TO AND DURING PROCEDURES ASSOCIATED WITH IMMEDIATE DENTURE INSERTION. PHYSIOLOGICAL RESPONSE TO STRESS.

From previous attendances at the dental surgery during the various stages of immediate denture construction, the patient can reasonably be expected to show symptoms of stress which may or may not be clinically obvious.

The awareness that teeth are to be extracted with possibly some degree of surgical intervention is sufficient to provoke a physiological response in the patient which is proportionate to past experiences, (A. G. Ship²⁵³).

BLOOD PRESSURE CHANGES.

Cheraskin and Prasertsuntarasai⁴² found that significant blood pressure changes occurred in normotensive and hypertensive adult subjects, prior to and following dental extractions. The systolic, diastolic, mean and pulse pressure levels obtained while the patient was seated in the waiting room, were higher than similar readings obtained with the patient in a basal condition. No significant increase, however, could be observed for the pulse rate.

This evidence, applied to dental procedures, supports the statement of Best and Taylor,²¹ that anxiety and emotional upsets produce an increased cardiac output without necessarily increasing the pulse rate.

I. I. Ship²⁵⁴ queries that these blood pressure changes, induced by dental procedures, are significant when related to other normal life situations, except in a small group of hyper-responsive individuals.

Further investigations by Cheraskin and Prasertsuntarasai⁴³ showed that the sedated hypertensive patients, on whom local anaesthesia with vasoconstrictor is used, fare better in terms of blood pressure changes, than the high blood pressure group of patients not given sedation or epinephrine. The suggested explanation is that excess endogenous epinephrine is released from the anxiety state caused by pain, always a possibility when using a local anaesthetic agent without a vasoconstrictor.

EOSINOPEINIA.

Dreyfuss and Feldman⁷² demonstrated that emotional stress produced a marked eosinopenia in medical students presenting for examination.

A. G. Ship²⁵³, using a similar method of measurement, showed a decrease in the number of circulating eosinophils in a series of dental manipulations, common to general dental practice. The degree of eosinopenia induced was directly proportional to the particular manipulation, oral surgery under local anaesthesia showing a significantly greater change. However, A. G. Ship²⁵³ in his observations was unable to dissociate the three factors of pain, emotion and tissue insult.

Similar results were noted by I. I. Ship and White²⁵⁵ where an eosinopenia was produced by oral surgery procedures. They were able to show that premedication with barbiturate reduced the stress response by 26%.

The value of these observations is open to question as the eosinophil count in health, is apparently subject to considerable diurnal variation, differences amounting to as much as 100% being recorded. The lowest counts are found in the morning (10am. to noon) and the highest at night (mid-night). The normal range for eosinophils is

4-400/c.mm., (Dacie⁵⁵).

The sequence of events leading to stress-induced eosinopenia can be summarised in the following way:-

- 1) stress initiates stimulation of the hypothalamus which then causes the anterior lobe of the pituitary gland to produce adreno-corticotrophic hormone.
- 2) This in turn activates the adrenal cortex, which then secretes corticoids and so mobilises the organism for action.
- 3) Among the effects of this secretion of corticoids is a decrease in circulating lymphocytes and eosinophils.

BLOOD SUGAR LEVEL.

Best and Taylor²² agree that there is sufficient volume of evidence accumulating that adreno-cortical hormone liberation (e.g., induced by the adrenaline mechanism of a stress situation) may cause a prompt hyperglycaemia and set in motion the changes to provide for continuation of the blood sugar rise.

Cheraskin, Flynn and Fess⁴¹ in non-diabetic and diabetic groups showed inconsistent results in the former group as regards blood sugar levels. However, the diabetic group in subsequent appointments consistently showed a blood sugar concentration which could be directly related to the degree of stress experienced previously.

BLOOD COAGULATION.

Best and Taylor²³ mention the increased coagulability of the blood resulting from the adrenaline mechanism.

In general surgery, de Takats and Marshall⁶¹ observed that marked fluctuations in the state of the clotting mechanism occurred, which could be correlated with the response of the body to stress. The gauge

for their measurements was the epinephrine - eosinophil pre-operative relationship.

Maslowski¹⁶³ found that oral and orthopaedic surgery, in a group of eleven patients, affected the coagulability of blood as demonstrated by the fibrinogen conversion index. More severe surgery produced a tendency to increased coagulability while less severe surgery produced tendency to decreased coagulability.

Irrespective of the coagulability shift, the plasma fibrinogen concentration increased post-operatively, indicating a response to the inflammatory process NOT an association with the rate of coagulation.

BLOOD LOSS.

A generally unappreciated factor in oral surgical procedures, such as multiple extractions, alveolar bone reduction and other surgical procedures which may be associated with insertion of immediate dentures, is the loss of blood which occurs, (Gores,⁹⁸ Roth,²³³ Johnson¹²³ and Gores et al.⁹⁹).

In general surgery, this question of blood loss has been investigated extensively over a wide range of operations, (Gatch and Little,⁸⁸ Collier, Crook and Iob⁴⁷ and Bonica and Lyter²⁵). The results of these investigations showed much similarity, as can be seen in the following table which compares the results of Bonica and Lyter²⁵ to a large number of other authors.

TABLE I.

<u>Type of Operation</u>	<u>No. of cases</u>		<u>BLOOD LOSS</u>				<u>Average ccs.</u>	
			<u>Max. ccs.</u>		<u>Min. ccs.</u>			
Thyroidectomies	15*	43**	739*	888**	111*	16**	320*	249**
Gastric resections	30*	99**	1650*	1432**	131*	150**	576*	441**
Appendectomies	36*	110**	349*	62**	19*	4**	76*	10**
Hysterectomies	61*	43**	1798**	629**	69*	40**	444*	358**

* Bonica and Lyter.

** Wide range of authors reviewed by Bonica and Lyter, (25).

Knowledge of the approximate amount of blood which may be lost is essential for the operator to plan pre- and post-operative procedures satisfactorily as has been mentioned by Collier and Maddock.⁴⁸

However, attention has only recently been focused towards the blood loss, (Gores et al.⁹⁹ and Johnson¹²³) and subsequent fluid imbalance, (Bergan, Gores and Wakim¹⁹) in operations commonly performed in oral surgery.

Gores, Royer and Mann⁹⁹ on a series of 47 patients carried out operations consisting of multiple extractions and "alveoloplasty of an extent necessary to prepare properly the alveolar ridges for denturés," under general anaesthesia. In twenty-one patients, the soft tissues in the region of operation were infiltrated with a local anaesthetic solution (3% piperocaine hydrochloride) containing a vaso-constrictor (epinephrine 1:56,000). A control group was, therefore, established by the remaining 26 patients who did not receive a local anaesthetic or vaso-constricting drug.

The grades 1 - 4 of alveoloplasty used by Gores et al.⁹⁹ have been previously defined. The method for quantitative measurement of the amount of blood lost used the following formula:-

$$\frac{\text{Total Hb in Gm. in lost blood}}{\text{Hb per 100cc. of patient's pre-operative blood}} \times 100 = \text{cc blood lost.}$$

The results of these investigations showed:-

- 1) The volume of blood loss ranged from 166-771ccs. two patients being above a volume of 500ccs. - Average 179ccs.

Comparison may, therefore, be made with the loss of blood occurring in major general surgery, such as gastric resection in which a minimum loss of 131ccs. has been recorded.

- 2) The greatest loss of blood occurred in the group of patients receiving extensive alveolar bone reduction, Grades 3 and 4.
- 3) The use of a vasoconstrictor considerably reduced blood loss in all grades 1 - 4 with a maximum loss of 40lccs. recorded (max. loss without vaso-constrictor, 77lccs).
- 4) Operating time was unaffected by the use of a vasoconstrictor, however, working conditions were greatly improved.
- 5) Healing was uncomplicated in all 47 patients.

Johnson¹²³ determined the quantitative blood losses sustained in a series of 175 patients requiring multiple extractions and alveolotomy. The surgery was performed by 8 operators. The results of these investigations showed:-

- 1) Blood losses ranged from 35-912mls. with an average loss of 223mls. with extraction of 18 teeth and alveolotomy in an operative procedure lasting 30 minutes.
- 2) Time and blood loss are directly related. The rate of haemorrhage favours the oral surgeon as it is uniform with no sudden rushes from large arteries as in general surgery. A slow, steady reduction of blood volume is better tolerated than rapid fluctuant rates of haemorrhage, (Best and Taylor²⁰).
- 3) The extent of haemorrhage in oral surgery procedures such as multiple extractions and alveolotomy, the blood losses are comparable to those encountered in major surgery.

REPLACEMENT THERAPY.

In general surgery, Collier, Crook and Iob⁴⁷ suggest that all blood losses over 300ccs. in healthy adults should be replaced, as even minimal blood loss retards convalescence. The relation of the amount of blood lost to the total blood volume has not been sufficiently emphasised.

Johnson¹²³ suggests that intravenous administration of a solution of 5-10% dextrose in water should be given to patients, requiring oral surgery, where anticipated blood loss exceeds 300mls. When haemorrhage exceeds 500mls., this loss should be compensated by the administration of whole blood.

In normal oral surgical procedures, this method of replacement is considered unnecessary for the average healthy adult. However, it is an observed physiological requirement that the fluid balance of the tissues must be maintained, (Johnson¹²³).

Bergan, Gores and Wakim¹⁹ analysed the fluid balance, on 14 patients in a 48 hour study, during and immediately after total odontectomy, (20-31 teeth) and alveoloplasty (grades 1 - 4 after Gores⁹⁹ et al.), under general anaesthesia. The results showed:-

- 1) Abnormal losses of fluid, averaging 436mls./sq. metre of body surface, occurred during the first post-operative day.
- 2) The water imbalance was principally caused by surgical blood loss and to a lesser extent, postanaesthesia emesis.
- 3) A minimal adequate intake of water was estimated to be 1250mls./sq. metre of body surface per 24hrs. "Most certainly patients convalescing from oral surgical procedures should be urged to drink more fluids."

BACTERAEMIA.

The danger of bacteraemia following tooth extraction must always be kept in mind, particularly to those patients who are physically below par and those suffering from subacute endocarditis, kidney infection or rheumatic diseases in general (Thoma²⁸³).

INCIDENCE.

The incidence of bacteraemia has been investigated by a number of authors with results showing a variation of from 10 - 46% in normal control groups (Burket and Burn,³² Lazansky et al.,¹⁴² Robinson et al.,²³⁰ Rhoads et al.,²²⁸ Merrill et al.,¹⁶⁹ and Cooley and Haberman⁵¹).

The great variation is attributed to inadequate techniques and varying techniques of measurement of the bacteraemic state, (Robinson et al.²³⁰).

INFLUENCING FACTORS.

- 1) Age - a relation between the age of the patient and incidence of bacteraemia was suggested by Lazansky et al.¹⁴², but subsequent reports by the same author in association with other workers could not substantiate this observation, (Robinson et al.²³⁰).
- 2) Operative Trauma - Burket and Burn³² and Lazansky et al.¹⁴² are of the opinion that the degree of trauma inflicted during the operative surgical procedures will increase the incidence of bacteraemia.

Robinson et al.²³⁰ subsequently disagreed with this observation.

- 3) Number of Teeth Extracted - General agreement is shown that multiple extractions significantly increase the bacteraemic interlude as against the extraction of one or two teeth, (142, 230, 154).
- 4) Oral Health - Where local periodontal or periapical infection

existed around the teeth, the incidence of bacteraemia increased,^{230, 154} although these observations could not be shown in other investigations.^{32, 142}

- 5) Use of Vaso-Constricting Agents - Cooley and Haberman⁵¹ suggest that the use of a vaso-constricting agent in the local anaesthetic solution has an anti-bacteraemic effect.

However, the conclusions of Louis¹⁵⁴ who used anaesthetic solution containing epinephrine 1 : 100,000, did not support this observation.

PROPHYLACTIC THERAPY.

The effects of antibiotic agents in reducing the incidence of post-operative bacteraemia has produced supportive evidence among authors (Rhoads et al.,²²⁸ and Merril et al.,¹⁶⁹).

Without exception, an antibiotic cover must be used for extractions in patients with rheumatic or congenital heart disease.^{228, 169} Failure to do so exposes the patient to unnecessary danger from the presence of pathogenic organisms in the circulating blood stream, no matter how transient the interval, (Thoma²⁸³).

The use of the sulphanilamide group of antibiotics has been investigated by Rhoads et al.,²²⁸). However, penicillin appears to be the antibiotic most commonly used.^{228, 169, 283}

Pressman²¹⁹ presents the following table for the administration of an antibiotic cover:-

- a) One hour prior to extraction, 400,000 to 1,200,000 units of fortified penicillin (mixture of crystalline and procaine penicillin), 1.0 gram of streptomycin, intramuscular route.
- b) One-half hour prior to extraction, one Sul-pondet or one Wybiotic

troche to be slowly dissolved in the mouth.

Sul-pondet - penicillin 20,000 units

 bacitracin 50 units

 sulphadiazine 0.130 gram

Wybiotic - neomycin 5 mgm.

 bacitracin 200 units

 polymyxin 2,000 units.

- c) Twelve to forty-eight hours after the extraction, 400,000 - 1,200,000 units of fortified penicillin, 1.0gm. of streptomycin, intramuscular route. To be given every 12 hours when added protection is deemed necessary. Penicillin V 250,000 units every 6 hours may be given for as long as necessary.
- d) Penicillin-sensitive patients may be treated by intramuscular tetracycline 100mg., Chloromycetin 1.0gm. or erythromycin 1.0gm. one hour prior to surgery as a substitute for the penicillin and streptomycin.

CHAPTER VII.HEALING OF THE ALVEOLAR TISSUES.INTRODUCTION.

"The removal of teeth, whether by accident or design, and the resultant disability, is probably the oldest and most common dental problem of mankind may well become the most frustrating problem of the dentist called upon to fit dentures to a mouth deficient in alveolar bone, (Radden²²³)."

As has been considered, inadequate alveolar bone may be the result of periodontal disease or occur progressively with age during the wearing of dentures which are locally traumatic, with or without systemic disease exerting an influence on the resorptive process.

However, a third factor which may influence alveolar bone loss is the method by which teeth are removed. These methods, and their application to immediate denture insertion, have been defined previously.

It is now proposed to examine the tissue changes associated with healing of the alveolar process using the various techniques, and by observing the tissue reactions, a rationale for controlling alveolar bone resorption or possibly initiating the deposition of new bone may evolve.

INVESTIGATIONS USING EXPERIMENTAL ANIMALS.

Various experimental animals have been used to examine the process of wound healing in the oral cavity namely, dogs, (Euler,⁷⁵ Schram,²⁴⁴ Claflin⁴⁵ and Versnel²⁹⁵), rats (Huebsch et al.¹¹⁸ and Smith²⁶⁶), hamsters, (Linn¹⁴⁸), and monkeys (Simpson^{258, 259} and Radden²²³).

These animals have provided the material on which investigators have examined the effects of tooth extraction, surgical procedures and artificially created periodontal conditions and treatment.

The assumption has been made in using experimental animals that the results from clinical observations, histological and histochemical investigations of wound healing, would prove to be essentially similar to the processes which occur in man.

Justification for making such an assumption has been subsequently verified by the value of the results obtained and the duplication of similar results in man in many instances. The principal difference has been the time factor whereby a specific stage of healing in the experimental animal may be related to that in man at a definite interval measured in hours, days or weeks. However, as considerable inter-individual variation occurs in man as a result of age, endocrine disturbances, cardiovascular difficulties, nutritional insufficiencies as well as local effects of infection, trauma etc., it is felt that the significance of the time factor must be over-ruled, to some extent, by presentation of a composite picture of the mechanisms by which healing occurs.

Awareness of these mechanisms will then allow the effects of local and systemic influences indicate whether the process of healing may be accelerated or retarded, and also at which stage this may occur.

EARLY INVESTIGATIONS, 1923-1940.

Euler,⁷⁵ in 1923, is conceded to have made the first systematic histological examination of undisturbed extraction wounds. Working on dogs, he extracted teeth at intervals, with the object of studying sockets in varying stages of healing from three to sixty-three days

and was able to set forth the following stages:-

- 1) Haemorrhage and coagulation occurs, filling the socket with blood clot and blocking off the ends of the vessels of the alveolar wall.
- 2) Organisation of the clot commences by proliferation of fibroblasts from the adjacent tissues.
- 3) Epithelium proliferates over the surface of the wound.
- 4) Bone resorption at the alveolar crests and along the lamina dura is evidenced at the same time as bone regeneration is seen proceeding from the socket walls.

Schram²⁴⁴ in 1929, investigated forceps and surgical extraction wounds in dogs and concluded that:-

- 1) Forceps extraction wounds heal rapidly by the organisation of the blood clot retained in the socket. Cancellous bone is projected into the organised clot from the bottom and sides of the wound in eight days, at the same time as epithelium has covered the surface of the socket. After forty-eight days, conversion of the organised clot into cancellous bone is complete and the new bone projects above the resorbed margins of the old socket, without any material loss of buccal or lingual plates.
- 2) Surgical extraction wounds heal more rapidly than forceps extraction wounds by the organisation of a relatively small and limited clot of blood. The speed of the organisation of the soft tissues is particularly striking. New bone appears, approximately eight days, on the margins of the old bone, nowhere else. Apparently this new bone does not rise from the mucoperiosteal flap.

In 1936, support to the observations of Euler⁷⁵ was given by Claflin,⁴⁵ who investigated normal and artificially infected extraction wounds, also using dogs. The results from this investigation, were essentially similar to those noted by him from human autopsy material, except for the time factor. Wound healing in the dog proceeds at a rate approximately 2-3 times faster than in man, with which observation Ooi²⁰² has subsequently agreed.

STAGES IN THE HEALING OF FORCEPS EXTRACTION WOUNDS.

In many respects, the healing of an extraction wound resembles that of a bone fracture. The danger of infection, however, is clearly greater as all extraction wounds communicate with the oral cavity, (Weinmann and Sicher³⁰⁸).

The stages in the healing of a tooth socket have been summarised by Weinmann and Sicher³⁰⁸ as follows:-

- 1) Formation of a blood clot filling the socket.
- 2) Organisation of the blood clot by proliferating young connective tissue.
- 3) Gradual replacement of the young connective tissue by coarse fibrillar bone.
- 4) Reconstruction of this region of the alveolar process by resorptive activity on the one side and replacement of the immature bone by mature bone on the other.
- 5) As in a clear compound fracture, epithelialisation and healing of the surface wound occurs simultaneously with the other reparative processes.

1) FORMATION OF A BLOOD CLOT.

The formation of a healthy blood clot in the extraction wound, as in any other type of wound, is of prime importance, (Weinmann and Sicher,³⁰⁸ Mangos,¹⁵⁷ Christopher,⁴⁴ Gwinm and Grimm,¹⁰¹ and Garehime,⁸⁶ Kronfeld¹³⁶).

Blood clotting is necessary to prevent excessive bleeding as well as to close and protect the wound. Apart from the mechanism involved by the blood in clot formation, safeguards in the circulatory system exist whereby bleeding is reduced by constriction of the local blood vessels, capillaries and arterioles, (Needham¹⁸⁹).

The blood clot fills the entire tooth socket and consists of red and white blood cells, in the same ratio as the circulating blood, in a meshwork of precipitated fibrin threads, (Kronfeld¹³⁶ Amler, Johnson and Salmon⁶).

2) ORGANISATION OF THE BLOOD CLOT BY PROLIFERATING YOUNG CONNECTIVE TISSUE.

a) GRANULATION TISSUE.

The granulation tissue is characterised by red cells, heightened influx of white cells, cells of the reticuloendothelial system and cords of endothelial cells associated with the elaboration of capillaries, (Amler et al.,⁶ Christopher,⁴⁴ Swinburn²⁷⁶).

Swinburn²⁷⁶ observed that the infiltration of the blood clot by the inflammatory cells occurred in an irregular wave sequence, leaving behind an open fibrin network almost completely devoid of cells.

Foreign organisms and inorganic matter in the wound are removed by ingestion or "phagacytosis" by the neutrophil polymorph leucocytes.

Apart from cells damaged by wounding, others may die later from oxygen starvation or from poisoning by foreign matter (living or dead), and their removal therefore, may be an extensive process. They are partly liquidated by autolysis, that is by their own proteolytic enzymes which become active in the absence of a normal inhibitor in the blood, and partly removed by phagocytosis, not by the blood neutrophils which are too small, but by the larger "macrophages" of the tissue, (Needham¹⁸⁹).

In studying the fate of the blood clot in experimental fractures, Harris and Ham¹⁰⁶ have found that so far as the formation of the external callus is concerned, it appears to be of no importance. "It is not invaded by granulation tissue in the early stages of healing and it appears to be more of an obstacle than anything else to the growth and fusion of the collars of osteogenic tissue that bring about union."

This observation on the role of the blood clot is in effect similar to its ultimate fate during extraction wound healing. The fact that granulation tissue arises firstly at the periphery of the socket, invades the centrally positioned blood clot and finally replaces it completely, (Amler et al.⁶), supports the idea of the blood clot being an "obstacle."

b) YOUNG CONNECTIVE TISSUE.

The young connective tissue is characterised by the appearance of spindle-shaped cells, collagen fibres, disappearance of granulation tissue and increased vascularity, (Amler et al.⁶).

The increased vascularity is caused by a sprouting of new blood vessels, however, the mechanism responsible is not known, (Howes¹¹⁶).

The appearance of spindle-shaped cells, fibroplasia, accounts for the healing of most subsurface areas after wounding. The process originates from a "fill" of mononuclear cells or from undifferentiated connective tissue cells, not from differentiated connective tissue structure, (Howes¹¹⁶). Whereas the mature fibroblast of the healing wound resembles that of connective tissue, the young fibroblast of the healing wound appears to have no counterpart in normal connective tissue, (Hairstone¹⁰²).

The elaboration of fibres, first reticulin, then collagen fibres, is accompanied by a reduction in the number of cells per unit of area, (Howes¹¹⁶).

3) GRADUAL REPLACEMENT OF THE YOUNG CONNECTIVE TISSUE BY COARSE FIBRILLAR BONE.

The invasion of the socket contents by osseous elements proceeds from the peripheral alveolar walls where the connective tissue is more mature, and where osteogenic fibres and osteoblasts are being elaborated, (Amler et al.⁶).

Mangos¹⁵⁷ noted that the "new bone is formed surprisingly evenly all round the wall of the socket from crest to fundus. This would suggest that the socket receives an evenly distributed blood-supply to all parts and that, in general, the healing process takes place evenly throughout the socket."

However, other authors consider that the greatest osteoid formation is evident at the base of the socket with newly regenerated spicules being directly attached to old bone, (Amler et al.⁶, Huebsch et al.¹¹⁸ and Raddem²²³). Progressive confluence of the spicules and trabeculae occurs, with gradual replacement of the connective tissue

elements, (Amler et al.⁶).

Some resorption of the extreme tip of the alveolar crests is often seen and the lacunae in these areas are usually empty-presumably through death of the bone from trauma during tooth extraction, (Simpson²⁵⁸). This observation has been described by Mangos¹⁵⁷ as "merely a rounding off of the sharp processes."

4.) RECONSTRUCTION OF THE ALVEOLAR PROCESS.

Maturation of the bone in the tooth socket proceeds with the progressive elaboration of osteoid matrix until complete filling has resulted. The superficial trabeculae combine to form an irregular surface between the alveolar crests, and in this region, bundles of connective tissue fibres are grouped together to form what will be the new periosteum, (Radden²²³).

As has previously been considered, the mechanism by which the deposition of new bone occurs in the tooth socket, is the same as the mechanism for bone formation in any other part of the body. Therefore, it is not proposed that it should be rementioned here.

Of particular note, however, and which must be remembered when considering the bone forming stage in the healing of the forceps extraction wound, is that the main source of the osteogenic elements is from the cancellous areas of the existing bone, (Radden²²³).

EPITHELIALISATION.

Epithelialisation is a process whereby epithelial cells grow over the surface of the extraction wound until completely fused, and so effecting surface closure, (Amler et al.⁶).

Howes^{115, 116} emphasises that the process of epithelialisation

TABLE II.

STAGES IN THE HEALING PROCESS, FORCEPS EXTRACTION WOUNDS, RELATED TO THE TIME FACTOR, (MEASURED IN DAYS).

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AUTHOR	MATERIAL	BLOOD CLOT	ORGANISATION		OSTEOID	MATURE BONE		EPITHELIALISATION	
			GRANULATION TISSUE	YOUNG CONNECTIVE TISSUE		INITIALLY OBSERVED	COMPLETED	INITIALLY OBSERVED	COMPLETED
EULER (1923)	DOGS	✓		2 - 3	8	14	28	2 - 3	8
SCHRAM (1929)	DOGS				8	14	48		8
CLAFLIN (1936)	DOGS	1		3	5 - 7		28 - 31	3	7 - 9
MANGOS (1941)	MAN (SYSTEMIC DISEASE) 7 BIOPSY 2 NECROPSY	✓		3	10	21	105		14
CHRISTOPHER (1942)	MAN					14	56 - 63		
HUEBSCH ET AL. (1952)	RATS (LONG EVANS STRAIN)	✓	1	3	5	13	25		
SWINBURN (1952)	MAN - 21 SPECIMENS	✓	3	5	14			2	
VERSNEL (1953)	DOGS - 4 SPECIMENS		4			11		4	
SIMPSON (1958)	MACACUS RHEBUS MONKEYS	✓		3	7		56	3	
OOI (1958)	DOGS		4		8		80	2	15
LINN (1959)	SYRIAN HAMSTERS	✓		1	4	7	13 - 16		
RADDEN (1959)	MACACUS RHEBUS MONKEYS	1		3	6 - 7	10 - 15	63	3	16
AMLER et AL. (1959)	MAN (CLINICALLY HEALTHY) 75 SPECIMENS	✓	2 - 3	4	7	18	100 →		24

and the formation of granulation tissue are two very different processes. Regenerating epithelium springs from pre-existing epithelium, whereas the formation of granulation tissue is concerned initially with the sprouting of new blood vessels and then fibroplasia - the process which accounts for the healing of most subsurface areas after wounding.

SURGICAL EXTRACTION WOUNDS - REFLECTION OF MUCOPERIOSTEAL FLAPS.

HEALING PROCESS.

Reflection of a flap of mucoperiosteum is necessary for all cases of tooth extraction involving some removal of bone. Usually such flaps heal well, provided they are repositioned correctly, although parts of their free margins sometimes become necrotic (Simpson^{258, 259}).

In reflecting a flap once an incision has been made down to bone, the periosteum strips away fairly readily as a thin avascular fibrous sheath, revealing, clinically at least, little continuity with the internal structure of the bone, (Radden²²³). Histologically small pieces of bone are avulsed with the flap and remain attached to it in some areas, (Simpson²⁵⁹).

Svoboda,²⁷² on edentulous jaws, carried out operations simulating alveolectomy on two patients, and subsequently obtained biopsy specimens at intervals ranging from 2-53 days. Conditions of operation were standardised, as much as possible, as regards degree and time of operation. As a result of these investigations, Svoboda²⁷² observed that:-

Few hours - A blood clot is firmly established, however, the

entrance of saliva into the wound interferes with clot formation and may cause delay in healing of the periosteal wound.

Six days - Organisation of the blood clot has proceeded rapidly with fibroblastic invasion. Remnants of the fibrin network are present with large numbers of red blood corpuscles lying freely in the tissues.

Thirteen days - Bone resorption is evident on all surfaces, with some small areas of regenerating bone also occurring.

Fifteen days - Increase in degree of new bone formation which shows progressive transformation of the alveolar process.

This transformation persists for some time and may continue throughout the life of the individual.

In examining the healing processes in thirty-seven macacus rhesus monkeys where a muco-periosteal flap was raised with tooth extraction, Simpson²⁵⁹ showed the stages of healing in more detail:-

Three days - The space between the flap and bone is quite narrow and filled with fibrinous exudate. A moderate degree of inflammatory infiltration permeated the flap and in some cases, fibroblasts and capillaries are seen growing out of the foramina towards the flap.

Seven days - Connective tissue fills the space between flap and bone and shows complete continuity with both the flap and the connective tissue in the foramina of the alveolar bone.

However, areas of bone resorption may be seen with empty surface lacunae.

Two weeks - The bone surface is being affected by both resorptive and repair activities. Connective tissue fibres are seen gain-



Fig. 16. 3 day specimen showing fibrinous exudate between flap and bone. Organisation of the exudate is starting near the foramen of the alveolar bone. Small bone fragments attached to the flap.
X100.



Fig. 17. 1 week specimen showing continuity of connective tissue in foramen with the organising exudate. There is probably no vital connection between organising tissue and bone at this stage.
X100.



Fig. 18. 2 week specimen showing attachment of connective tissue fibres to new bone deposited on areas of earlier resorption. X600.

After Simpson.²⁵⁹

ing attachment to new bone forming on previously resorbed areas. This bone activity continued until the end of the experiment at eight weeks.

Simpson²⁵⁹ concluded, as a result of these investigations, that there is some superficial resorption of the underlying bone when a mucoperiosteal flap is raised, although resorption of the external alveolar plate is a normal sequel to tooth extraction in the macacus rhesus monkey.

ELEVATION OF A MUCOPERIOSTEAL FLAP BEYOND THE MUCOGINGIVAL JUNCTION.

It has been observed that where the mucoperiosteal flap is reflected more than approximately 5mms. beyond the gingival line in the anterior region and 1.5mms. in the posterior region, scar tissue forms, (Matson,¹⁶⁵ Swenson²⁷⁵).

As previously defined, the mucosa above the mucogingival junction is non-hornified, vascular and with a submucosa which binds the mucosa movably to the periosteum.

The problems associated with adaptation of a denture border to scar tissue formed in this area, can be readily appreciated, (Swenson²⁷⁵).

ROLE OF THE PERIOSTEUM.

From the foregoing individual observations that some resorptive activity resulted on the bone surface exposed by elevation of a mucoperiosteal flap, it is of interest to consider the role of the periosteum, if any, in the healing process.

Under normal conditions in adult life, the periosteum does not contain osteogenic elements, however, when some stimulus, such as

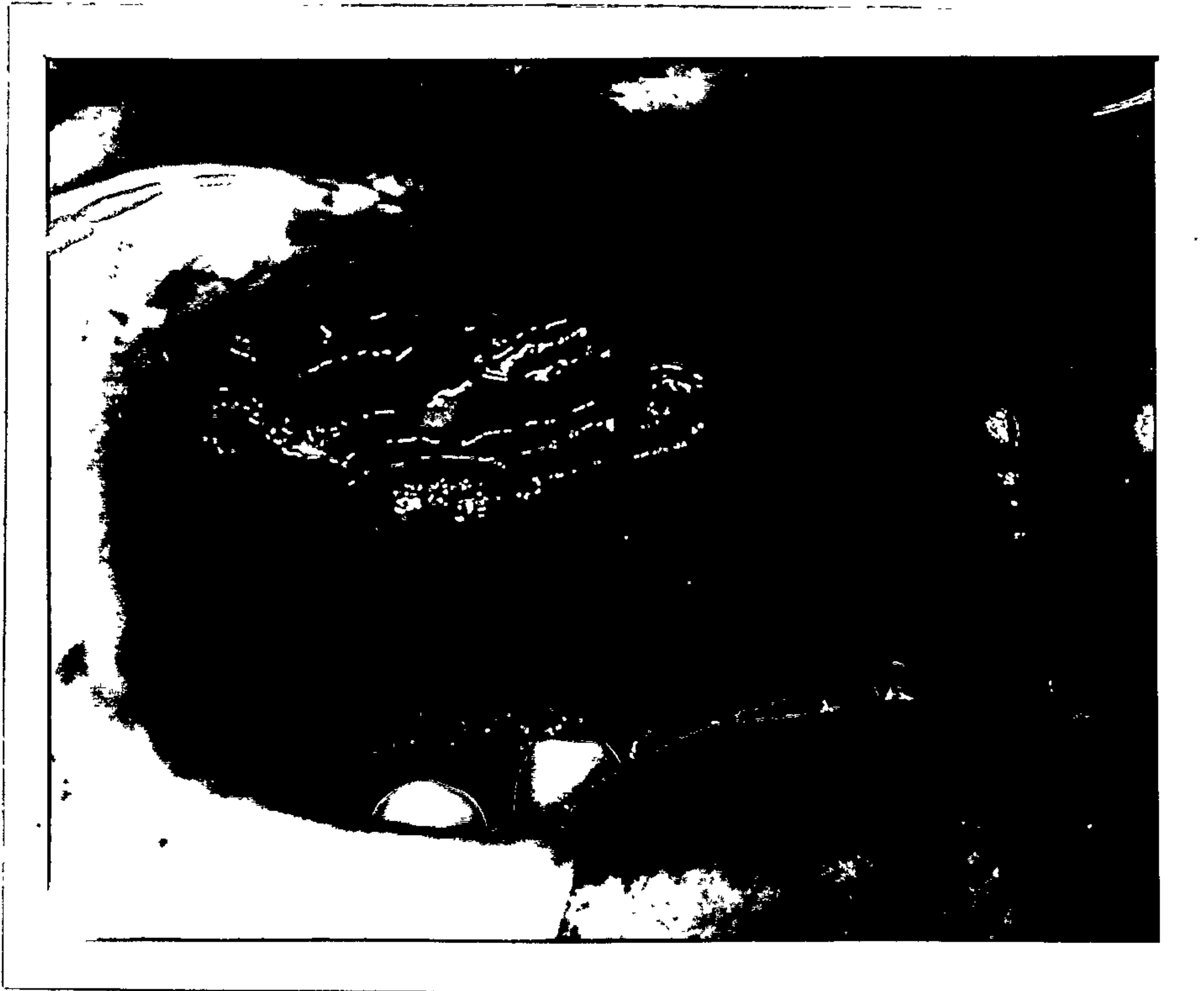
CASE B.W.

Fig. 19. Removal of hypertrophied tissue, produced through denture trauma, has resulted in scar tissue formation. Subsequent problems in adaptation of a denture periphery over such an area are appreciable.

injury, occurs, then osteoblasts appear and new bone is laid down, (Radden²²³).

Pollock and Ghormley,²¹⁸ in studies of the fractures of long bones in rats, are in agreement with McLean and Urist¹⁸⁷ as to the importance of the periosteum in bone healing. By the second day following fracture, the periosteum, from the site of fracture to the neck of the humerus,, is thickened and on the following day, shows deposition of osteoid subperiosteally.

Linghorne and O'Connell^{146, 147} artificially created periodontal pockets about the canine teeth in dogs by surgical incision and removal of a section of bone and perio-dontal membrane approximately 7 x 6mms. From sections subsequently made, at intervals from five days to one year, they observed that:-

- 1) Slight regeneration of the alveolar bone occurs at the cut surfaces with considerable soft tissue reattachment.
- 2) The origin of the osteogenic cells, whether from the connective tissue of the gingiva or the bony margins of the wound is not proved. However a characteristic thickening of the inner layer of the periosteum near the cut edge of the alveolar process indicates proliferation of these cells following the operation, with differentiation into osteoblasts a likely possibility. New trabeculae appear to originate from the same area.
- 3) Where grafts of bone or tooth structure are inserted in the surgical pocket, the calcified material appears to be responsible for the differentiation of osteoblasts.

The suggestion is made that it is the resorbing calcified

material that provides the stimulus to differentiation of osteoblasts, not the cellular content of the graft.

Dedolph and Clark⁵⁹, after a preliminary raising and replacing of mucoperiosteal flaps, removed thirteen block sections, which included the teeth and surrounding tissues, at varying time intervals from six patients. From histological examination they concluded that at the end of three weeks:-

- 1) The epithelial attachment was complete, the attachment of periodontal membrane fibres and other connective tissue elements was restored and the inflammatory response was mild or absent.
- 2) No evidence of bone resorption could be seen with reattachment of the periosteum.

SUMMARY.

The results of these investigations, therefore, may be summarised as follows:-

- 1) Some slight superficial resorption occurs on the external cortical plate of bone as a result of elevation of mucoperiosteal flaps.
- 2) The periosteum, as a result of mild stimulation, appears to have an osteogenic function. However, in each instance of bone regeneration it is noted that the areas, on which new bone forms, are:-
 - a) Where the periosteum has been replaced directly on cortical bone.
 - b) The cut edges of cortical bone where teeth are still present.

- 3) Elevation of the mucoperiosteal flap beyond the mucogingival margin, results in the formation of scar tissue.

RELATION OF THE SEPARATE ELEMENTS IN WOUND HEALING - FORCEPS AND SURGICAL TOOTH EXTRACTION.

The sequence of events during the healing of forceps and surgical extraction wounds has been discussed, and consideration will now be made to the significance of the individual structural elements in the immediate area of tooth sockets by the various methods of tooth removal.

PERIODONTAL MEMBRANE.

FORCEPS EXTRACTION.

During forceps extraction, where considerable force and manipulation are required, much of the periodontal membrane is removed with the tooth. The portion remaining behind is so damaged as to be unable to contribute, in any way, to the regenerative process, (Radden²²³).

Mangos¹⁵⁷ and Ooi²⁰² observed that the bundles of fibres of the torn residual periodontal membrane, undergo degeneration which appears to be a hyaline one. At a later stage, approximately two weeks, there is no evidence of the periodontal membrane as such, and it appears to have merged or been absorbed by newly formed granulation tissue, (Mangos¹⁵⁷).

Survival of the periodontal membrane most often occurs in the apical region, less frequently towards the crests of the bony alveolus, and comparatively rarely in the middle third of the socket. Where it does survive, recovery is greatly retarded with delay in

the proliferation of the connective tissue elements, (Radden²²³).

SURGICAL EXTRACTION.

Radden²²³ is of the opinion that, in conservative surgical extraction where the teeth are removed with a minimum of trauma, the remaining periodontal membrane does take an early and active part in the regenerative process.

EPITHELIAL SHEATH OF HERTWIG.

FORCEPS EXTRACTION.

Mangos¹⁵⁷ and Radden²²³ agree that the epithelial remnants of the Sheath of Hertwig are contained in the periodontal membrane and likewise undergo degeneration. There was no evidence of their presence as such, in the healing socket or of proliferative activity.

SURGICAL EXTRACTION.

Radden²²³ noted that in the case of surgical removals where much of the periodontal membrane remained in good condition, epithelial cell rests could be seen. However, signs of proliferation did not accompany the presence of these epithelial inclusions.

EPITHELIAL TISSUES. MECHANISM BY WHICH EPITHELIALISATION IS EFFECTED.

General Considerations.

The mechanism by which the epithelium extends to cover the wound site is purposeful, and most active, as evidenced by the time at which the epithelialisation process commences and the rapidity with which it is completed.

Amler et al.⁶ observed that, at the fourth day, epithelium

began to proliferate along the periphery of the tooth socket, even before the underlying granulation tissue had been replaced by connective tissue.

Radden²²³ considered that the basal cells of the stratified squamous epithelium proliferate, in the third day, across the surface of the exposed connective tissues immediately beneath the surface mat of polymorphonuclear leucocytes.

Mangos¹⁵⁷ showed that a complete layer of epithelium covered the wound site at fourteen days in subjects with severe systemic disease. However, Amler et al.⁶ believe that complete epithelial regeneration cannot occur in less than twenty-four days and may take thirty-five days in healthy individuals.

HEALING PROCESS.

McHugh and Persson¹⁷⁷ used fluorescence microscopy to investigate the healing gingival epithelium, after experimental gingivectomy in dogs. As a result of this investigation, the healing epithelium has been described in four stages:-

Stage 1 is seen during the first two or three days after operation, when cells from the deeper layers of the epithelial edge of the lesion slide out into the blood clot.

Stage 2 commences about four days after operation. Proliferation of the deeper layers of the epithelium some little distance from the edge of the lesion commences, and rapidly forms a large "peg" process which extends down into connective tissue. Serial sections have shown that similar processes are produced all round the periphery of the wound. The "peg" formation acts as a "factory," producing large numbers of



Fig. 20A. Epithelial activity showing "peg" formation some little distance from the edge of the lesion at seven days.
Magnification X50.

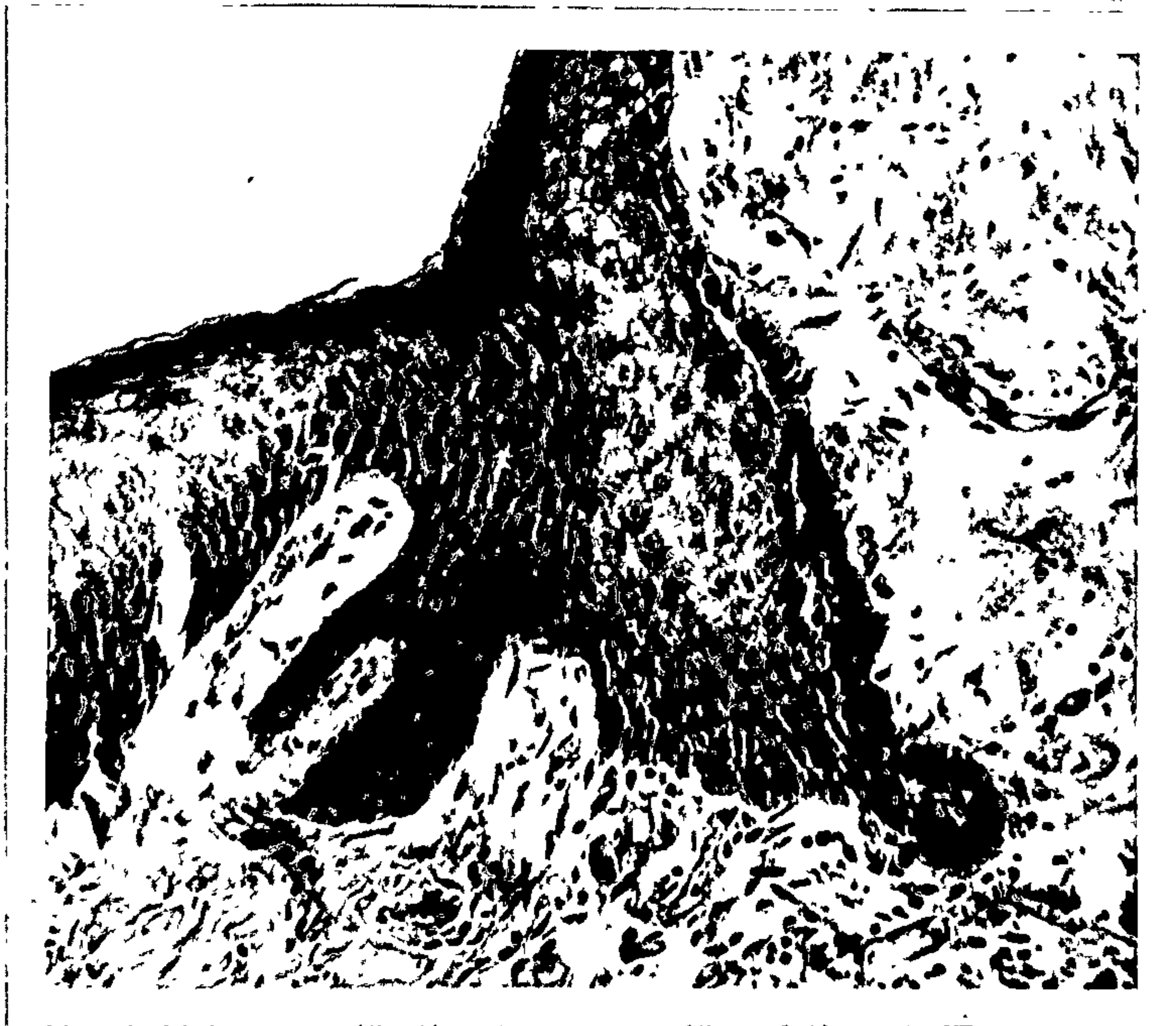


Fig. 20B. A higher magnification X120 of the "peg" seen in Fig. 20A.

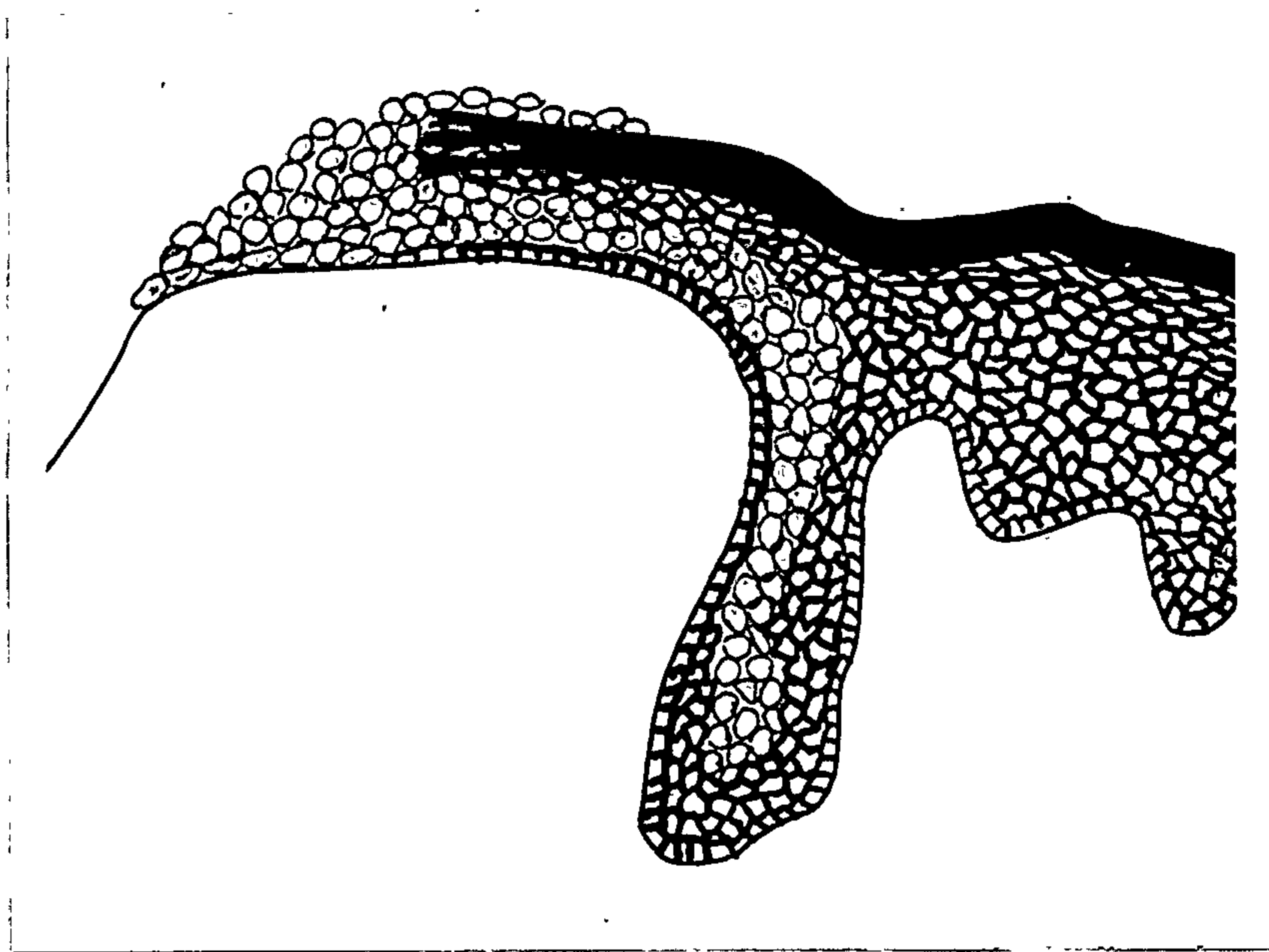


Fig. 21. A diagrammatic representation of the epithelium at the healing edge of the lesion, showing young cells passing out of the "peg" to the surface.

After McHugh and Persson.¹⁷⁷

young epithelial cells which stream out from the "pegs" to the healing edge. Here they "bubble up" to the surface, some pass back over the old epithelium, but most slide over the granulating surface to cover the lesion with layers of epithelial cells.

Stage 3 is seen after nine days when fine epithelial processes are produced by proliferation of the deeper layers of the new epithelium. These processes extend down into the superficial layers of granulation tissue.

Stage 4 is sometimes observed in the epithelium adjacent to the tooth. Extensive thick down growths of epithelium, often with degeneration of the cells in the centre, are seen.

Although the investigations of McHugh and Persson¹⁷⁷ involved the surgical procedure of gingivectomy, the results for the healing gingival epithelium are similar to those observed by other authors for tooth removal.

Smith,²⁶⁶ when he surgically removed maxillary first molars in rats, showed:-

24 Hours - Proliferative epithelial activity at the fundus of the crevicular remnant and in rete pegs adjacent to the wound. The epithelium is proliferating towards the areas of inflammatory exudate.

3 Days - Complete epithelial extension by rete pegs to unite with the crevicular epithelium in the area of dense inflammatory exudate.

STIMULUS TO EPITHELIAL GROWTH.

Smith²⁶⁶ suggests that the epithelial response is proportional to the concentration of the inflammatory infiltration. The possibility

of a substance, named an epitheliotaxin, should be considered as providing the necessary stimulus to epithelial growth, although such a substance has not been determined.

Swinburn²⁷⁶ believes that fibrin provides the tactile irritation, as well as serving as the substratum, to epithelial proliferation.

Howes^{115, 116} concedes the nuclear division of the epithelial cells in the basement layer and suggests that the newly formed cells wander out over the wound by amoeboid motion and then re-stratify to complete the architecture of newly formed epithelium.

ALKALINE PHOSPHATASE.

Amler et al.,⁶ on human forceps extraction wounds, showed a high concentration of alkaline phosphatase beneath the epithelium of a thirty-nine day specimen.

The presence of alkaline phosphatase and its activity was investigated during the growth of oral epithelium in rats by Ring,^{226, 227} who presumed that the enzyme served a similar function in man. He demonstrated that the activity of the enzyme was high in the vicinity of the healing cut gingival surface, with prominence in the fibroblasts and fibres. Ring²²⁷ suggested that the activity of alkaline phosphatase is associated principally with the sub-epithelial tissues in the healing socket and secondarily with the keratinisation of the regenerated epithelium.

GLYCOGEN AND GLYCOPROTEINS.

It must be remembered that wound healing in the mouth takes place in a wet environment, whereas the epithelium of the skin ideally requires a dry environment for its elaboration.

Mucoproteins, which are contained in mucin, are known to increase after injury and provide resistance to bacterial invasion and certain enzymes such as alpha Amylase, the enzyme found in the saliva, and trypsin. Howes^{115, 116} suggests, therefore, that the presence of mucoproteins may play a large part in the resistance picture to bacteria along with the enzyme systems in oral wound healing.

The presence of glycogen and glycoprotein in the regenerating epithelium has been observed by Amler et al.,⁶ in human extraction wounds.

Turesky and Glickman^{288, 289} in examination of the healing gingiva in rats, following gingivectomy, supported the observation that the normal sparse content of glycogen in epithelium was increased in areas of hyperplasia associated with inflammation.

EFFECT OF pH.

Baldrige¹⁴ in a study of cutaneous wounds inflicted on guinea pigs, showed that the rate of healing was hastened by the administration of the antihistamine, pyrrobutamine pre- and post-operatively.

The pH of the wounds in the treated animals showed a definite trend towards alkalinity with pH range 6.8-8.1 as against normal pH range 5.8-7.2. The alkaline medium seems to allow more rapid digestion of dead tissue cells by the leucocytic enzymes. This heterolysis of dead tissue allows the amoeboid activity of the epithelial cells to proceed more rapidly.

However, Taubman²⁷⁹ is unable to agree with the observations of Baldrige¹⁴ with respect to an alkaline medium facilitating wound healing. He considers that the initial reaction of the healing socket is slightly acid with a progression towards alkalinity as

healing progresses.

Needham¹⁹⁰ has satisfactorily explained these apparently diverse observations of Baldrige¹⁴ and Taubman.²⁷⁹ Increased local acidity in the demolition phase of wound healing is reflected in all aspects of metabolism. As an example, it is seen that acid phosphatase is active in demolition, but alkaline phosphatase in the repair period.

FACTORS INFLUENCING THE TIME FOR COMPLETE EPITHELIALISATION.

DIAMETER OF THE TOOTH SOCKET.

With forceps extraction wounds, the presence of a circular band of fibrous tissue, ligamentum circulare, surrounding the neck of each tooth is responsible for the infolding of the mucous membrane over the surface of the wound, (Mangos,¹⁵⁷ Lisowski,¹⁴⁹ Simpson,²⁵⁸ Kronfeld¹³⁶).

On the extraction of the tooth, owing to the strong tissue tension, contraction takes place of these fibrous bands of tissue, affording protection to the newly formed blood clot, (Mangos¹⁵⁷).

LACERATION OF THE GINGIVA.

FORCEPS EXTRACTION - It is readily appreciated that the removal of teeth by forceps extraction results in some tearing and stripping of the attached gingiva, (Amler et al.,⁶ Radden²²³).

Mangos¹⁵⁷ noted that conservation of the mucous membrane around the socket was necessary to protect the blood clot and accelerate healing.

Amler et al.,⁶ observed repeatedly that ragged edges of epithelium are inclined to slough, and evidenced by hydropic cells and disintegration of the intercellular bridges. They suggest that reflection of the gingiva before simple extraction is indicated, in order

to avoid laceration or trauma to the tissues.

Morgenstern¹⁷³ concedes that, other factors being equal (health, age etc), healing proceeds in direct ratio to the amount of trauma which has been inflicted.

SURGICAL EXTRACTION - When a clean incision is made in the epithelium, Amler et al.⁶ observed that a minimum of tissue sloughing resulted.

Radden²²³ considered that the healing process of surgical extractions, where freshened epithelial surfaces were placed and held in apposition, presented an entirely different picture from other extraction methods. The epithelial fusion proceeded more rapidly, although not necessarily in a normal arrangement.

HEIGHT OF THE ALVEOLAR CREST.

The height of the bony alveolar crest is adjusted, at the time of tooth removal, according to the prominence of the inter-septal bone and the particular surgical procedure adopted, alveolotomy etc. The healing of the epithelium will, therefore, proceed, as has been mentioned, according to the degree of trauma experienced.

FOREIGN BODIES.

The presence of foreign bodies, such as bone and root fragments calcareous deposits, is usually found around the alveolar crests and over the mouth of the tooth socket in both forceps and surgical extraction sites.

Delay in healing as a result of retention of these foreign bodies has been observed by Simpson,^{258, 259} Linn,¹⁴⁸ Smith²⁶⁶ and Swinburn.²⁷⁶ Glickman et al.⁹⁵ and Simpson²⁵⁸ have shown that a process of

enucleation of the foreign body by epithelial engulfment occurs, until finally an unbroken epithelial surface results.

The basilar surface of the epithelium always approximates healthy granulation tissue, (Smith²⁶⁶).

Smith²⁶⁶ concluded that there is a relationship between retained bone and root fragments, inflammatory exudate and an epithelial response. The degree of epithelial response is proportional to the concentration of inflammatory infiltration.

PERIODONTAL CONDITION.

It is generally agreed that regressive changes in the periodontal tissues, results in delay in healing following tooth extraction, (Murray,¹⁷⁵ Taubman,²⁷⁹ Bourgoyne²⁶). The degree of involvement of the periodontal disease will determine, to a very great extent, the delay in healing which may be anticipated.

For example, with chronic periodontitis, the resultant alveolar ridges have already become diminished in shape and size, (Murray¹⁷⁵). The condition of gingivitis, however, with increased vascularity, may have little or no influence on the rate of healing (Kohler and Ramfjord¹³³); rather, may the "flushing effect of the haemorrhage" stimulate healing by more rapidly providing the tissue-building elements, (Johnson¹²³).

LOCAL INFECTION.

Disturbed healing of a tooth extraction socket is clinically known as a "dry socket." As suggested by the name, the socket after two-three days is empty of blood clot and contains food debris. The blood clot has disintegrated and the walls of the socket are exposed,

The condition is accompanied by pain and the surrounding gingiva is inflamed. Healing proceeds from the fundus of the socket towards the surface and shows considerable delay in relation to the normal healing process by organisation of the blood clot.

The immediate cause for the condition is the invasion of the socket by pathogenic micro-organisms with predisposing factors of trauma during extraction and mechanical removal of the blood clot by mouth rinsing or other manipulations, (Kronfeld,¹³⁶ Weinmann and Sicher³⁰⁸).

FIBROPLASIA.

In the first of a series of papers, in which he proposes to treat individually the cell types that comprise the healing wound, Hairstone¹⁰² made a morphological study of the fibroblast in a twenty-four day post-extraction fibroplasia from a human alveolar socket using light microscopy and low power electronmicroscopy.

The fibroblast derives its name from the belief that it produces intercellular fibres. However, the mechanism of fibrogenesis is uncertain, that is whether fibres are formed:-

- 1) intracellularly or upon the cell surface and extruded into the intercellular substance, OR
- 2) from elements present in the intercellular substance in response to fibrocytic or other enzymes.

Hairstone¹⁰² concluded from his studies that:-

- 1) The young fibroblast in the healing wound differs morphologically from the newly divided cell in normal connective tissue.

This may be explained by the fact that the fibroblast of connective tissue is reproduced mitotically, whereas the wound fibroblast is generated from an undifferentiated cell.

- 2) Similarities could be noticed between the young fibroblasts and certain endothelial cells of associated capillaries. In view of the primitive nature of the young fibroblasts morphologically, the possibility exists that monocytes may develop into fibroblasts, endothelial cells and histiocytes, either directly or with intermediate phases.
- 3) Extensive tubules within the cytoplasm of young fibroblasts formed sponge-like networks. Such cellular networks are believed to hasten wound filling through expansion from within as cells surrounding the wound promote closure from without.
- 4) A specific relationship between collagen fibres and fibroblasts could not be observed, however, conclusions could not be made without further specific investigation.

OSSIFICATION.

The mechanism, by which bone tissue of the body is formed and resorbed, has been considered in detail previously. In relation to the healing tooth socket wound, the separate elements, associated with these processes of bone formation and resorption, have not received undue attention. Mention will now be made where specific applications have been examined.

FORCEPS EXTRACTION WOUNDS - BONE FORMATION.

The formation of new bone by direct attachment to the old bone spicules, without preliminary resorption of the old bone has been

observed by Hubbell and Austin¹¹⁷ in dogs, Christopher⁴⁴ and Amler et al.⁶ in human extraction wounds.

By the seventh day, the presence of osteoid, principally at the base of the socket, is evident in an extremely high metachromatic ground substance bounded by osteoblasts laden with large amounts of alkaline phosphatase in the cytoplasm, (Amler et al.⁶).

At fourteen days in human extraction wounds, Swinburn²⁷⁶ observed that a noticeable concentration of osteoblasts occurred along what seemed to be the direction of future trabeculae. The masses of osteoblasts were separated by bundles of large collagen fibres and because of the coarse fibrillar structure and very cellular nature of the new bone, it was impossible to determine accurately the junction of new bone and pre-osseous tissue.

As mineralisation takes place, trabeculae are formed gradually, filling at least two-thirds of the socket fundus by the thirty-eighth day, (Amler et al.⁶).

ALKALINE PHOSPHATASE.

The presence of alkaline phosphatase has been associated with the development of collagen fibres in studies of bone formation by Loe.¹⁵³

Ring,^{226, 227} from examination of the growth of oral epithelium in rats, suggests that this enzyme is involved in:-

- 1) The growth and function of the outgrowing capillaries.
- 2) The activity of fibroblasts in connection with development of connective tissue fibres.
- 3) The activity of macrophages in performing their scavenger function.

Amler et al.,⁶ in studying the healing process in man observed that:-

- 1) Alkaline phosphatase activity was absent from the clot formation. However, the presence of this enzyme could be demonstrated within two - three days with the appearance of granulation tissue in the socket.
- 2) The intensity of alkaline phosphatase activity showed progressive increase at the periphery of the socket with the appearance of firstly young connective tissue, and then osteoid matrix.
- 3) As the bone matrix becomes more highly organised, little or no alkaline phosphatase could be observed, except towards the surface of the healing socket, where the bone regeneration occurs last.

As has been mentioned, phosphatase is undoubtedly present in all calcifying areas, and is thought to provide the means for liberation of free phosphate ions (Neuman and Neuman¹⁹⁶).

GLYCOPROTEIN.

The presence of glycoprotein follows a similar pattern as alkaline phosphatase. With the development of osteoid at the seventh day, an integral part of this complex is glycoprotein associated with the development of osteogenic fibres, (Amler et al.⁶).

However, with development of the bony frame-work, Amler et al.⁶ considered that the mature portion of the bone spicule shows a greater concentration of glycoprotein component than the peripheral, osteoid portion.

From awareness of the chemical composition of the ground substance of mature bone tissue, the presence of glycoprotein can thus be readily explained, (Eastoe⁷⁴).

BONE RESORPTION.

The presence of osteoclasts, between six and seven days, on the

crests of the interdental septa has been noted by Radden²²³ using monkeys. However, this resorptive process is anticipated when using the macacus rhesus monkey for experimentation, (Simpson²⁵⁹).

Swinburn²⁷⁶ in human wounds, was of the opinion that osteoclastic activity was obviously confined to the buccal aspect near the alveolar crest and to some of the canals.

Mangos¹⁵⁷ showed the presence of osteoclastic activity at ten days in human material subject to systemic disease. He considered that two mechanisms result in bone absorption namely:-

- 1) Vascular absorption occurring as a result of an active hyperaemia induced by the trauma of the extraction.
- 2) Osteoclastic absorption which is slow, and does not satisfactorily explain the fairly rapid disintegration of the lamina dura; but which is readily explained by the theory of vascular absorption.

However, Swinburn²⁷⁶ observed at fourteen days, that although osteoclastic activity was most pronounced, no correlation could be made to the number and size of blood vessels or the degree of inflammatory cell infiltration.

SURGICAL EXTRACTION WOUNDS - ALVEOLOTOMY AND ALVEOLECTOMY.

With surgical tooth extraction, as in alveolotomy and alveolectomy, involving stripping of the periosteum and removal of cortical bone, it is apparent that there is lessened surface area of cancellous bone available for regenerative processes. Some slowing down of the bony replacement, therefore, seems inevitable and is, in fact, the observed result. Return to normal bony architecture, with the building of cortical plate, is delayed, (Radden²²³).

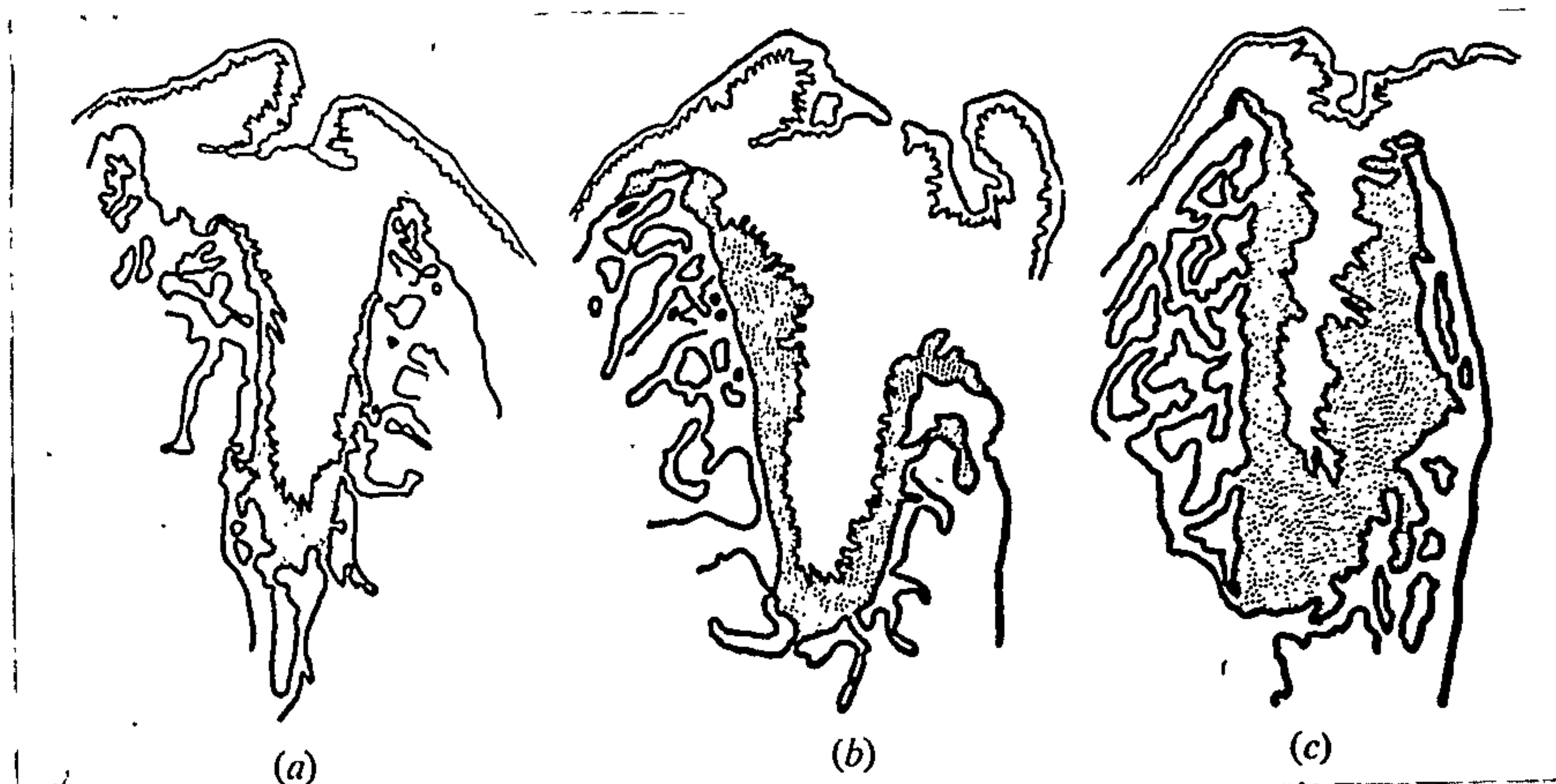


Fig. 22. Comparison of the bone regeneration at thirteen days in the macacus rhesus monkey following:-

- a) forceps extraction
- b) removal of cortical bone plate
- c) intra-septal alveolotomy.

After Radden. ²²³

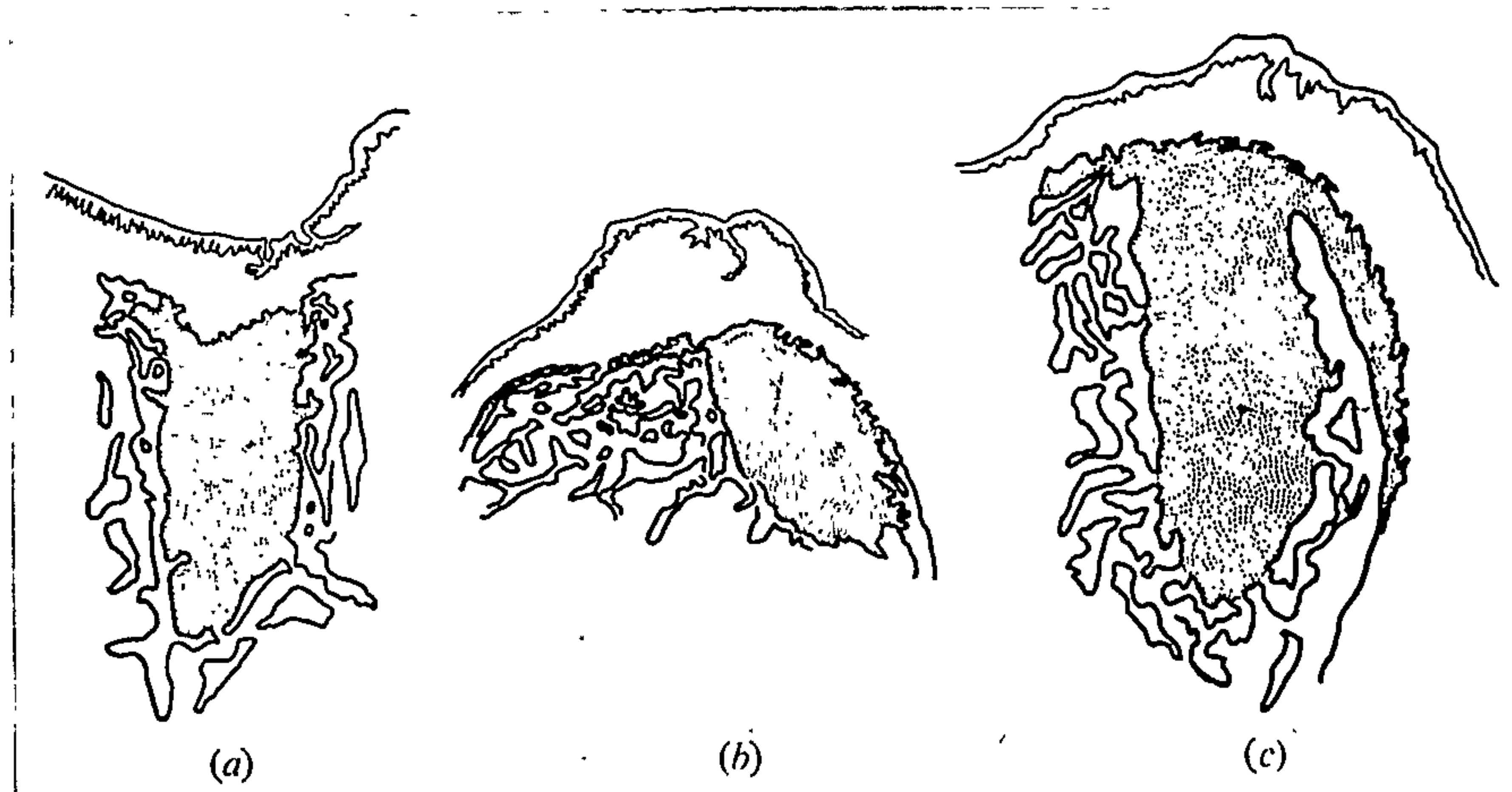


Fig. 23. Comparison of the bone regeneration at forty-seven days in the macacus rhesus monkey following:

- a) forceps extraction
- b) removal of cortical bone plate
- c) intra-septal alveolotomy.

After Radden.²²³

INTRA-SEPTAL ALVEOLOTOMY.

With an intra-septal alveolotomy technique, in which collapse of the cortical plate is effected without violation of the periosteal attachment, the blood clot in the socket is minimal, and reconstruction commences early, since there is no loss of inner cancellous bony surface, (Radden²²³ and Hayward and Thompson¹⁰⁸).

Radden²²³ also suggests that the alveolar bone crest, which becomes more readily infected when the periosteum is reflected, apparently receives sufficient stimulus from the operation as to provide proliferation of the bone-forming elements.

EFFECT OF INSTRUMENTATION ON BONE DURING SURGICAL PROCEDURES.BONE FRAGMENTS.

The mechanism, by which bone fragments lying near the surface of the wound are engulfed by proliferating epithelium and evulsed, has been discussed. However, the possibility of infection of these fragments has been considered by Simpson,²⁵⁸ who showed a severe inflammatory response with delayed healing, and likely abscess formation.

Fragments of bone lying more deeply in the wound, either in the tooth socket or between the mucoperiosteal flap and cortical plate, are usually well tolerated, (Simpson²⁵⁹). It has been observed that healthy bone fragments may often act as centres of ossification in the regeneration process.

The fate of necrotic bone spicules, other than enucleation, is presumably resorption by osteoclastic activity, (Simpson,²⁵⁸ Radden²²³).

Urist and McLean,²⁹⁰ in studies of the fractures of bones in rats, have demonstrated that particles of bone, including bone salts, have been observed in foreign body giant cells and in macrophages during the resorption of necrotic bone. Fragments of dead cortical bone have been



Fig. 24. 3 day specimen showing concentration of inflammatory cells near bone fragments at site of surgery. The irregularity of bone surface is produced by chiselling.
X100.



Fig. 25. 3 week specimen showing bone fragments in the new connective tissue between flap and bone acting as centres of ossification.
X100.

noted to undergo decalcification in advance of the disintegration of the bone matrix. This differs from the process of resorption of living bone, in which the bone mineral and organic matrix are removed simultaneously.

BONE FRAGMENTS WITH ATTACHED PERIOSTEUM.

The typical example of a large bone fragment remaining attached with the periosteum, is in cases of intra-septal alveolotomy where there is a relatively minor disturbance to environment and vascular supply. A major contribution to the healing process is effected by providing from the inner surfaces of the bone fragment, new bony trabeculae which rapidly fill the reduced socket space resulting from this operation, (Radden²²³).

In other cases, provided infection is absent, pieces of bone with attached periosteum are readily accepted by the connective tissue elements and utilised as a base for the deposition of new bone, as well as providing some of the cells necessary for this growth.

METHODS OF INSTRUMENTATION.

As a result of the observed influence of bone fragments in the healing process, it is appropriate to consider the methods available for removal of bone, namely:-

- 1) Chisel and hand mallet (Simpson,²⁵⁸ Walker²⁹⁹).
 - 2) Engine-driven burs at normal and high speeds, (Walker,²⁹⁹ Lesney,¹⁴³ Wood,³¹³ Mazarow¹⁶⁸).
 - 3) Engine-driven mallet and ultra-sonic device with rapidly vibrating Bard Parker blade, (Mazarow¹⁶⁸).
- Mazarow¹⁶⁸ showed that where a smooth bone surface is established, repair occurs more rapidly. The instrument of choice is the smooth

fissure bur in an air-turbine driven arrangement.

Chisels, both hand and engine-driven, appear to produce a more ragged and uneven surface, (Simpson,²⁵⁸ Mazarow¹⁶⁸), although Walker²⁹⁹ favours the use of the hand chisel, claiming that:-

1) The bone surface is not subjected to thermal trauma and remains vital.

2) Debris is of a size easily seen and removed.

Wood³¹³ and Lesney¹⁴³ agree that there is no contra-indication to the use of burs in bone surgery, provided they are sharp and the area is frequently washed with normal saline solution. Frictional trauma to the bone is thus avoided and a smooth surface obtained.

Syringing and careful cleansing of the wound in all surgical operations, will help reduce any unfavourable sequelae to the retention of bone fragments.

X-RAY DIAGNOSIS IN WOUND HEALING.

Various studies have been made to assess the value of radiographic evidence in wound healing by comparison with histological data at a certain stage in the healing process.

In dogs, Hubbell and Austin¹¹⁷ showed that the osteoid tissue did not contain sufficient inorganic material as to make radiographic diagnosis significant.

Linn¹⁴⁸ however, related ground sections of wound healing in hamsters treated with alizarin red S vital dye to the radiographic appearance.

Mangos¹⁵⁷ on human material, obtained radiographs under as uniform conditions as could be established and noted that:-

CASE P.B. Female, aged 24 years, at time of insertion of partial maxillary immediate and full mandibular dentures, 31st August, 1960.

Time of removal of maxillary teeth:-

Right 1st. and 2nd. bicuspid, 2nd and 3rd. molars,
22nd June, 1960.

Left 1st. and 2nd. bicuspid, 29th June, 1960.

Right and left centrals and laterals with alveolectomy,
31st August, 1960.

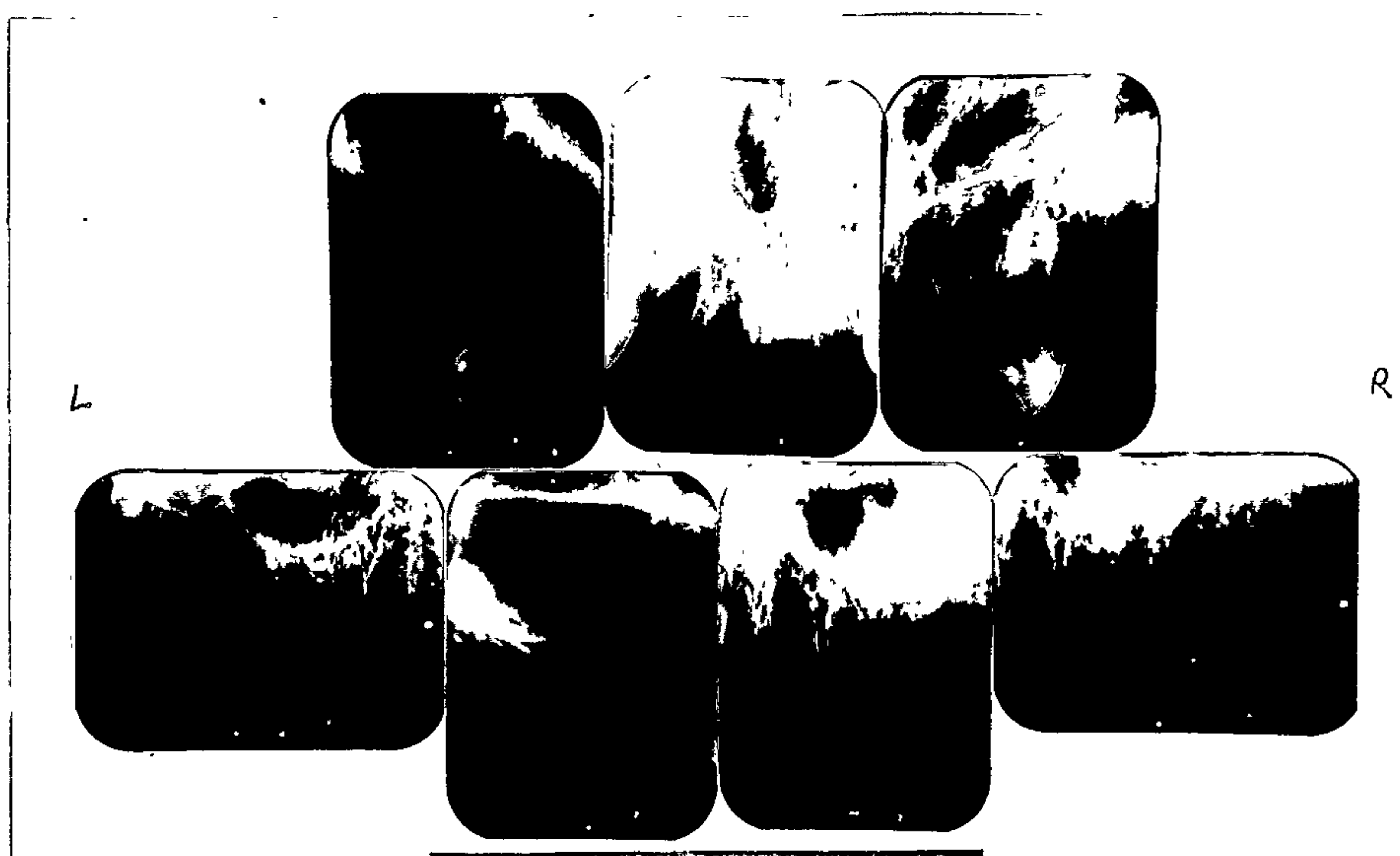


Fig. 26. Radiographs obtained 20th September, 1960, showing the various stages of the healing of the alveolar tissues.

CASE P.B.

Fig. 27. Subsequent radiographs obtained 14th December, 1960; 15 weeks following partial maxillary immediate denture insertion. The appearance of the anterior tooth sockets supports the observations made by Mangos, (157) and Amler et al. (6).

- 1) The earliest time that some change could be observed in the socket tissue is about three weeks, when the shadow of the socket contents appears a little more dense and the outline of the lamina dura slightly less well defined.
- 2) At five - six weeks, the lamina dura is quite indefinite in outline. The socket contents are more dense and some slight rounding at the alveolar crests can be seen.
- 3) At eight - ten weeks, there is practically no evidence of the lamina dura and the socket appears more narrow. The alveolar crests are rounded off, although the actual reduction in crest height appears to be slight.
- 4) At fifteen weeks, the socket appears to be filled to the crests with bone of a slightly less dense character than the surrounding bone.

Amler et al.⁶ and Ooi²⁰² found similar evidence of the radiographic appearance of the healing tooth socket with loss in definition of the lamina dura at about five - six weeks, and subsequent increasing radiopacity of the socket contents to a maximum at about fourteen - fifteen weeks.

The conclusion may thus be made that "The X-ray findings give only an approximate idea of the bone changes taking place in the socket, but confirm the histological findings, " (Mangos¹⁵⁷).

INFLUENCE OF VITAMINS A AND C, CORTISONE AND HYALURONIDASE ON WOUND HEALING.

VITAMIN A.

Hirschi¹¹¹ showed some retardation in bone regeneration in the healing of extraction wounds in Vitamin A deficient hamsters. The soft

tissue healing appeared unaffected, with normal epithelial coverage.

However, any application of these observations to man, remain unsubstantiated, (Barnicot and Datta¹⁵).

VITAMIN C.

The relation between wound healing and vitamin C receives general support, as does the fact that failure of wounds to heal normally is due primarily to failure of collagen production, (Bourne²⁷ Needham¹⁹⁰).

Turesky and Glickman,^{288, 289} in examining the healing of gingiva after gingivectomy in rats on adequate and deficient diets in vitamin C, observed in the scorbutic animals that the ground substance failed to form, only gel-like pools of procollagen could be seen.

Dunphy, Udupa and Edwards⁷³ observed, in guinea pigs on a scorbutogenic diet, that fibroplasia, mucopolysaccharide production and reticular procollagen material are not inhibited, however, collagen synthesis is impaired.

As can be seen, although vitamin C deficiency is conceded to affect collagen production, there is no certainty as to how this is done; particularly as the mechanism for the elaboration of collagen fibres is still in doubt, (Bourne²⁷ Hairstone¹⁰²).

It is suggested that the influence of vitamin C in forming connective tissues is primary, the symptoms of scurvy being secondary as a result of this function (Lloyd and Sinclair¹⁵⁰).

The administration of vitamin C, both before and after tooth extraction, has been suggested as improving the healing rate significantly in man, (Campbell and Cook³⁶).

CORTISONE.

It has been noted that the effects of cortisone on wound healing

are virtually identical with those produced by vitamin C deficiency, (Lloyd and Sinclair¹⁵⁰). The delay in healing is associated with a less firm, and therefore reduced tensile strength cicatrix, (Doolen,⁶⁹ Shafer²⁵⁰ and Schautz²³⁹).

The inter-relation of growth of granulations and epithelialisation is very pronounced, and the latter process does not take place over exuberant granulations. New epithelial cells will extend down to depressed granulations or grow downhill over them, but the process will not change direction and grow down to and then across granulations at right angles. Even when large doses of cortisone stop the growth of granulations, new granulations are still formed under the advancing edge of epithelialisation, thus suggesting a reciprocal relationship between epithelialisation and the growth of granulations, (Howes¹¹⁶). Presumably, therefore, cortisone does not inhibit epithelial growth.

However, Shafer,²⁵⁰ in examining the healing of extraction wounds in cortisone treated rats, observed that both granulation tissue formation and epithelialisation were retarded.

Lloyd and Sinclair¹⁵¹ suggest that, whereas scurvy appears to prevent true collagen formation by the fibroblast, cortisone appears to prevent the proliferation of fibroblasts.

HYALURONIDASE.

Hyaluronidase is an enzyme derived from testicular extract. The possibility that ascorbic acid may control the action of hyaluronidase, in some way, in the synthesis of collagen has not been clarified, (Lloyd and Sinclair¹⁵¹).

It is possible that hyaluronidase is concerned in the conversion

of a precursor to collagen; ascorbic acid may promote this conversion, or it may, possibly in addition, promote chondroitin sulphate synthesis for the replacement of hyaluronic acid, (Lloyd and Sinclair¹⁵¹).

Campani³⁴ examined the behaviour of acetylglucosamine and sulphur in the healing tissues of wounds, because these chemical substances are active in the formation of certain acid mucopolysaccharides such as hyaluronic acid, sulphate hyaluronic acid, chondroitin sulphuric acid and mucoitin sulphuric acid. These acids are essential components of the basic substance of connective tissue. The results showed that the peak value for acetylglucosamine was obtained on or near the sixth day after infliction of the wound, declining later to initial values. An almost opposite value trend is shown by sulphur.

Carothers,³⁹ in using hyaluronidase with local anaesthesia for tooth extraction, considered that a significant reduction resulted with respect to post-operative pain and swelling, intra-oral haematoma and the healing rate. Presumably hyaluronidase effected depolymerisation of hyaluronic acid in the connective tissue ground substance. By temporarily liquefying the natural barriers, hyaluronidase opens pathways in the tissues for freer diffusion and consequent absorption of fluids.

VARIOUS AGENTS USED IN ORALWOUND CONTROL.

A multiplicity of agents has been introduced into dental practice for use in the tooth socket following forceps or surgical extraction, principally with the aim of inducing more rapid blood clot formation, controlling infection or reducing post-operative pain and swelling. The majority of investigations has been based on clinical observation or patient reaction to the particular agent being examined, an in-

conclusive basis for discussion.

Where a systematic histological examination of the healing wound was carried out, with and without the use of the agent being tested, the results stressed the importance of the formation of a healthy blood clot to induce satisfactory healing, (Versnel,²⁹⁵ Hubbell and Austin¹¹⁷),

HAEMOSTATICS.

The group of absorbable haemostatics, cellulose, gelatin and fibrin foam, alginates, appear to have some value in promoting blood clot formation, (Silverman,²⁵⁷ Lavieri,¹⁴¹ Garehime,⁸⁶ Byrd,³³ Radden,²²² Drebes,⁷¹ Rumble²³⁷ and Sutton²⁷¹).

Silverman²⁵⁷ suggests that gelatin sponge, impregnated with thrombin and penicillin, has an immediate action in which the fibrinogen of the blood acts with the thrombin to produce the fibrin clot.

Garehime⁸⁶ is of the opinion that sodium alginate, a granular powder, applied to bleeding points, "tends to form a coagulum sealing the wound by combining with the ionised calcium of the blood and forming a layer of calcium alginate."

Radden²²² doubted whether fibrin foam has any haemostatic properties other than that of mechanical occlusion of the socket.

Versnel²⁹⁵ showed that the use of oxidised cellulose caused a delay in the rate of healing in extraction wounds in dogs and remained as a foreign body for a much longer period than had been generally supposed, before being absorbed. Swinburn²⁷⁶ regards this agent as a non-irritating foreign body.

A reduction in post-operative pain and swelling has not been

observed with the use of the haemostatic group of agents, (Garehime,⁸⁶ Byrd³³).

ANTIBIOTICS.

Penicillin, (Versnel,²⁹⁵ Gwinn and Grimm¹⁰¹), sulpha compounds, (Davis et al.,⁵⁶ Versnel,²⁹⁵ Gwinn and Grimm¹⁰¹), aureomycin, (Verbic²⁹⁴) and oxytetracycline, (Davis et al.,⁵⁶) have variously been used following tooth extraction.

Verbic²⁹⁴ suggests, from clinical observation and statistical evaluation, that soluble aureomycin tablets reduced the incidence of decomposition of the blood clot in the socket by providing a locally bactericidal effect.

However, the removal of these materials in the tooth socket may ultimately delay healing because of their presence as a foreign body.

CHLOROPHYLL OINTMENT.

In the same year, 1952, Drebes⁷¹ and Shatton and Kutscher²⁵¹ agreed that the use of chlorophyll ointment had no value in the treatment of extraction wounds, although no deleterious effects could be observed.

DRESSINGS AND PASTES.

Hubbell and Austin,¹¹⁷ in an examination of the effects of pastes (medicated and non-medicated) and gauzes (dry, lubricated, medicated and non-medicated), observed slight differences in healing which were referable to the mechanical action of the dressings in displacing the blood from the central portion of the socket during clot formation. This accounted for the formation of a smaller clot which became completely organised in slightly less time than a normal socket. However, a delay in epithelialisation, as a result of the dressings, was obvious.

Gerry and Ogden⁹⁰ advocate the use of moisture proof pressure dressings after surgical procedures to "eliminate the development of so-called dead spaces, which in turn inhibits haematoma formation and the accumulation of intercellular fluid in the surgical area."

CONCLUSIONS ON THE HEALING OF THE ALVEOLAR TISSUES FOLLOWING TOOTH EXTRACTION BY THE VARIOUS METHODS.

Radden²²³ has satisfactorily summarised the process of healing of the alveolar tissues following the removal of teeth and compared the various techniques which may be used as follows:-

- "1) So long as excessive force is not required, extraction of teeth with forceps, although leaving considerable blood clot exposed to the oral fluids, heals almost as rapidly and results in less reduction of alveolar bone and mucosal surface than with any other method of extraction.
- 2) Surgical removal of teeth with alveolectomy, involving loss of labial cortical bone, may result in early but not necessarily normal epithelialisation of the wound. It gives a relatively delayed return to normal of the bony architecture, alteration of contour and actual reduction of the alveolus and the mucosal surface.
- 3) Inter-septal alveolectomy with fracture of the buccal cortical plate without stripping of the mucoperiosteum, may also result in early but not necessarily normal epithelialisation, rapid obliteration of the reduced socket with new bone, but also gives alteration of the contour of the alveolus, not always for the better, and possibly reduction of the mucosal surface.

- 4) A surgical technique with minimal reflection of mucoperiosteal tissues, removal of sufficient alveolar bone to permit ready elevation of teeth, careful apposition of freshened epithelial edges and immobilisation of flaps, gives a healing process approaching that of first intention healing. Under such conditions the remaining periodontal membrane, previously reported to be inactive in the regenerative process, does take an early and active part. Moderate surgical damage to the periosteum of the soft tissue flap results in deposition of lamellar bone external to the cortical plate.
- 5) In all methods of tooth removal, the earliest and the major contribution to bone formation comes from the cancellous bone surrounding the socket. Both the periodontal membrane and the periosteum play a comparatively minor part in this bony reconstruction."

RELATION OF THE HEALING OF THE ALVEOLAR TISSUES TO IMMEDIATE DENTURE INSERTION.

MEASUREMENT OF TISSUE CHANGES.

Lisowski¹⁴⁹ undertook a comparative study of alveolar ridge resorption under immediate dentures where "conservative" and "radical" surgical procedures had been carried out.

Five full maxillary immediate dentures were constructed for each technique and by careful measurement of casts procured at suitable intervals, an assessment could be made of the resultant alveolar resorption. The results of this investigation by Lisowski¹⁴⁹ suggested that:-

- 1) Alveolar resorption, with consequent loss of denture

retention, is aggravated proportionally to the extent of surgery.

- 2) Extensive surgery, except in the case of unusual abnormalities, is detrimental to and contra-indicated in immediate denture prosthesis.

Lam,¹³⁹ in measuring the tissue changes coincident with immediate partial denture insertion, observed that the maximum alveolar contour change occurred within four weeks after tooth extraction. A progressive reduction in the resorptive activity resulted in a relatively stable condition at the fifth month. Emphasis on the importance of relining procedures to maintain tissue contact was noted by Lam.¹³⁹

FORMATION OF A BLOOD CLOT.

The importance of blood clot formation in wound healing has been stressed previously also mention has been made of the delay occasioned by the entrance of saliva into the wound.

The observation has been generally made that an immediate denture:-

- 1) "acts as a bandage and reduces the loss of blood,"
(Nagle and Sears¹⁸⁸).
- 2) covers the extraction sites as a protective barrier to the entrance of saliva, (Helmore¹¹⁰).
- 3) prevents trauma to the blood clot from food debris and tongue movements, (Frahm⁸²).

HISTOLOGICAL INVESTIGATIONS.

Meyer¹⁷⁰ examined histologically the healing process after forceps tooth extraction and the insertion of full immediate dentures. Essentially the healing of the tooth socket followed the same stages

as have been previously defined notably:-

Eight Hours - ruptured Sharpey's fibres and injured small blood vessels adhere to the coagulum which fills the alveolus.

The periosteum remains firm, even though some degree of hyperaemia exists.

There is a reduction in the post-operative swelling and irritation of epithelial and connective tissues adjacent to the socket periphery.

Twenty-four Hours - A grey-white layer covers the surface of the wound and is formed by polymorphonuclear leucocytes. This accumulation of cells provides a temporary and relatively compact sealing for the wound.

One Week - Epithelialisation is observed with proliferation of cells from the basal cell layers of the epithelial tissues at the gum margins.

Granulation tissue forms from the peripheral walls of the tooth socket.

Bone spicules remaining in the socket are quickly enclosed by epithelial cells and eliminated.

Three Weeks - The tooth socket is narrowed by "cicatrisation" and newly formed osseous tissue appears.

It is believed that the most comprehensive and specific study of the healing processes, which occur following immediate denture insertion, has been carried out by Hedegård.¹⁰⁹

His work covered two groups of patients requiring maxillary anterior forceps extractions, immediate dentures being inserted in one group of nine patients and the other group of six patients re-

mained without prosthetic replacement. A section was taken from the central incisor region of one side immediately following tooth extraction in both groups. A similar section was obtained three months later from the central incisor region of the other side. From these sections a histological comparison could be made of the tissue changes which occurred in the tooth socket over a period of three months in a group of patients wearing an immediate denture and a group without any prosthetic replacement.

The requirements for patients used in this study were rigidly examined for:-

- 1) Sound general health.
- 2) Presence of both maxillary central incisors without periapical bone destruction and with comparable bone height according to X-ray examination.
- 3) A removable denture of any kind never to have been worn.
- 4) Absence of severe paradontosis.

The changes observed in the two groups, after the three month period, will now be considered for the separate tissues involved.

EPITHELIAL TISSUES.

NON-DENTURE GROUP - The epithelial layer remained histologically unchanged as evidenced by the presence of the horny layer. Despite the increase of direct trauma to the buccal alveolar mucosa occurring during mastication, no tendency towards inflammatory reaction could be observed in the sub-epithelial layer (lamina propria).

IMMEDIATE DENTURE GROUP - Significant changes could be noted with disappearance of the horny layer and obvious parakeratosis of the epithelial surface.

Although clinically the changes in the mucous membrane could not be seen, severe cellular infiltration was present in the lamina propria in several cases.

Presumably both these reactions are evidence of the traumatic action of the denture base.

OSSIFICATION OF THE SOCKET.

NON-DENTURE GROUP - The trabecular network appears to be built up from the apical region in a coronal direction, as the projections mostly seem to come from the already newly formed bone apically situated in the alveolus.

The original buccal alveolar plate has been almost entirely resorbed in many cases - at least in the area from which the biopsy specimens have been obtained (height 10-14mm. in mid-part of tooth socket). It is suggested that this bone resorption results from the loss of function after tooth extraction, that is, the alveolar socket is subject to atrophy due to inactivity.

IMMEDIATE DENTURE GROUP - A completely different impression is presented in this group. The buccal wall is not only observable in all of the specimens, but the resorptive activity is, in most cases, limited to the alveolar crest with slight extension towards the buccal surface.

From the inner surface of the tooth socket, trabeculae project, giving the definite impression of intense appositional growth as if in answer to external mechanical forces.

CONCLUSIONS ON THE HEALING OF THE ALVEOLAR TISSUES FOLLOWING IMMEDIATE DENTURE INSERTION.

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The conclusions of Hedegård, as to the healing of the alveolar tissues following forceps extraction and the insertion of full maxillary immediate dentures, are, therefore, presented as supportive

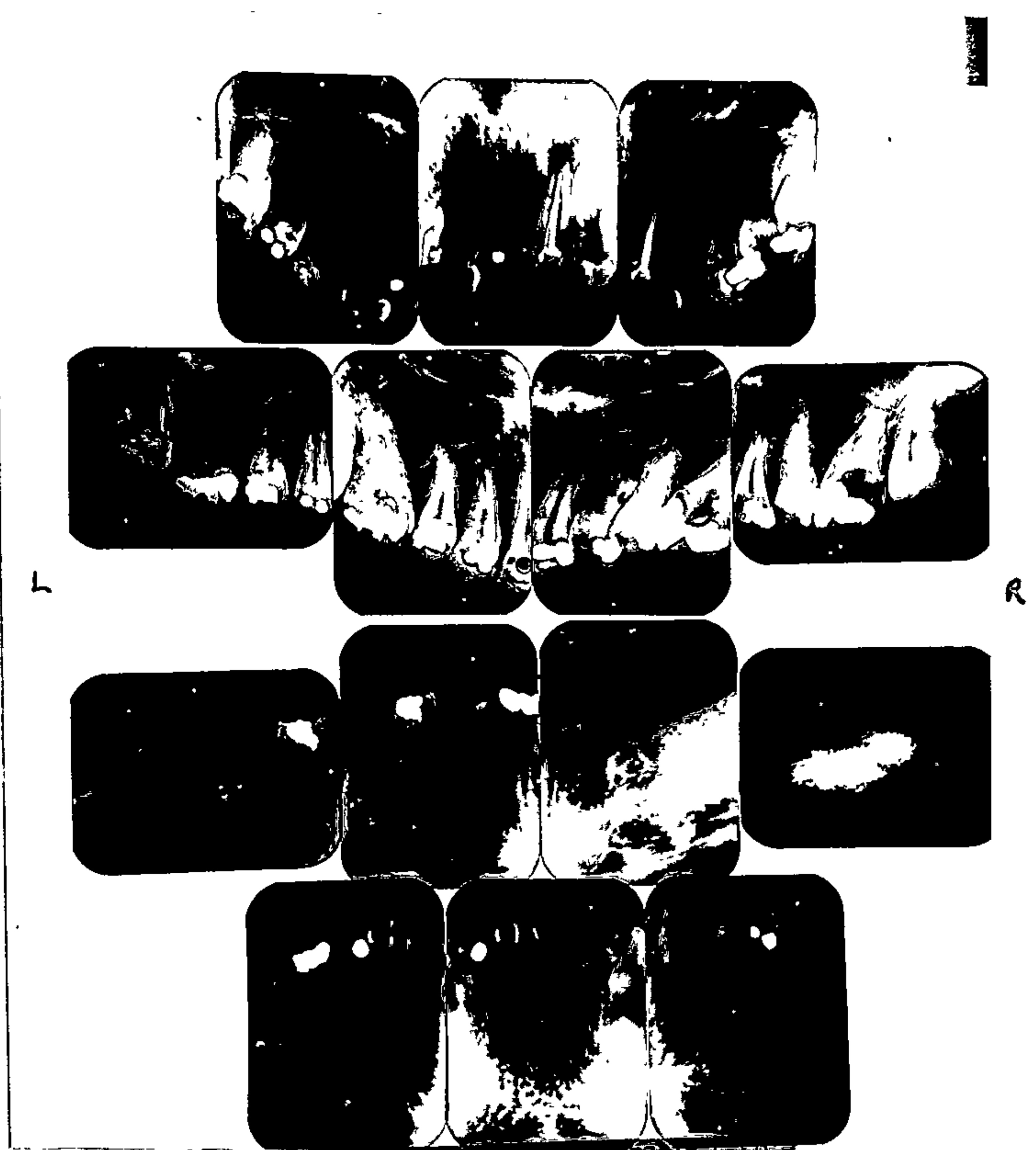
CASE P.P.UNIVERSITY
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Fig. 28. The condition of the remaining teeth shows gross carious lesions. The radiographic appearance of the supporting bone suggests a satisfactory trabecular arrangement and bone density. A periapical lesion is present at the upper right central. Full maxillary and mandibular immediate dentures inserted under general anaesthesia, 28th October, 1959.

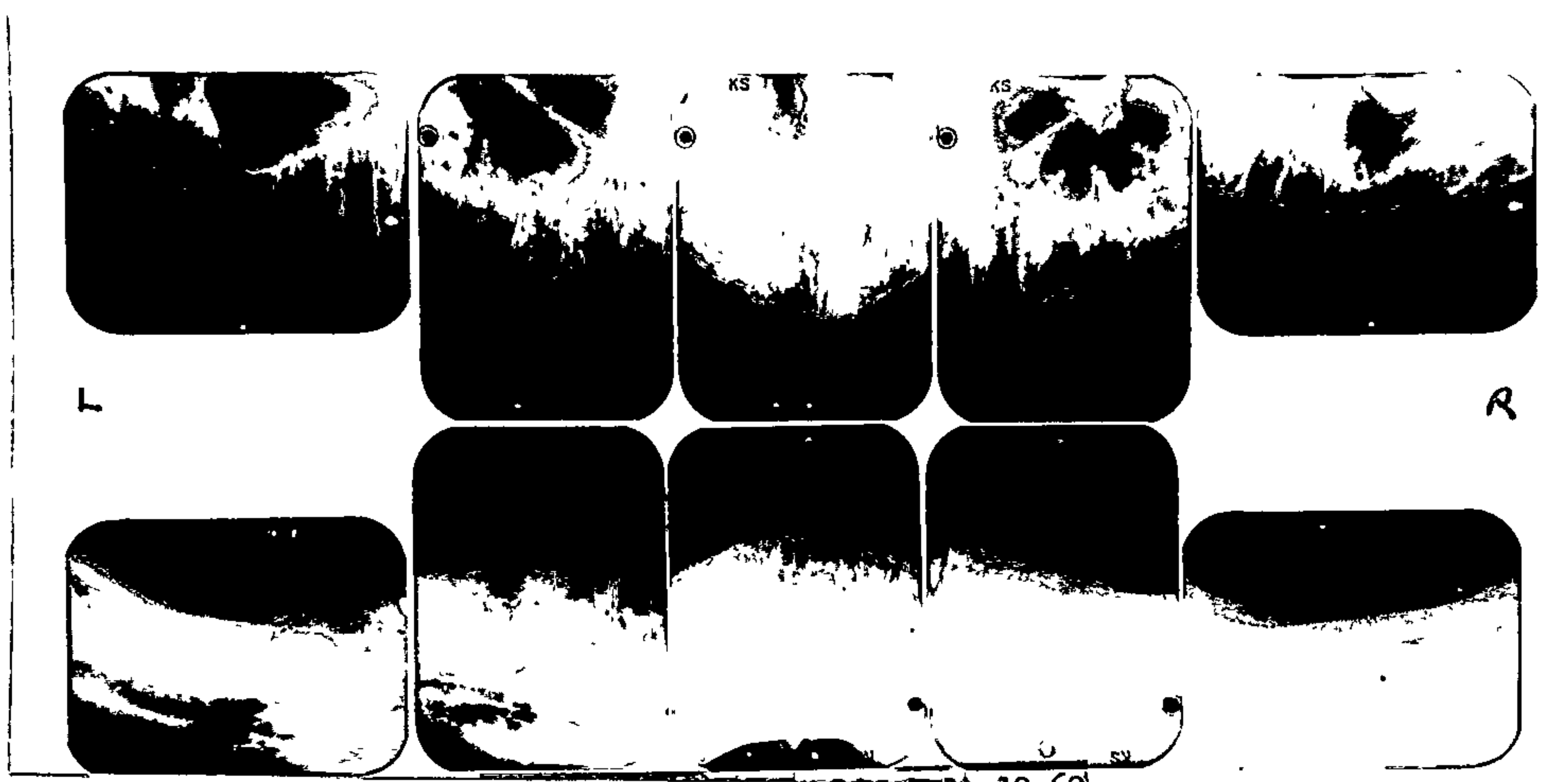
CASE P.P.

Fig. 29. Radiographic appearance 14th December, 1960, provides supportive evidence to the conclusions of Hedegård, (109).

Emphasis, during the intervening 14 months, has been placed on denture maintenance with relining procedures (-/F reline, 18/11/59; F/F reline, 7/12/59; -/F reline, 25/1/60), occlusal adjustment and the insertion of new dentures 12/8/60.

The trabecular arrangement and bone density of the alveolar process suggests a satisfactory support for denture wearing, and the clinical appearance of the mucosa is healthy.

The development of a cortical bony layer over the crest of the maxillary alveolar process and anteriorly over the mandibular alveolar process is indicated; presumably in response to the functional forces, exerted by the dentures, which are within the physiological limits of tolerance of the bone tissue and, in effect, provide a stimulatory influence.

evidence to the clinically observed advantages of this form of dental treatment.

"Thus the present material gives two different pictures of the healing of the socket after extraction. As the only great difference between the two patient groups is the immediate denture, the preserving of the buccal bone plate and the different arrangement visualised of the trabecular growth starting from its inner surface in the immediate denture group should be directly correlated with the fitting of dentures. There is furthermore, a definite impression of faster maturing of the trabecular bone in the latter group, which is not surprising considering the immediate and higher requirements on the ridge to withstand the forces introduced through the denture base."

As for the changes observed in the mucosa, "the disappearance of the horny layer and the increase in cellular infiltration, are most probably indications of traumatic action of the denture base. That a "rubbing" and "rocking" movement of the denture could be the cause of the removal of the horny layer seems obvious. It might also be expected that the injuries following small surface traumata could be more pronounced in the shallower lamina propria than in the more distant submucosa"

CHOICE OF ANAESTHESIA FOR IMMEDIATE DENTURE INSERTION.

As may be appreciated, local anaesthesia is most commonly used for tooth extraction and any surgical procedures associated with immediate denture insertion. However, there are certain disadvantages

to the use of a local anaesthetic solution, either with or without the inclusion of a vaso-constricting agent, which have been summarised by Cotter and Budill⁵² as follows:-

- 1) Possible after-effects of pain as a result of perforation of the periosteum.
- 2) Local swelling of the tissues.
- 3) Tissue damage in an area rendered ischaemic by a vaso-constrictor.
- 4) Haematoma formation.
- 5) Psychic shock induced in a patient sensitive to "needles."

As the alternative, Cotter and Budill⁵² prefer that intravenous anaesthesia with sodium pentothal should be used for immediate denture insertion, claiming that the advantages are:-

- 1) Rapid action with loss of consciousness within a few minutes.
- 2) Sense of well-being experienced by the patient.

Windecker et al.³¹¹ agree that general anaesthesia is satisfactory for immediate denture insertion, particularly where a full clearance of teeth is proposed. They are of the opinion that more rapid healing is brought about by the minimum of trauma which is caused by the patient being under general anaesthesia.

However, the procedure of hospitalisation and attendant costs, must be regarded as a disadvantage to the use of general anaesthesia for immediate denture insertion, except in specific cases.

HYDROCORTISONE ACETATE AND IMMEDIATE DENTURE INSERTION.

Karpim¹²⁶ observed the effects of hydrocortisone acetate ointment and neosporin ointment combined with 1% hydrocortisone acetate in a group of forty-one patients receiving immediate dentures. From

clinical observation, he suggested that:-

- 1) Reduction of swelling and post-operative pain resulted.
- 2) Rate of healing improved with suppression of inflammatory response.
- 3) Some delay in the blood clotting time may result.

NUTRITION IN RELATION TO ORAL SURGICAL PROCEDURES AND THE DENTURE PATIENT.

"Malnutrition may result in diseased states of the oral tissues in lack of response to accepted therapeutic measures, or in the delay or absolute failure of the processes of repair and recovery. The persistent dry socket, ... and the development of secondary infections following surgical procedures may all result from lack of nutritional elements essential to the process of repair," (Dingman⁶⁶).

The patient presenting for immediate denture insertion, may already have been existing in a tenuous equilibrium for many years through interference with normal masticating processes and emotional and physical stress. With the accompanying procedures to immediate denture insertion of multiple extractions and oral surgical procedures, nutritional deficiencies may be precipitated.

NUTRITION AND ORAL SURGICAL PROCEDURES.

As has been considered, the loss of blood associated with oral surgical procedures has been generally underestimated and may, in the case of multiple extractions and/or alveolar bone remodelling, be comparable to the blood loss sustained in general surgery. Although plasma volume replacements occur within twenty-four hours, red cell replacement requires approximately six - eight weeks, (Johnson¹²³).

The loss of other cellular elements and the requirements for tissue regeneration in wound healing, offer a challenging nutritional problem, since the intake of the patient's regular food is impaired by the surgical procedure.

NUTRITION AND THE IMMEDIATE DENTURE PATIENT.

The insertion of a denture may interfere with normal masticatory function for a variable length of time according to the degree of adjustment attained by the patient.

However, the insertion of an immediate denture, with the attendant period of tissue healing as well as denture adjustment, may so reduce the tolerance to certain types of food that important items are automatically deleted from the diet.

The importance of adequate diet and nutrition has been fully appreciated for the patient wearing dentures to ensure the maintenance of healthy soft tissues and supporting alveolar bone, (Detroit Dental Clinic Club,⁶² Smedley²⁶² and Gardner⁸⁵).

THERAPY.

Prior to oral surgery and immediate denture insertion, dietary guidance and supplementation should be instituted when necessary, (Roth,²³² Walker²⁹⁸). Delay in treatment should be made when possible, until the patient's nutritional status is satisfactory.

The simplest and most practical nutritional system to follow is the "basic seven,"^{*} Used daily as the basis of the normal diet, this system ensures an adequate amount of every essential nutrient, (Detroit Dental Clinic Club⁶²).

* See Table III.

TABLE III.

<u>"BASIC SEVEN" FOOD GROUPS</u>	<u>APPROXIMATE DAILY MEASURE</u>	<u>CHIEF NUTRIENTS SUPPLIED</u>
1. Leafy green or yellow vegetables	One or more servings	Vitamin A chiefly; also, B ₁ , C, calcium, and iron
2. Citrus fruit or juice	One-half cup juice or two whole fruits	Vitamin C
3. Potatoes, other vegetables, and fruits	Two or more servings	Calories, minerals, and vitamins
4. Milk and milk products (fluid, evaporated and dried milk, cheese, and ice-cream)	Children - 1qt. milk Pregnant women - 1 qt. milk. Other adults - 1 pt. milk	Proteins, calcium (this group is the best source), and vitamins A, B ₂ , and D
5. Meat, poultry, fish, dried peas, beans, and eggs	One or more servings; one daily preferably (at least 4 per week)	Proteins, iron, and vitamins B ₁ and B ₂
6. Bread, cereals, and flour (natural whole grain, preferably, or enriched)	Two servings	Calories, iron, vitamin B ₁ , and proteins. (These are vegetable proteins and are not so readily available as in Group 5).
7. Butter or fortified margarine	To satisfy appetite and energy needs	Calories and vitamin A

Although grain, cereal, and vegetable proteins are "incomplete," their availability is greatly increased when consumed with animal proteins. For example, milk on cereal greatly increases the availability of the protein in the cereal.

Difficulty, which may be experienced in chewing some of these foods, may be overcome by preparation in such a way that little or no chewing will be required.

Where necessary, supplementary vitamin tablets may be prescribed until the oral tissues respond within normal limits. However, it must be appreciated that vitamin supplements will not heal dental tissues

or overcome ineffective diagnosis and dental procedures, (Roth²³²).

By proper nutrition it is often possible to slow down or even prevent tissue changes under dentures which contribute to tenderness, soreness and lack of fit, (Detroit Dental Clinic Club⁶²).

CHAPTER VIII.CONTRA-INDICATIONS TO IMMEDIATE DENTURE CONSTRUCTION.PSYCHOLOGICAL - EVALUATION OF PATIENT.

Patients sometimes present where local and systemic factors apparently favour immediate denture insertion, however, such treatment does not proceed to a satisfactory conclusion.

The cause, presuming the denture complies to a satisfactory technical and clinical standard, may be traced to a psychological maladjustment of the patient, either consciously or subconsciously. This implies "that a careful evaluation of a patient's behaviour, coupled with the biophysical findings, aids considerably in the evaluation of a prognosis," (Nagle and Sears¹⁸⁸).

To aid in establishing the psychological adjustment of the patient to an immediate denture, the following factors require consideration:-

- 1) The motivation of the patient in seeking dental care - for aesthetic reasons or for the relief of pain, (Nagle and Sears¹⁸⁸).
- 2) The capacity of the patient to adjust to the stress involved during the transition from the remaining natural dentition to the artificial substitute, (Nagle and Sears¹⁸⁸).
- 3) The desire by the patient for this service (Klein¹³¹) and appreciation of the possibilities and limitations, (Hughes^{119, 120} and Smith²⁶³).
- 4) Patient acceptance of the responsibility required by extended clinical treatment with attendant inconvenience and additional time factor, (Nagle and Sears¹⁸⁸).

INFLUENCING FACTORS - AGE.

The relationship between the age of the patient and the degree of psychological adaptation is very real, (Klein¹³¹ and Smith²⁶³) but no general principle can be applied. The psychological response must be evaluated for the individual.

Inhibiting factors include fear, anxiety, tension and frustration which during dental treatment may involve a vicious psychosomatic cycle, possibly resulting in severe tissue break-down to the dissatisfaction of all involved.

SYMBOLISM OF NATURAL TEETH.

Collett and Briggs⁴⁹ mention the symbolic meaning of the natural teeth and quote two groups of patients in which:-

- 1) Acute awareness of the loss of the natural teeth resulted in the dentures serving as "bureau drawer pieces."
- 2) Conscious efforts to deny the loss of teeth prevented the servicing of the dentures, despite serious tissue damage through the wearing of an ill-fitting appliance.

DENTIST-PATIENT RELATIONSHIP.

Collett and Briggs⁴⁹ and Moulton¹⁷⁴ conceded the importance of the dentist-patient relationship. For the dentist in appreciating the occupational hazards of depression and fatigue which may reflect in his manner to the patient involving unconscious conflicts of aggression and hostility. Where similar reactions are experienced by the patient, the value of further treatment must be queried.

FINANCIAL.

Where financial circumstances are restrictive, immediate denture service should not be considered, unless a mutually agreeable arrange-

ment is made between the patient and operator, (Swenson,²⁷⁴ Garn⁸⁷).

Follow through treatment after immediate denture insertion is imperative, and the patient must realise the financial obligations during treatment planning. Failure by the patient to seek denture maintenance for financial reasons, should never occur.

RELATION BETWEEN LOCAL-SYSTEMIC DISEASE.

The approach to dental treatment has evolved from the early "tooth-centred" approach to the "patient-centred" approach.

Burket³¹ states that:-

"While the anatomic field of operation of the dentist, the oral cavity, is limited by well defined boundaries as far as other medical specialties are concerned, it has become increasingly appreciated that the procedures performed by the dentist must be considered in terms of the patient as a biologic entity the oral cavity cannot be considered apart from the rest of the body, for it is an integral and necessary part of the total patient."

It is apparent then, that any disease processes appearing in the mouth must always be considered in relation to the general health of the patient, or to medication which the patient may be receiving from the physician.

Whether the oral lesions are of primarily local origin, whether local factors appear to predominate over the systemic background, or whether the oral lesions are manifestations of systemic disease, is the responsibility of the dentist to decide when planning treatment.

Cheraskin⁴⁰ suggests that the observable pattern of disease fits into a formula which may be expressed as follows:-

Systemic substrate X Exciting factor = Observable evidence of disease.

He quotes as an example, the absence of or varying degree of alveolar bone loss which may occur between individuals with abundant and apparently even amounts of calculus formation. In one individual there may be no alveolar bone loss whereas in another, extensive bone destruction may occur.

The oral tissues are subjected to constant stress during speech and particularly mastication where frictional forces and temperature changes may be considerable. Therefore, the exciting factor of the above equation may always be considered to have some value, (Cheraskin⁴⁰).

The conclusion to be drawn is that "evidence of a systemic disease in the oral cavity is very apt to be present, even when the systemic substrate is minimally pathologic," (Cheraskin⁴⁰).

LOCAL DISEASE CONDITIONS.

TEETH AND PERIODONTIUM.

From the foregoing discussion, it may be concluded that the local factors involving disease of the remaining natural teeth and periodontal tissues - without obvious systemic influence - may be satisfactorily treated by immediate denture construction.

This does not imply that the oral tissues should not be restored to as healthy a state as the condition of the teeth will allow, before denture construction. The effect of periodontal disease on the healing process and the incidence of a post-extraction bacteraemic state have already been considered.

However, these local factors present treatment problems rather than contra-indications to the insertion of an immediate denture.

OSTEORADIONECCROSIS.

Osteoradionecrosis is mentioned here as a local factor because

of the possibility that a patient, who has previously experienced radiation therapy for malignant disease in the head and neck region, should present for normal dental treatment.

The sequelae in and around the oral cavity to irradiation of various forms, has become increasingly apparent with the advancement in the treatment of malignant disease of the oral cavity, pharynx, larynx and face by this means. Radiation destroys or impairs the vitality of the tissues, lowering the defense barriers to infection and the normal reparative processes after infection or trauma.

Topazian²⁸⁷ has summarised the effects of radiation on the tissues as follows:-

"The difference in sensitivity of various tissues to irradiation is apparent. Young cells are more sensitive than mature cells, and endothelial or epithelial cells are more easily affected than connective tissue cells. Cartilage is more sensitive than bone, whereas muscle and nerve are the most resistant tissues."

Indirect radiation can produce the lesions of osteoradionecrosis with consequent pain, disfigurement and even death, sometimes many years later - despite the apparent clinical success in the treatment of the malignant neoplasm, (del Regato⁶⁰).

In a small group of patients, del Regato⁶⁰ noted:-

- 1) The teeth showed rapid occlusal and incisal wear.
 - 2) Progressive caries - like lesions appeared at the cemento-enamel junction, sometimes producing complete tooth crown destruction or fracture from 12-18 months after treatment.
- Associated hypersensitivity of the teeth to heat, cold and sweets occurs with diminution in the quantity of saliva.

As a result of these observed changes, the desirability of extracting all teeth, both sound and certainly all infected or carious teeth, prior to irradiation has received general approval among authors, (Kanthak,¹²⁵ del Regato,⁶⁰ La Dow,¹³⁸ Cook⁵⁰ and Topazian²⁸⁷). Certainly any extraction of teeth following irradiation should be delayed for several years, and even then, approached with the utmost care, (Topazian²⁸⁷).

The wearing of a denture over an irradiated area with possible trauma is contra-indicated. Topazian²⁸⁷ has suggested that an interval of 18-24 months as being minimal.

La Dow¹³⁸ has summarised the process of osteoradionecrosis as follows:-

- 1) Intensive X-ray or radium therapy interferes with normal bone nutrition.
- 2) Trauma leads to bacterial invasion of the underlying connective tissue structures.
- 3) This infection is resistant to therapeutic measures.

SYSTEMIC DISEASES.

From the preceding considerations on bone, as a tissue and an organ, and the examination of the processes involved in the healing wound of the tooth socket, with and without surgical involvement, the influence of systemic factors, hormonal, nutritional etc. have been discussed.

Therefore, it is not proposed to reconsider these systemic influences here as contra-indicating the insertion of an immediate denture.

Certain specific conditions will be discussed because of the frequency with which they either are mentioned as contra-indications in the relevant literature or appear in patients presenting for treatment in routine dental practice.

DIABETES MELLITUS.

This is a metabolic disease, essentially of middle life, but not uncommon in juveniles. It exhibits a hereditary predisposition, the susceptibility being a mendelian recessive characteristic, (Burket^{30b}).

Diabetes is concerned primarily with disturbed carbohydrate metabolism, however, the utilisation of both fats and proteins is also affected, (Burket^{30b}).

The influence of the pancreas suggests an endocrine function, acting through the islets of Langerhans, concerned with carbohydrate and fat metabolism, (Resch²²⁵). With the secretion of insulin by the beta cells, the glycogen storage in the liver and muscles is regulated along with its mobilisation and combustion for use as an energy agent. It is deficiency in the production of insulin which results in diabetes mellitus, (Resch²²⁵).

GENERAL SYMPTOMS.

The classic symptoms of the disease may not be recognised by the patient without specific questioning. These include, (Burket^{30b}):-

1. Loss of weight accompanied by an increased appetite and intake of food.
2. Increased thirst.
3. Passage of large amounts of urine.
4. General weakness.

ORAL LESIONS.

Oral manifestations of the disease may be the first clinical symptoms, but definite diagnosis requires laboratory investigation.

Among the early symptoms to be found in the oral cavity are:-

- 1) The gingiva appear a deep red colour, (Burket^{30b}), thickened and of increased crevicular depth, (Ziskin, Siegel and Loughlin³¹⁶).
- 2) Some degree of periodontal involvement with loss of alveolar bone, (Niles,¹⁹⁸ Resch,²²⁵ Stahl, Wisan and Miller²⁶⁷).
- 3) Changes in the bony structure with generalised osteoporosis, (Resch²²⁵).

Person²¹⁷ and Swenson²⁷³ report cases of advanced alveolar resorption in young adults with diabetes mellitus.

The suggested mechanism involved has been summarised as follows, (Person²¹⁷):-

- 1) The protein matrix of bone is contributing to the nitrogen depletion.
- 2) Bone forming processes are depressed for the same reason.
- 3) Bone salt calcium is withdrawn by the acidosis caused from kidney dysfunction.
- 4) Excretion of the body fluids is stepped up to neutralise the acidosis.
- 5) Degenerative changes occur in the arteries and arterioles supplying the alveolar bone.

TREATMENT.

Any dental procedures, including immediate denture insertion, in the person with controlled diabetes is similar to that in a non-diabetic. However, this implies direct consultation with the physician

as to the patient's general physical condition to allow full pre-operative measures to be taken, (Sindoni²⁶⁰).

Complications such as acidosis or coma, delayed healing processes or localised osteitis are sequelae which can generally be reduced to a minimum under controlled conditions. It is the unfortunate person who is unaware of the diabetic state or who has uncontrolled diabetes in whom such complications arise.

Satisfactory management of the diabetic patient involves:-

- 1) Pre-medication with a suitable agent to prevent elevation in blood sugar level, (Best and Taylor²², Cheraskin, Flynn and Fess,⁴¹ Howard and Marlette¹¹⁴ and Burket,^{30b}).
- 2) Choice of Anaesthetic - Burket^{30b} prefers a local anaesthetic, without adrenaline to minimise ischaemia with possibly tissue slough and post-operative infection.

Howard and Marlette¹¹⁴ suggest general anaesthesia using pentothal sodium.

- 3) Post-operative care which includes observation of the patient for signs and symptoms of a hypoglycaemic reaction. This condition is frequently signalled by blurred vision, impairment of speech, profuse sweating, twitching of facial muscles and extremities, or even by unconsciousness (insulin coma). Administration of sugar solution is sufficient to correct the condition except where the patient is in an insulin coma, when intravenous administration of glucose is advisable, (Sindoni²⁶⁰).

TUBERCULOSIS.

Tuberculosis is a widespread infectious disease affecting human beings, animals and birds. Human or bovine strains of *Mycobacterium*

tuberculosis, an acid-fast staining organism, are responsible for the disease in man, (Burket^{30c}).

Predisposing factors are inadequate nutrition, general debilitating diseases and unusual physical exercise.

Symptoms show progressive weight loss, fatigability and afternoon temperature rise, $0.5-2^{\circ}\text{F}$, with possibly a persistent cough accompanied by bloody sputum, (Burket^{30c}).

Treatment is by chemo- and antibiotic therapy with emphasis on rest and nutrition, and is measured in terms of years.

Dental treatment is directed to periodic and comprehensive attention, with the aim of establishing sound oral hygiene. Suppurative periodontal lesions, producing transient bacteraemia during chewing, and rough broken-down teeth, producing trauma, must be eliminated, (Burket^{30c}).

Tancheater and Sorrin²⁷⁸ have shown that neglect of the mouths of tuberculous patients has been notably responsible for the development of dental symptoms. However, they were unable to demonstrate in extremely debilitated advanced pulmonary tuberculosis, an increase in either the caries incidence or alveolar bone destruction.

Burket^{30c} observed that "oral tuberculous lesions are characterised by severe, unremitting and progressive pain which interferes seriously with proper nutrition."

HAEMOPHILIA.

Haemophilia is a blood dyscrasia which, although rare, may show first evidence by excessive haemorrhage following dental extractions, (Burket^{30a}). It is a sex-linked recessive hereditary disease occur-

ing only in males but transmitted by females.

The feature of the disease is that the blood fails to clot normally, producing a prolonged bleeding period. Rubin, Levine and Rosenthal²³⁶ have recognised three types of haemophilia:-

- 1) A H G, a deficiency of antihaemophilic globulin.
- 2) P T C, a deficiency of plasma thrombo-plastin component.
- 3) P T A, a deficiency of plasma thrombo-plastin antecedent.

Differentiation of the three types may only be made by laboratory diagnosis, but is essential for effective post-operative management of the patient by transfusion using whole blood or blood fractionate, (Findlay and Nicholl⁷⁷).

Any dental operation performed on a haemophiliac must be regarded as of major importance, requiring full co-operation between the dentist, physician and haematologist, (Rubin et al.,²³⁶ Nichols and Baldrige,¹⁹⁷ McIntyre et al.,¹⁷⁸ Findlay and Nicholl⁷⁷).

USE OF DENTAL SPLINTS.

Of particular interest is the use of dental splints, either fixed or removable, for control of bleeding in the haemophiliac following tooth extraction, (Fleuchaus,⁷⁹ Findlay and Nicholl,⁷⁷ McIntyre et al.,¹⁷⁸).

Findlay and Nicholl⁷⁷ showed an average reduction in bleeding time of 1.5 days in a group of 15 patients using such splints. However, the principal value appears to depend on complete stability of the appliance. Local reaction, of venous and oedematous mucosa near the affected area, is considerably greater when the appliance has some mobility, (Findlay and Nicholl⁷⁷).

Nichols and Baldrige¹⁹⁷ suggest that the minute traumata, associated

with movement of the splint, provides further sites for haemorrhage.

Therefore, despite the fact that dental splints are used following tooth extraction in the haemophilic patient, an immediate denture is contra-indicated.

DENTAL SIGNIFICANCE OF CERTAIN MEDICATIONS.

"Many of the drugs now in general use in medicine may cause body changes which will necessitate modification of dental procedures or, in some instances, may temporarily contraindicate any form of dental treatment,"(Ostrander²¹¹).

ADRENOCORTICAL STEROIDS.

Rheumatoid arthritis, allergic states, inflammatory diseases of the eye, ulcerative colitis, pulmonary fibrosis and renal and hepatic disease are, at times, treated with the adrenocortical steroids, cortisone or hydro-cortisone or with corticotropin (ACTH) which stimulates additional secretion of the adreno-cortical steroids, (Ostrander²¹¹).

Depression of the natural defense mechanism of the body, including inflammation, is a side effect of treatment by these agents. As a result, post-operative infection is more likely to occur in such a patient.

ANTICOAGULANT AGENTS.

Dicumarol is commonly used for anti-coagulant therapy during and following such conditions as pulmonary embolism, thrombophlebitis, arterial occlusion, venous thrombosis and coronary occlusion. This drug is taken orally which means the patient is able to continue normal daily occupations, (Ostrander²¹¹).

The risk of haemorrhage following any oral surgery, however, simple, is very great for such patients and appropriate local measures for control must be taken, (Ostrander²¹¹).

Schmitt, Ingram and Harpole²⁴³ have reported management of extensive haematoma formation following dental extractions in a patient receiving unreported anticoagulant therapy.

Dinon and Strang⁶⁷ suggest that the oral administration of Vitamin K₁ (Mephyton) 2.5-10mg., will effectively restore the prothrombin time to safe levels. However, some temporary allergy to the anticoagulant drug may subsequently follow.

By consultation with the patient's physician, temporary interruption of the anticoagulant therapy may be possible, but certainly close observation of the patient must be maintained for post-operative haemorrhage, (Ostrander²¹¹).

ANTIHYPERTENSIVE AGENTS.

Dental treatment of the patient receiving antihypertensive medication is one of degree, depending on the particular drug in use.

For patients receiving rauwolfia preparations, cessation of the drug on the day of surgery is usually sufficient. Observation for a hypo-tensive episode, characterised by dizziness, pallor, cold perspiration or actual syncope, is necessary with placement of the patient in a recumbent position immediately, (Dinon and Strang⁶⁷).

The more potent ganglionic (sympathetic and parasympathetic) blocking agents require that such patients should be hospitalised for oral surgical procedures, (Dinon and Strang⁶⁷).

In summary:- "The care of the dental-cardiac patient includes prophylactic measures and management techniques which are in certain

respects unique for these particular patients. With such management, most cardiac patients can be generally considered satisfactory risks for necessary dental operative procedures." (Dinon and Strang⁶⁷).

"IN ADDITION TO THE ADVANTAGE IN ACCELERATING THE HEALING PROCESS, IMMEDIATE DENTURES REDUCE HAEMORRHAGES BY AIDING THE COAGULATION AND BY STIMULATING A QUICKER DEPOSITION OF NEW OSSEOUS TISSUE TO FILL THE ALVEOLUS, BY HELPING MARGINAL TISSUES TO MOULD INTO THE DESIRABLE RETENTIVE FORM, AND BY AIDING THE PATIENT IN BECOMING ACCUSTOMED TO WEARING DENTURES."

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