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Histological Evaluation of Cast Crown Contours in Experimental Animals

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HISTOLOGICAL EVALUATION OF CAST CROWN CONTOURS IN EXPERIMENTAL ANIMALS

by

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DEDICATION

To my lovable and understanding wife, Joan, who continues to inspire me to pursue personal goals and whose vibrant and cheerful personality makes me aware of how beautiful life can be, I dedicate this paper.

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VITA

The author, Joseph L. Caruso, D.D.S., was born in Chicago, Illinois. He attended primary and secondary schools on the northwest side of Chicago. In 1961 he graduated from DePaul University in Chicago with a bachelor of arts degree in philosophy. He was elected to the Blue Key National Honor Fraternity in 1960.

In 1961 he entered Northwestern University Dental School and received his Doctor of Dental Surgery Degree from Northwestern in June, 1965.

He served as a Captain in the United States Army Dental Corp in Munich, Germany until 1968.

In 1973 he held an appointment as Clinical Instructor in Fixed Prosthetics at Loyola University Dental School. He entered graduate school at Loyola in 1974 and received a Certificate of Speciality in Fixed Prosthetics in 1976.

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INTRODUCTION AND STATEMENT OF THE PROBLEM

INTRODUCTORY REMARKS

The purpose of this study was to determine the effects of buccal and lingual contours of complete cast restorations on the supporting periodontal structures when the marginal termination of the restorations were supragingival or at the crest of the gingiva. The current dental literature is replete with effects of varied axial designs of cast restorations on supportive tissues (Perel, 1971; Morris, 1962).

Empirical data from clinical observations has led to categorical statements that have been opposed to each other. Tylman, 1960, believed, "The margin of crown previously placed beneath the crest of the gum tissue twenty to twenty-five years ago maintains the same healthy relationship today." Löe, 1962, stated, "That any known type of dental restoration extending into the subgingival area causes damage to the periodontal tissue either by providing possibilities for bacterial retention and or by direct irritational effect of the material per se..." This situation has thoroughly disconcerted clinicians.

The current attitude of dentistry is to have, when indicated, margins above or at the level of the gingival crest. (Glickman, 1972; Tylman, 1978).

There currently is sparse experimental evidence on crown contours of restorations. The last decade has refined preventive methods which have enabled the dentist to restore

and preserve the dentition from additional caries and periodontal disease. Preventive dentistry has had its greatest impact in the profession during the last decade. (Formation of the American Society for Preventive Dentistry, 1968). These advancements have made the dentist acutely aware of the biomechanical design of restorations. Proper home care on the part of the patient can be made easier when areas proximating artificial crowns are more accessible for the patient during programmed oral hygiene procedures.

This study will evaluate histologically and measure crevicular fluid volume from the gingiva of over and undercontoured cast restorations using Rhesus monkeys as experimental animals.

STATEMENT OF THE PROBLEM

It was the intent of this study to determine the effects of varied axial crown contours on the gingivae. Gingival responses were evaluated histologically and by monitoring inflammation levels through crevicular fluid volume.

Sixteen teeth to receive cast gold crowns were prepared on two adult female Rhesus monkeys. Eight crowns were overcontoured and eight crowns were undercontoured. Eight teeth in each animal were used as controls. Margins were terminated at the level of the gingival crest. Each animal had four overcontoured and four undercontoured crowns on contralateral positions of both arches. Each type of crown was compared to their controls on the opposite side of the same arch.

The collected data on the gingival index, plaque index, crevicular fluid volume and the inflammatory cell response was statistically evaluated by analysis of variance.

CHAPTER II

REVIEW OF THE LITERATURE

A. Historical Perspective

Orban and Mueller (1929) reviewed the literature on the clinical significance of the gingival crevice and the epithelial attachment. They indicated knowledge of the epithelial attachment was of great concern and practical importance to the clinical practitioners. The article noted the epithelium was attached to the surface of the tooth not only at the cemento-enamel junction but also involved a considerable surface of the tooth. The depth of the gingival crevice was not believed to be solely at the cemento-enamel junction. They also stated the gingival crevice is not self-cleansing. Orban and Mueller refuted G. V. Black's statement concerning "extension for prevention." They felt extention into the gingival crevice was detrimental to the periodontal structures. "The proper prophylaxis should not be to place the gingival margins of fillings and crowns under the free margins of the gum as a preventive measure, but rather to establish through mouth hygiene and maintain shallow crevices." They stated it was not possible to reflect the gingiva back far enough to keep the restoration permanently under the gum; therefore, the operator should not begin to terminate the restoration at that point. The authors concluded there was insufficient evidence for extending crowns beneath the free margin of the soft tissue. A better gingival design for restorations can be achieved with supragingival margins.

G. V. Black (1899) introduced the principle of extension for prevention. Since the cast gold inlay and crown came approximately twenty years after Black's publication on extension for prevention, he was mainly concerned with proximal surfaces, occlusal surfaces and the buccal surface of Class V Restorations. He felt since the surface extension of decay does not involve the enamel under the margin gingiva, that gingival margins of proximal cavities should be placed in these immune areas. "Therefore, in the preparation of cavities in the proximal surfaces of the teeth, the gingival margin should be placed under the margin of the healthy gum. This, in part, is the concept for 'extension for prevention'."

Coolidge (1931) reviewed the position of the epithelium attachment at various ages and concluded the attachment migrated apically during the aging process. He also stated most normal appearing gingiva also had histologic evidence of inflammation. Coolidge felt faulty dentistry would add to the breakdown of the epithelium attachment and resulted in varying degrees of periodontal involvement. This was especially true when these restorations were in close proximity to the gingiva.

Wheeler's (1931) article dealt with the placement of gingival margins in full crowns. He noted the gingival margin was the most arduous and the most critical portion of crown preparation. He noted that once the original contour of a tooth was lost during preparation, the operator had difficulty in replacing this contour. He believed it was

best to leave 1 mm. width of enamel above the normal attachment in order to prevent injury to the supporting structures during preparation. Wheeler would rather have margins above the gingiva than jeopardize the tooth by endangering the supporting tissues. He also stressed the importance of smoothness of the restorations at the gingiva in order to reduce injury to the supporting structures. He was of the opinion most crown failures are due to insufficient knowledge of contours. "If we over build, the gum margin will be protected too much. Stimulation during mastication will be lacking and food material will collect and cause irritation from harbored food material and bacteria. Under-contouring results in the gum tissue being driven back and recession of the periodontal membrane."

Blackwell (1940) made an attempt to defend G.V. Black's concept of extension for prevention. He reviewed the current concept of the epithelial attachment and the supporters of abandoning Black's concept of extension for prevention. He noted, with reasonable precautions, margins could be placed subgingivally in order to protect the patient from recurrent caries without permanently injuring the epithelial attachment. He also found one of the major problems of dentistry is the prevention and control of dental caries. However, he concluded the majority of cases failed because the margins were not placed under the gingivae.

Coolidge (1946) discussed mechanical irritants as causative factors in gingivitis. Three groups were cited as

factors: (1.) food impaction, (2.) impingement from imperfect contour of teeth caused by carious defects and imperfectly finished restorations with rough edges around gingival margin, (3.) traumatic injury. In his opinion, care must be taken to remove all overhangs and to finish the crown or inlay satisfactorily before cementation. He concluded gingivitis caused by mechanical irritants is one of the most frequent inflammatory diseases occuring in the oral tissue. To prevent this, original tooth form must be reestablished during fabrication of the restoration.

B. Classic Literature

Ramfjord's (1952) article discussed local factors in periodontal disease. He stated periodontal disease involved a combination of mechanical and biological problems. He recognized faulty dentistry caused periodontal disease. His studies showed food impaction resulting from improper crown contour can cause inflammation by plaque retention. He sited Orbans' (1947) article which noted local factors caused eighty to ninety per cent of the cases of periodontal disease.

Waerhaug (1953) studied the reaction of the gingiva to artificial crowns situated below the gingival margin. Two dogs were used in the experiment and a total of seventeen crowns which were made of ordinary thermo-curing acrylic resin were cemented on prepared teeth. The observation period varied between twenty-eight and sixty-four days. He observed the epithelium was joined closely to the acrylic crowns in a similar manner as the epithelial attachment around a natural tooth. He believed the acrylic itself does not cause any significant irritation. Under imperfectly adopted crowns where there was space between the crown and tooth, necrotic tissue was observed which caused irritation of the epithelium and connective tissue. Cement was also considered to be a strong irritant. In addition, he viewed ten well fitting porcelain jacket crowns and five gold crowns during human autopsy. He concluded there was no difference between tissue reaction to artificial crowns in dog and man. He felt tissue did not react differently to porcelain, gold and

acrylic resin. He stated a well adopted artificial crown need not cause an irritation when the cervical margin of the crown does not come closer than .5 mm. to the bottom of the pocket. According to Waerhaug, a perfect fitting necessitates thorough removal of all living and necrotic tissue between the tooth and crown before cementation.

Hagerman and Arnim (1955) discussed the relation of recent research on the gingiva to clinical practice of crown and bridge. They reviewed Waerhaug's investigation concerning the histologic concept of the gingival pocket. They concluded Waerhaug's findings did not coincide with the concept of the gingival pocket described by Gottlieb. This finding was of paramount importance theoretically and practically in order to distinguish between the physiologic and pathologic condition of the gingiva. Waerhaug's conclusion was no firm organic union exists between the free gingiva and tooth surface. Waerhaug said it was possible for the gingiva to defend itself against injury. For example, a temporary ingress of bacteria surrounding a matrix band. Hagerman and Arnim noted Zander inserted cellulose acetate strips .1 mm thick between the free gingiva and enamel surface. Zander's work supported Waerhaug. The appearance of the junction between epithelium and acetate film was identical to an epithelium enamel junction. A cuticle formed on enamel as well as on the sides of the acetate strip. Hagerman viewed the connective tissue fibers of the free gingiva as a dynamic, living responsive tissue functioning

as protective cover for the underlying periodontium. Hagerman and Arnim wrote, "A dense band of fibers encircle the tooth and this band provides the support for maintaining physiologic adaptation of this tissue to the tooth." They felt restorations could be placed beneath the free margin of the gingiva when there was no cement line exposed, no overhangs and when the protective contour was maintained.

Waerhaug (1952) placed India ink in the healthy gingival sulcus of young dogs to demonstrate the dynamic state of the gingival sulcus. He noted within an hour after placement an emigration of leucocytes emigrated through the sulcular epithelium along with an increased transudation of fluid. Most of the ink was removed by crevicular fluid after two hours. He concluded saliva could not penetrate below the gingival margin and "in healthy pockets where a normal epithelial cuff is closely fitted around the tooth to the gingival margin, the secretion is rather minute."

Waerhaug and Stein (1952) introduced pure cultures of pathogenic bacteria into free gingival pockets of dogs and the histologic reaction was recorded after a forty-eight hour period. The conclusions were: (1.) all pockets exhibit a constant flow of cellular elements and tissue fluid, (2.) healthy calculus free gingival crevice is sterile, (3.) bacteria within the sulcus caused necrosis of the epithelium and inflammation of the connective tissue with a subsequent exudate formation.

Waerhaug (1956) studied the effect of zinc phosphate

cement fillings on gingival tissues. Ten teeth in three monkeys and one tooth in a dog were used for the experiment. Cavities were prepared on the buccal surface extending to the bottom of the clinical pocket. Cement was inserted and remained in place for periods varying between eighty-two and three hundred thirty-eight days. Histologic examinations were performed and his conclusion was: "It was observed that under favorable condition an approximately normal epithelial cuff could be formed on the cement in limited areas." Zinc cement seemed to cause an irritation due to its chemical nature. Crevices of different widths were found between the fillings and the tooth. In these crevices cells degenerated or bacterial plaque causing severe inflammation in the adjacent tissue was formed. In most cases the entire cement filling was covered by a continuous mat of bacteria and the inflammatory reaction was completely governed by these.

Orban, Kollar (1956) et al. dealt with the problem of the existence or nonexistence of an organic attachment of the epithelium to the enamel surface. Six dogs and four adult monkeys were employed in the experiment. Three types of experiments were carried out. Their conclusion showed in young dogs it was impossible to detach the gingiva from the enamel of the tooth. They found the gingival epithelium is attached to the enamel surface and the attachment of the epithelium to the tooth should be considered as part of the dento-gingival junction. They also suggested the term "attached epithelial cuff" should be used instead of the term

"epithelial attachment."

Waerhaug (1956) studied the effect of rough surfaces upon gingival tissue. Subgingival enamel surface was ground away with diamond burs resulting in a rough surface. His conclusions were: (1.) rough surfaces do not in themselves irritate the epithelial cells with which they came in contact, (2.) the irritating effect of subgingival calculus is caused by bacteria or their toxins, (3.) a rough tooth surface facilitates the retention of bacterial plaque, (4.) restorations inserted below the gingival margin should be well polished.

Waerhaug (1957) studied the reaction of gingival tissue to self-curing acrylic restorations. Twenty-three self-curing resin restorations were placed in twenty-three teeth of four monkeys and two dogs. Class V cavity preparations extending subgingivally were made. The observation period varied between thirteen and three hundred thirty-eight days. The findings were: (1.) self-curing acrylic restoration produced a chronic inflammatory reaction in the adjacent gingival cuff, (2.) the crevice was filled with plaque, necrotic material or epithelium, (3.) a plaque-like material was found on the surfaces of the resin and in contact with the pocket epithelium, (4.) all these conditions could lead to a deepening of the clinical periodontal pocket.

Zander's (1958) paper concerned itself with tissue reaction to dental calculus and to filling material. He

viewed the tissue defense of inflammation as a response to bacterial and chemical agents. "Ordinarily the tissue cells cope with this attachment by factors that destroy the enzymes liberated by microorganisms. It is known that the microscopic crevices located below the gingival margin are filled with microorganisms of the same type found in calculus plaques and this is the most significant factor responsible for the similarity of the reaction of periodontal tissue to calculus and to dental restorations."

Perel's (1958) article was concerned with hygienic consideration in crown and bridge prosthesis. He felt cavity margins beneath the gingival margin were no longer advisable. The author concluded since the gingival margin receded after a varying lapse of time, there was no reason to extend the margin beneath the gingiva. Subgingival margins of restoration were considered not hygienic.

Morris (1958) described the gingival pocket. He found the position of the gingival margin was in part determined by the buccal or lingual prominence of the adjacent tooth surface. It was more apical with greater prominence and more coronal with lesser prominence. Essentially, a point or area on a tooth may have been more inaccessible by an exaggeration of the crown contour. This same effect was heightened when the alveolar bone became thickened. This lack of accessibility increased the susceptibility of gingival involvement.

Amsterdam (1959), while discussing the role of coronal contours, stated, "(the crown) must be designed as to deflect

food over the crevice and onto the keratinized surface of the attached gingival tissues." It was the author's opinion in most instances of advanced periodontal disease the tooth preparation should terminate just short of the epithelial attachment which allows for full protection of the root from sensitivity and caries. This also enhanced the creation of a new physiologic relationship of the clinical crown to its investing structure.

Weinberg's (1960) manuscript dealing with esthetics and the gingival in full coverage stated, when margins of preparations were placed well below the gingiva, periodontal disease can result. He found gingival recession caused by these subgingival margins did not afford any more protection against caries than if the finish lines were initially placed up to or only slightly below the free margin of the gingiva.

Waerhaug (1960) indicated the preparation for a restoration which terminated subgingivally could cause considerable damage to the gingiva. "The danger with the subgingival restoration is they facilitate the formation and retention of plaque which may lead to destruction of the periodontal aparatus due to its apical migration." However, he found consideration must be given to caries rate, predisposition for periodontitis, oral hygiene and esthetics. He concluded: (1.) gingival inflammation will disappear when sub and supragingival plaque is completely removed, (2.) if plaque has it's origin in spaces between crown and the preparation it cannot be removed, (3.) in these cases the restoration should

terminate above the gingival crest.

C. Recent Literature

Koivumaa and Wennstrom's (1960) paper concerned itself with changes in gingival margins adjacent to gold crowns. Their report was on a series of patients who received gold crowns on premolars and/or canines. Some of the crowns were anatomically correct while others were bulbous and overcontoured. Each patient had both type of crowns in his mouth. The authors found the correct shape of crowns is of major importance for the health of the gingival margins. They concluded the bulbous contoured crowns elicited an inflammatory response while anatomically designed crowns extended below the gingiva did not cause any damage to the periodontal tissues.

Stein and Glickman's (1960) article dealt with prosthetic consideration essential for gingival health. They stated, "When possible, all preparations should terminate well above the gingival margin." They found overcontouring or undercontouring results in a disruption of the normal deflection of food. They concluded restorations must be designed so they meet the biologic requirements of the periodontal tissues.

Ogilvie (1960) stated any placement of a dental restoration involved varying degrees of injury to the periodontium. "Whether this injury is permanent depends on the skill of the dentist." He concluded excellent marginal adaptation, proper buccal and lingual contour and surface finish of a restoration located below the gingiva are of prime importance if gingival

disease is to be avoided.

Ostlund (1960) felt the dentist's first concern in the maintenance of the oral health should be the removal of factors which contribute to gingivitis. According to the author and supported by Waerhaug (1956) it was not surface roughness and marginal irregularities in themselves that caused gingival injury. They considered the effect of the accumulation of microorganisms on these imperfect surfaces as more detrimental. It is the author's opinion that marginal excesses and deficiencies, unpolished restorations and excess cement in contact with the gingival tissue could lead to gingival inflammation.

Gavin and Collins (1961) studied the occurrence of bacteria within the clinically healthy gingival crevice. They agreed with others that gingival crevices containing calculus or deposits will certainly contain bacteria. Gingival crevices of twenty-six subjects were investigated to determine the presence or absence of bacteria. Paper points which were introduced into the crevice through the lumen of a sterile hypodermic needle were used to absorb the fluid. These points were cultured at thirty-seven degrees centigrade for three days. This investigation showed viable but potentially harmful organisms exist within the majority of clinically healthy gingival crevices.

Wheeler (1961), while discussing labial and lingual curvatures at the cervical portion of the tooth, stated, "These cervical contours have considerable physiologic importance." He found some authors who believed these

curvatures held the gingiva under tension and protected the soft tissues through their ability to deflect food material. Also the contours allowed sufficient functional stimulation for necessary tissue massage.

Ingraham (1961), in reviewing the procedure for restoring Class V Restorations, advocated the slightly accentuated cervical convexity of the crown at the level of the free gingival crest. "This convexity protects the gingival crest from the traumatic impact of food. In instances where the gingival extension of the preparation must be carried far below the cervical line of the tooth, the height of cervical convexity of the restoration must reestablish the original relationship of the cervical contour of crown to the crest of the gingiva and to the gingival attachment." He maintained a slight increase in the degree of cervical convexity is
essential to maintain gingival tissue under tonal tension and to protect it from the traumatic impact of food.

Morris (1962) was concerned with the problem of minimizing gingival irritation as it related to the axial contour of cast crowns. The author felt the theory of the artificial "bulge" in the crown was an inaccurate view of the gingiva coronal anatomy and physiology. He firmly believed this "bulge" caused, rather than prevented gingival inflammation. His clinical investigation and theoretical discussion cast doubt on the operation of a food impaction mechanism into the buccal or lingual gingival crevice. Although he cited experimental and clinical evidence which indicated

over contouring of the restoration causes gingival inflammation, it was elusive to mark a point beyond which a contour becomes excessive. He concluded the rationale of muscular molding and cleansing, rather than of food impaction explained the clinical phenomena and was a more accurate guide for the construction of gingivally tolerated full crowns.

Herlands (1962) in his article, discussed the morphology of artificial crowns with reference to periodontal health. In the discussion of gingival extension he reviewed the various schools of thought: (1.) "at the gingival crest," (2.) "slightly below the crest," or (3.) "slightly above the crest." He felt in a normal periodontal situation the gingival margin should be slightly below the free gingival cuff. Cooperation in home care was a factor with regards to extension of crown margins. He graphically compared the two philosophies; (1.) Food Impaction, (2.) Muscular Action. The first regarded the bulges as protection against impaction of food into the buccal and lingual crevice, while the second pictured a constant cleansing and molding action by muscles and food which can be impaired when the necessary intimate contact is prevented by bulges of crown and bone. The review was as follows:

Food Impaction

1. No coronal contour - unhealthy: direct food impaction and no protection.
2. Slight physiologic convexity - healthy: deflection of food to outer surface of gingivae.

3. Thick crown contours - unhealthy: food deflected away from gingivae, no stimulation.
4. Thick crown contour with gingival recession - unhealthy: distant bulge cannot prevent muscular contact with gingivae.
5. Thick bone "Physiologic" crown contour - unhealthy: food can be impacted on wide gingival surface and thence toward gingival crevice.

Muscular Action

1. No coronal contour - healthy: most efficient muscular action.
2. Slight physiologic convexity - healthy: most efficient muscular action.
3. Thick crown contour - unhealthy: muscle contact prevented by crown bulge.
4. Thick crown contour with a gingival recession - healthy: distant bulge cannot prevent muscular contact with gingivae.
5. Thick bone "Physiologic" crown contour - unhealthy: muscular contact prevented by bone bulge.

The author related that over contoured crowns caused rather than prevented gingival inflammation. He concluded the rationale of muscular molding and cleansing, rather than food impaction, more adequately explained clinical phenomena and was a more accurate guide for the construction of gingivally tolerated full crowns.

Morris (1963) reviewed available information of

periodontal aspects of restoration dentistry. He felt inflammation was directly proportional to the irritation. The irritants were the food, calculus and bacteria nestled in the gingival sulcus or periodontal pocket. He found a coronal shift in position of the margin of the gingiva could be the result of gingival inflammation itself or of the shape and position of the crowns. His review indicated the thicker crown shape created an area of gingival stagnation. Also the margin tended to grow up toward the height of contour and formed a pocket.

Toto and Sicher (1964) conducted histological investigation on the mode of attachment of the epithilial attachment. Jaws of rats and mice and gingival specimens of man were used. Sections were stained with periodic acid schiff for neutral mucopolysaccharides and with toluidine blue for metachromasia of any acid mucopolysaccharides. They concluded a neutral mucopolysaccharide was present at the basement membrane, intercellularly and as a cuticle on the dental surface of the attached epithelial cuff. The mucopolysacchoride was elaborated by the epithelial cells. This mucopolysacchoride binded all of the cells to each other and to both the connective tissue to the tooth.

The Ash, Gitlin and Smith (1964) studies were conducted to determine the degree of correlation between plaque and gingivitis. The study was conducted on seventy-eight patients who had above average oral hygiene and were placed on a preventative recall system. Plaque and gingival scores were

obtained prior to prophylaxis and at five, seven, thirty, and sixty days following prophylaxis. The results of the study indicated there is a high positive correlation between the degree of plaque and the degree of gingivitis present.

Löe's (1964) article on the physiology of the gingival pocket reviewed the histogenesis of tooth and epithelium formation. He reviewed historically the various theories of the epithelial attachment, along with the many views on the presence or absense of bacteria in the gingival pocket. He concluded the development of the epithelium attachment was still insufficient and further research was needed to clarify these theories.

Eccles in his (1964) article investigated the care of the gingival tissues near interproximal restorations. He reviewed current theories of the histological structure of the interproximal gingiva. He also examined clinically the effects of filling materials on the gingival tissues. He concluded mature gingival tissue had a remarkable capacity for repair but it was greatly reduced if bacterial plaque, marginal defects or rough surfaces on restorations were present. He felt care should be exercised in tooth preparation, impressions and matrix techniques in order to reduce damage to the soft tissue. Well contoured, finished fillings and the choice of nonirritating materials for subgingival restorations would help preserve gingival health. He also found the maintenance of good oral hygiene is the most important factor in the care of gingival health around

restorations.

Löe, Holm-Pedersen in their (1965) article examined the buccal aspects of the gingiva of three hundred thirty-six maxillary incisors, cuspids and bicuspids from one hundred eighteen adult humans. The Gingival Index System (Loe and Silness) was used to score the gingiva. This attempt was to determine the presence or absence of fluid from normal and inflamed gingiva. They concluded the crevices of normal human gingiva do not exhibit flow of fluid and mechanical stimulation of the periodontium did not produce fluid from these crevices. Inflamed gingiva showed the presence of fluid, the amount of which varied according to the severity of the inflammation. They suggested crevicular fluid is an inflammatory exudate and the absence or presence of fluid represented a definite clinical criterion in the distinction between normal and inflamed gingiva.

Prichard (1966) in his textbook on advanced periodontal disease stated the buccal and lingual surfaces and the embrasures of castings must be contoured in order to protect the gingival margin and the interdental papillae. He found subtle coronal contours deflected food over the free gingival margin onto the keratinized attached gingiva. "These contours protect the free gingival margin from injury by food passage during mastication." An excessive bulge causes an area for food retention. He also felt this protective coronal form was not necessary if the gingival margin was in a receded position on the tooth root because

the force driving the food was spent before it reached the gingiva. He also investigated the relation of casting margins to the gingiva and illustrated there was no question gingival irritation usually resulted from margins which terminated in the gingival sulcus. "From a periodontist's point of view, it is ideal to place the castings even with but not beneath, the free margin of the gingiva."

Dummett (1966), in discussing local factors in the etiology of periodontitis, mentions iatrogenic factors in the initiation of periodontitis. Once again he supported other researchers that overhanging margins lead to plaque formation and rough surfaces of restoration resulted in gingival irritation.

Akitoshi and Mori (1967) reported on a histological investigation of the periodontal tissues of a young adult male. They attempted to evaluate the extent of gingival inflammation. The authors showed the spread of gingival inflammation probably occurred through the transceptal fibers along the blood vessels directly into the interdental canals of the alveolar crest, and inflammation spread indirectly through the periodontal membrane to the alveolar process which resulted in circumscribed osteoporotic changes of the alveolar process.

Hazen and Osborne (1967) in reviewing the relationship of operative dentistry to periodontal health felt by over contouring a restoration, gingival disturbances can be initiated. They found the gingival area did not require

this extra protection. This overcontoured area near the gingiva provided a nidus for bacterial retention and made it harder for the patient to keep the area clean. This resulted in gingival inflammation in response to the bacterial mass on the tooth and restoration. They claimed, "It would seem better to restore the normal tooth and contour or in some instances to even undercontour slightly."

Marcum's (1967) paper represented a histological assessment of canine gingival tissue approximating teeth which received cast gold crowns with various positions of gingival margin placement. Sixty-six gold crowns were placed in six dogs; of these twenty-two crown margins were finished 2 mm. above. Twenty-two crown margins were even with the gingival crest and twenty-two were below the gingival crest. Each dog had all three types of margins. The results showed crowns with margins finished above and below the gingival crest resulted in the most severe inflammatory response, while crowns finished even with gingival crest caused the least inflammatory response. He felt the slight to severe gingival response caused by margins above the crest was due to plaque formation and adherence of food debris. The slight to severe response from crowns placed below the crest may be due to the minute crevice between the natural tooth structure and the margin of the gold. Plaque formation was also a paramount consideration. His conclusion was the least response in crowns with margins even with the crest may be dueto better marginal finish and a more satisfactory crown

contour that deflected food away from the gingival crevice.

Löe (1968) found dental restorations ranked high as a contributory factor in the etiology of periodontal disease. The identification of gingival fluid as an inflammatory exudate facilitated the assessment of absence and presence of inflammation at the subclinical level. Research indicated an apical shift of the dento-gingival junction was not a physiological aging process but was part of the periodontal response to marginal injury. Loe felt any rotating instruments below the gingival margin presented a trauma of varying degree to the crevicular epithelium and epithelial attachment. From a periodontal point of view, all margins of gold, porcelain and acrylic crowns or inlays were considered ill fitting. Cements were determined soluable in mouth fluids with a resulting space developing around crowns. This occured irrespective of whether the margins were sub or supragingival. He found there was ample evidence that any dental restoration extending into the subgingival area caused damage to the periodontal tissue either by providing niches for bacterial retention or by a direct irritating effect of the material used. His feeling was efforts should be made to avoid subgingival preparations or at least reduce the contact area between fillings and crowns and the gingival tissues. "In viewing the current knowledge of the pathogenesis and etiology of caries and periodontal disease as well as the current principles for prevention, it is evident that the concept of extension for prevention is obsolete and

and should be revised." In summary, the paper described the essential features of the biology and pathology of the marginal periodontium influenced by restorative procedures.

Injury to the gingival tissue occured: (1.) during the preparation and by rotating instruments below the gingival margin, (2.) from retraction material in connection with and taking of an impression. However, he found both are reversible. "Evidence indicated that any known type of dental restoration extending into the subgingival area causes damage to the periodontal tissue either by bacterial retention or irritating effect of the material per se."

Oliver, Holm-Pedersen, Löe (1969) scored and reviewed sixty labial and buccal gingival areas in fifty-three patients, aged seventeen to twenty-seven. Exudate samples were collected and measured and biopsies of the same area were performed and examined microscopically. Density of the inflammatory cell infiltrate was assessed and planimetric measurements at two hundred times magnification were made of total connective tissue area of inflammation and the per cent of inflamed tissue to toal connective tissue was calculated. Statistical data demonstrated a close relationship between the gingival index scores and the gingival exudate measurements. When no clinical evidence of inflammation was present, there was no exudate in the majority of crevices. Clinically normal gingiva tended to show an absence of inflamed cells beneath the crevicular epithelium. In mild clinical inflammation both gingival exudate and definite signs of inflammation were

seen in the specimens. Moderate inflammation showed an increase in both exudation and inflammatory changes in the connective tissue.

In Larato's (1969) article, the gingival tissue adjacent to six hundred thirteen Class V Restorations was examined for the presence of gingivitis on a clinical basis. His conclusions were: (1.) Class V Restorations with subgingival margins caused more gingivitis than restorations with cervical margins finished even with or slightly above the free gingiva, (2.) gold foil restorations and subgingival margins had the lowest incidence of inflammation, (3.) marked decrease in gingival inflammation was observed with margins finished even or above the free gingiva and the decrease was greatest in amalgam and gold foil restorations, (4.) silicate cements and acrylic resin restorations had a high incidence of gingival inflammation even when the cervical margins were even with or slightly above the free gingiva, (5.) amalgam and gold foil would seem to be the restorations of choice in respect to their influence on gingival health.

Bjorn (1969) studied two hundred twenty-five sets of intr-oral radiographs for defects of margins of cast crowns and their effect on the bone level of those teeth with crowns. It was noted that marginal defects were associated with periodontal bone destruction. It was observed for plaque and bacteria, a .2 mm. shelf located between tooth and cast crown initiated the process which resulted in periodontal breakdown.

The aims of Bjorn's (1969) article were: (1.) radiographic assessment of defects of the margins of fillings and crowns and a statistical analysis of their frequency, degree and distribution of the periodontal structures on two hundred twenty-five sets of full mouth x-rays, (2.) radiographic assessment of the periodontal bone height, (3.) analysis of relation between defects of the margin of restorations and approximal bone height. He found the restorations that were extended apical to the gingival margin caused harm to the periodontal tissue especially when their marginal fit was unsatisfactory. He provided proof periodontal tissue did not tolerate defects on restorations placed beneath the gingival margin.

Satinover (1970) reviewed the literature pertaining to margin termination of crowns. He said, "Regardless of the margins of restorations being above or below the gingiva, they are doomed to failure in a patient with poor oral hygiene. Below the gingiva a restored tooth may not have time for recurrent decay." His conclusion was periodontal disease can be controlled when the combination of good oral hygiene and supragingival margins are incorporated into dental therapy.

Schwartz's (1970) article reviewed the various causes of crown failure. He concurred with others that periodontal disease can be minimized by an evaluation of periodontal health before treatment and by placing restorations with margins, contours and embrasures that were compatible with the supporting structures.

In the Silness (1970) article, the periodontal condition of two hundred forty-two abutment teeth with full and partial crowns was compared with periodontal condition of two hundred forty-two contralateral teeth. The study showed when the margin of a cast crown had been placed below the gingival crest, an increased accumulation of plaque occurred around the abutment tooth when it was compared to the contralateral non-restored tooth. Teeth with full coverage crowns confirmed his finding that healing around subgingival restorations cannot be obtained unless the margins are made accessible for tooth cleansings.

Stallard (1970) examined three groups of twenty-five patients to assess the clinical significance of the inflammatory process in periodontal disease. "It was apparent that inflammation was an essential component of periodontal disease." Alterations in the color, contour and texture of the gingiva were the most common clinical signs of periodontal disease, but a poor correlation with the severity of the inflammatory reaction was demonstrated upon histological examination.

Silness (1970) studied the relationship between the location of crown margin and the periodontal condition. The periodontal condition of three hundred eighty-five lingual abutment tooth areas with varying location of crown margins was compared with three hundred eighty-five contralateral tooth surfaces which were not restored. Ther periodontal condition was assessed by Plaque Index (Silness & Loe, 1964), Gingival Index (Loe and Silness, 1962) and by measuring

pocket depth (Glavind and Loe, 1967). The location of crown margins was recorded according to Margin Index (Silness, 1970). His conclusion was supragingival margins seemed to be the most favorable location. Margins at or below the gingival crest interfered significantly with gingival health and the most harm occurred when the margin was placed subgingivally.

In Karlsen's (1970) experiment three adult dogs and three monkeys were used. Twenty-one full gold crowns, six micro bond crowns, fifteen Class V gold inlays and nine Class V acrylic resins were prepared. One third of the different types of restorations were finished 1 mm. more or less above the gingival margin while the rest were extended into the pocket. The observation period varied from two to twelve months. The results showed gingival inflammation was an almost constant finding in subgingival restorations when compared to the response in the supragingival cases. The gingival conditions were related to the marginal fit, especially in restorations in contact with the soft tissue. He concluded the reactions of the human gingiva were similar to those in dogs and monkeys, therefore the findings should be considered when crowns and fillings were prepared.

Mount (1970) reviewed the various theories on margin placement. He stated the problem of the relationship of the gingival margins of crowns to the gingival tissue were both mechanical and biological. He found wherever possible the margin of the preparation should be prepared level with the gingival crest; however, when esthetics are concerned the

margin must be placed subgingivally. When the gingival crevice is involved adequate preparation is the most important factor to minimize periodontal damage. Mount felt it was very important all restorations in contact with soft tissue be highly polished because rough areas within the gingival crevice retained plaque and caused gingival inflammation.

Attstrom (1970) histologically evaluated the presence of leukocytes in crevices of healthy and chronically inflamed gingiva. The aims of this investigation were: (1.) are leukocytes present in crevices of healthy gingiva?, (2.) if so, which leukocytes were present and what differences existed compared to crevices of chronically inflamed gingiva?, (3.) what relationship was there between presence of leukocytes in the crevices and the presence of inflammatory cell infiltrates in the connective tissue of healthy gingiva? The results indicated healthy gingiva always contain neutrophils, lymphocytes, and monocytes. The number of leukocytes found in chronically inflamed gingiva point to the possibility of utilizing the crevicular leukocyctic number as a parameter for evaluating inflammatory changes in the gingiva. The presence of leukocytes within healthy crevices reflected an inflammatory process within the tissue which was not detected by single histological section. He concluded further experiments were necessary to evaluate the condition under which leukocytes left the dentogingival blood vessels and emigrated into the gingival crevice.

Glickman (1972), in his texbook, Clinical Periodontology, stated that to properly locate the gingival margin of restorations the position of the healthy gingival sulcus must be established before the tooth is prepared. Preparation should not be finalized until the gingiva is healthy. "Periodontal pockets should not be permitted to remain undisturbed for the ostensible purpose of keeping the root cover or hiding the margin of the restoration." When considering the location of margins of restoration he felt crown margins should be located at the base of the gingival sulcus. The margin of the preparation should not terminate at the crest of the marginal gingiva. Regardless of how perfect the margin of the cemented restoration appeared, it was a broad rough area when viewed microscopically. Plaque forming bacteria was retained and grew. This resulted in gingivitis and caries. Restorations should not be forced into the gingival connective tissue beyond the epithelial attachment. Preparations beyond the base of the sulcus detached the epithelial attachment and the gingival fibers cannot be reattached when tooth structure was replaced by the crown.

Glickman found attachment proliferates along the restoration and the gingiva bulges away from the tooth causing pocket formation. He maintained the operator should avoid the gingival third of the tooth. The facial and lingual contour of crowns were important in the preservation of gingival health. Undercontoured facial and lingual surfaces disturbed normal food deflection and caused food impaction

and accumulation in the gingival sulcus. Overcontouring the facial surfaces created a ledge which deflected food beyond the gingival margin onto the attached gingiva. Also overcontouring on the facial interfered with mechanical cleansing action of the cheek against the tooth surface.

Mannerberg (1971) attempted to determine whether a crown was capable of causing local gingivitis. Thirteen patients with single porcelain crowns on central and lateral incisors were selected. The cases were examined clinically and radiographically. Color photographs were taken. The findings showed the buccal gingival pocket in all of the crowns showed inflammatory changes. This correlated with the leucocyte count and exudate flow from these areas. It appeared crowns, where margins were placed half the depth of the gingival pocket, permanent inflammatory irritation occured in the gingiva. "This is because the porcelain crown cannot be shaped so well that the point between the crown and the tooth is so smooth as not to interfere with oral hygiene. Plaque deposits can therefore be retained around the border between porcelain crown and the prepared tooth." The author also concluded that the investigation should be regarded only as a preliminary study. Further research was needed to help prevent certain aspects of periodontal disease.

Renggli and Regolati (1971) studied gingival inflammation and plaque accumulation on well adapted supragingival and subgingival proximal restorations. Five hundred fifty-four Army recruits were studied. Twenty-nine out of five

hundred fifty-four had on the mesial side of four selected teeth either a sound tooth surface or a filling with supra-gingival margin. Inflammation of the inter-dental gingiva adjacent to the sound tooth surface and the filled surfaces as well as plaque accumulations on these surfaces were scored. He concluded gingivitis was more severe beside fillings with subgingival margins than beside those with supragingival margins. Also, plaque accummulation was greater on fillings than on sound tooth surfaces. The amount of plaque noted was independent of where the filling margin was located.

Skurow and Lytle (1971) stressed the importance of proper contour related to the embrasure area in order to maintain optimum periodontal health. They suggested a provisional restoration be placed in order to determine the ideal contour for the final restoration. Obliteration of the interproximal embrasure space and excessive contour of restorative material lead to periodontal breakdown. The interproximal embrasure was a zone which had been neglected by the dentist.

Burch (1971) The article dealt with crown contours between the occlusal surface and the cervical area of individual teeth. His findings were: (1.) faciolingual crown dimensions should be no more than 1 mm. larger than the faciolingual width of the tooth at the level of the cemento-enamel junction, (2.) facial contours found in gingival third of the crown should not bulge more than ½ mm. facially beyond the cemento-enamel junction, (3.) proximal contact point should be in the occlusal third of the crown, (4.) proximal surfaces

should be always flat or slightly concave buccolingually. He asserted margins should be terminated at the gingival crest. Inadequate contour thickness caused insufficient support of the gingival limit and resulted in loss of gingival tone while too much contour or thickness lead to an increased tonus of the gingiva, resulting in a break in tissue integrity.

Eissmann (1971) explored the contours of axial tooth surfaces in relationship to their environment so they may function physiologically. "Profession does not subscribe to prior concept of tooth form but rather to interrelation of form and function." He found if inflammation progressed to the depth of the physiologic crevice destruction of the collagenous fibers occurred and this change was irreversible. Plaque on axial surfaces was more destructive than premature occlusal contact. Protective contours were convexities which prevented food impaction. Stimulating contours were concavities which provided ready access for the cleansing of tooth surfaces and for the massaging of gingival tissues. He stated, "There can be no stereotype form for any tooth surface. Its contour must represent a functional interpretation of protection versus stimulating features. This was relative to four factors: (1.) clinical crown length, (2.) tissue architecture, (3.) contour of adjacent teeth, (4.) character of opposing occlusion. Before one applies a concept of protective curvatures one should carefully consider what is to be protected: the gingiva or the dental plaque." The marginal area must constitute the smoothest most gradual

transition from tooth structure to restoration.

The margin placement should be placed on tooth surface fully exposed to a cleansing action. The contour of restoration must afford an optimum cleansing action. Extension for prevention in its present day interpretation means margins be placed in areas where they can be finished by the operator and maintained by the patient. They should be supragingival and designed to blend harmoniously with existing tooth curvatures. The key to successful margin placement was to minimize plaque retention. "Physiologic contouring must fully afford a massaging action to the gingiva." His conclusion was restorations ending near the gingiva or subgingivally compromise tissue health.

Perel (1971) found the placement of protective contour above the marginal gingiva did not enhance the health of sound gingiva and it predisposed the soft tissue to inflammatory changes. Cast crown should not be fabricated to receive deflective axial contours, esthetics permitting. He suggested further histological studies be conducted on human beings.

Perel (1971) reported the effects of tooth contour on the gingiva. Buccal and lingual convexities on mandibular teeth of dogs were removed and the subjacent tissue were studied clinically and histologically. The effect of overcontour in the cervical region was recorded. Class V preparations were made to terminate .5 mm. from the crest of marginal gingiva. Acrylic was placed. Undercontouring

resulted in no significant change either clinically or histologically within nine weeks of the study. Overcontouring resulted in gingival inflammation with changes seen (clinically and histologically) in areas subjacent to buccal tooth surface. The results were limited to six dogs with nine weeks. He concluded undercontoured axial surface did not alter tight adaptation of buccal and gingival collar to tooth structure.

Richter (1973) observed patients that had full crown restorations on permanent first molar teeth. Twelve crowns were placed. The restorations were designed so half of the facial margin was positioned subgingivally and half supragingivally. Patients received preventive care instruction. Recalls were made at yearly intervals with the last recall at three years. Löe's Gingival Index was employed. In summary, there was no difference in health of the gingiva and no difference in change of the sulcus depth, gingival contour and plaque accumulation. The results of the study suggested that fit and finish of full gold crown restorations may be more significant to gingival health than the location of the finish line. However, he did conclude despite these results crown margin should whenever possible be placed supragingivally.

Yuodelis, Weaver and Sapkos (1973) found successful restoration must be viewed from contour, occlusal anatomy, marginal adaptation, proximal contacts, esthetics and function. Plaque which was close to the free gingival margin was the principle factor in caries and periodontal disease. Over

contouring encouraged the accumulation of plaque. They stated it was doubtful the gingival sulcus was in need of extra protection. In their opinion the cervical bulges over-protect the plaque. The greater the degree of facial and lingual bulge, the more plaque was retained in the cervical region. The flatter the contour was, the less plaque retained. He preferred to flatten the facial and lingual contours and had observed excellent gingival response. They explained it may be due to having the cervical region more accessible for home care.

Trivedi (1973) studied the buccal gingival areas adjacent to one hundred eight premolars. Class V restorations using amalgam silicate cement and acrylic were formed in forty-eight teeth with sixteen specimens for each restoration. Cast gold restorations were cemented in six teeth. The gingival cavosurface angle terminated about .4 mm. gingival to the marginal crest. The results were as follows: (1.) amalgam was found to be less injurious to gingiva than silicate or acrylic, (2.) overhang margins were injurious to gingiva, (3.) injury to gingiva was caused by specific restorative materials, poorly adopted margins and inadequate home care, (4.) gold was the material of choice, followed by amalgam.

Wheeler (1974) in his texbook on Dental Anatomy stated buccal and lingual contour have considerable physiological importance. He found these curvatures hold the gingiva under definite tension and also protect the gingival margins by deflecting food material away from the margins during

mastication. The proper degree of contour resulted in food being deflected over the gingival margin thus preventing undue frictional irritation. If the contour was absent or too slight the gingival tissue was driven apically and this resulted in recession of gingiva and possible pathological changes. However, if the contour was too great the gingiva is protected too much and loses tissue tone. Food material and debris packed around the gingival area under this excessive contour. This may be accompanied by stagnation of foreign material and chronic inflammation of the gingiva. He stated the normal contour from the cemento enamel junction to the crest of contour was approximately .5 mm. in extent. Regarding the epithelial attachment, he felt the apparatus can be injured during full crown preparation. Careless preparation was one way of injuring the tooth as well as careless reproduction of form in the final restoration. Wheeler found one way to avoid this was to leave margins exposed wherever possible. This facilitated smooth finish and proper form. The location of all margins should be decided upon by a logical and scientific approach to diagnosis and prognosis.

Volchansky (1974) studied the surface characteristics of teeth and restorations using a scanning electron microscope and with a Taylor-Hobson Talysurf Model III to measure surface roughness. The following surfaces were examined: enamel, cementum, amalgam, synthetic, gold inlay, porcelain fused to gold and calculus. Enamel showed a slightly pitted surface. The gold inlay had numerous surface depressions

as well as a large number of scratches. Cementum presented many small elevations. Silcate cement had surface cracks and depressions. Porcelain consisted of flakes of material. Calculus showed large and small aggregations of material with valleys between them. His conclusion was enamel was probably the smoothest and most acceptable surface in the mouth and all natural and restored surfaces should be compared to it.

Nemetz (1974) concerned himself with tissue management during crown preparation. He claimed to insure longevity and esthetics it was imperative to evaluate the periodontal health of the patient. He advocated preventive measures before operative procedures. He concluded above or below the gingival margins restorations were doomed to failure in a patient with poor oral hygiene.

Newcomb (1974) supported other authors statements that subgingival margin caused gingival inflammation. He advised to "avoid the gingival third" when doing crown preparations. The study was clinical and included fifty-nine patients (nineteen to fifty-three years) with anterior veneer crowns and subgingival labial margins. The method of evaluation was the Gingival Index (Loe and Silness) and the Plaque Index. The results were subgingival margins displayed higher labial gingival indices and crevice depths than their uncrowned control teeth. However, the plaque scores by Plaque Index were significantly lower for the crowned teeth. The conclusions were: (1.) strong negative correlation between gingival inflammation and the distance of the crown margin

from the base of the crevice, (2.) positive correlation between gingival inflammation and the distance of the crown margin below the gingival crest was distorted slightly by the effect inflammation has on crevice depth, (3.) the least inflammation was observed when subgingival crown margins are placed at the gingival crest or just into the gingival crevice.

Wise (1975) agreed with other authors regarding subgingival margins, gingival inflammation, dental restorations and plaque. The article compared the plaque retaining capacities of gold, a gold alloy for veneering and porcelain, a vaccum veneering porcelain and cured acrylic resin. The conclusions were: (1.) no statistical difference between the plaque retaining capacities of acrylic resin and porcelain, (2.) porcelain had lower plaque retaining capacity than ceramco metal, (3.) porcelain had lower plaque retaining capacity than Type III Gold, (4.) acrylic resin had lower plaque retaining capacity than Type III gold and ceramco metal, (5.) gold Type III had lower retaining capacity than ceramco metal. The possibility existed that different types of plaque formed on different materials.

In Jameson's (1976) study the crevicular fluid volume between restored and nonrestored teeth was compared on thirty-two adult patients. The author found a significant difference between the amount of crevicular fluid collected from restored teeth compared to nonrestored teeth. He concluded inflammatory changes associated with subgingival full coverage restorations can be measured using a crevicular fluid meter and subgingival

margins should be avoided whenever possible. If subgingival margins cannot be avoided patients should be instructed in preventative measures and a definite recall instituted.

Maruyama (1976) observed twenty-four women and eight men ranging in age from sixteen to seventy-two years. Each patient had received porcelain-bonded-to-gold crowns. The study was directed to evaluate the gingival capillary morphology around complete crowns. The conclusions were: (1.) clinically normal gingiva adjacent to natural teeth did not exhibit dilated capillaries, (2.) more than one-forth of the capillary loops in the gingiva adjacent to the complete crowns showed dilation, (3.) dilation and complex capillary loops were found in the clinically normal gingiva adjacent to complete crowns. He felt the capillary microscope was an aid in the diagnosis of gingiva adjacent to complete crowns.

Larato (1975) agreed subgingival margins are associated with inflamed gingiva. The study was to determine whether cast crowns with subgingival margins were more frequently associated with pathologic pocket depths than were nonrestored contralateral teeth. He also investigated the influence of the frequency of tooth brushing on the pocket depth adjacent to the teeth. The result showed no positive relationship could be found between tooth brushing frequency and the pocket depth adjacent to teeth having crowns with subgingival margins. In nonrestored teeth, pocket depth increased with increased age of the patient in both restored

and nonrestored teeth and also with patient with cast crowns.

In Parkinson's (1976) study twenty-five complete metal cast crowns and twenty-five porcelain fused to metal crowns were compared to fifty contralateral teeth. He concluded overcontoured complete metal and porcelain-fused-to-metal crown allowed plaque to form around the gingival area. In his opinion, the less the axial accentuation of prominence on artificial full crown restorations, the less the quantity of plaque desposition. He found satisfactorily designed and executed dental restorations must be adhered to avoid the introgenic sequelae of plaque accumulation. In summary, the facial and lingual surfaces of teeth restored with a restoration which was overcontoured exhibited greater mean plaque accumulation than did the contralateral teeth. However he noted this relationship between plaque and excessive contours must not be considered wholly dependent and conclusive. Parkinson stated until demonstrated otherwise, the creation of artificial crown contours that were greater than natural tooth convexities must be considered another parameter promoting endemic plaque niches. The methods of clinical assessment were made according to the plaque index system proposed by Silness and Loe.

Okeson (1976) indicated proper tooth contour was essential to the preservation of the healthy periodontium. The article reviewed natural tooth contours and applied that knowledge with achieving these contours in restorations. A method of evaluation was to observe the tooth from three

perspectives; (1.) proximal, (2.) facial and lingual, (3.) occlusal.

Palomo (1976) suggested plaque accumulation and periodontal disease are related. Again the attitude was subgingival margins were associated with increased gingival inflammation. Histologically more inflammatory infiltration had been found in connective tissue of the gingiva adjacent to subgingival restorations than in the gingival connective tissue adjacent to restorations with supragingival margins. If a patient had a low carbohydrate intake and was plaque free, there was less chance of developing new caries. This suggested extension for prevention was not valid in the light of our current knowledge. "Preventive measures have lead us to view the role of extension for prevention as obsolete." Prevention of periodontal disease may be attained by using supragingival margins for restorations. Palomo stated most common error in crown construction is overcontouring the proximal surfaces. He concluded the best prevention was to prepare crowns adequately and to teach dental technicians the importance of the location of margins.

Sackett's (1976) article reviewed various author's feelings on crown contour. "The role of crown contours in health has been accepted as part of a mutually protective mechanism where in the teeth through the individual contours and collective alignment protect the gingival tissues and hence the attachment apparatus." Amsterdam, Abrams, Eissman, Radke, Noble and Coomer agreed contours prevent food

impaction. Wheeler suggested insufficient contour results in gingival recession as a result of trauma to the tissue from the bolus of food during mastication and overcontour may result in an area of accumulation of plaque in proximity to the gingival margin. Amsterdam and Fox - suggested an adequate crown contour was needed to reflect food over the gingival crevice and onto the keratinized attached gingiva. Others agreed in principle with the concept of protection (Cohn, Cohen and Chacker, Dummett, Ramfjord). Morris questioned the validity of the concept axial crown contour was protective in nature. He suggested for impaction to occur, a substance must be driven by a force towards a cul-de-sac which is easily entered. His concept was muscular action plays the main role in the maintenance of gingival health. This did not discount for the existence of a mutually protective mechanism but represented an alternative way of explaining how such a mechanism worked. Waerhaug - described the effect of rough surfaces on gingival tissues and suggested the plaque retention associated with a rough surface was a possible etiologic factor in the initiation of periodontal disease. Perel suggested overcontouring lead to overprotection and subsequent damage to the gingival tissue. Eissmann, Radke and Noble stated protective contours were those which prevent food impaction and stagnation. Wheeler and others suggested a system which was self cleansing and thus self sustaining. In this study forty-two pairs of test control sites were selected in twelve females ranging from seventeen

to nineteen years of age. Test sites were the gingival buccal aspects of maxillary and mandibular bicuspids. The adjacent bicuspids and canines were control sites. Acrylic overcontours were reproduced from twelve gauge half round wax wire which were cemented to the tooth surface with Durelon. The results indicated there was a significant change in gingival tissue in relation to overcontour. Wheeler et al. concluded standardized axial overcontours acted in some manner so as to alter the structural integrity of the subjacent gingival tissues of the forty-two test sites. Twenty-seven showed clinical signs of gingival inflammation and alteration of normal soft tissue architecture after a period of forty-two to forty-nine days. In the evaluation of test sites to control site; the gingival sulcular fluid score quotients were suggestive of some degredation of the gingival tissues at the test sites but no significant correlation was found. The conclusion was that alteration of normal crown form by overcontouring the buccal, axial third of a tooth may be a factor which predisposes the subjacent gingival tissues to inflammatory disease.

Saltzberg (1976) used a scanning electron microscope to study the junction between restorations and gingival cavosurface margins. The study demonstrated a definite interfacial void between the cervical margins of the tooth preparation and gold inlay, composite resin and amalgam restorations. Also these marginal defects permited plaque formation within them. Restorations which may be "clinically acceptable" may

not be ideal because of the properties of the restorative materials. He concluded the development of new restoration materials that will bond to the tooth surface should be instituted.

Mahajan (1976) did histological evaluations of interdental papillary tissue adjacent to full coverage restorations and non restored teeth. Her findings showed; (1.) clinically normal gingiva from non-restored teeth had few inflammatory cells, (2.) normal gingiva adjacent to restored teeth had more inflammatory cells and dilated blood vessels, (3.) inflamed gingiva adjacent to restored teeth had heavy infiltration of inflammatory cells and dilated blood vessels, (4.) loss of collagen fibers occurred around blood vessels where inflammation was present, and (5.) the mitotic index of squamous epithelium increased as associated with full coverage restorations.

Wagman's (1977) article dealt with the role of coronal contour in gingival health. "Since there is a direct cause and effect relationship between bacterial plaque accumulation and gingival inflammation, it seemed important that coronal contours should be viewed critically." His article was based on clinical assessment of coronal contours. He believed the subgingival convexity of a tooth or restoration should extend buccally or lingually no more than one half of the thickness of the gingiva. He viewed this concept as a protective mechanism for the gingival crevice and promotes a knife-like free gingival margin which was important in plaque control. Also,

the facial and lingual surface contours should have gradual curvatures in all directions to facilitate the rubbing and cleansing function of the lips, cheeks and tongue. He felt undercontour is better than overcontour where clinical judgement was vague.

Goodacre (1977), while understanding subgingival margins of crown can lead to periodontal involvement, developed a technique to fabricate metal ceramic crowns which had no metal collar. This improved the esthetics of anterior crowns when the margins were supragingival. These collarless crowns were indicated for patients with thin, finely textured gingival tissues. The finish line was placed supragingivally with less risk of tissue trauma and without the display of a metal collar.

In Tylman's (1977) textbook the chapter on crown contours and gingival response summarized the findings of others and concluded the prevalent concept concerning crown contours indicated the protective-deflective artificial contours had a tendency to initiate gingival inflammatory response by providing a protective plaque-accumulating area. This area can hinder oral hygiene procedure by making the cervical third of the clinical crown less accessible. He also supported the many authors who found the nearer a subgingival crown margin approached the base of the gingival crevice, the more likely it was that severe gingival inflammation occurred. He also recommended supragingival margins whenever esthetics, DMF Rate and vertical space permitted.

MacEntee (1978) conducted an investigation on a histologically evaluation of tissue response to emporary acrylic resin crowns. Three commonly used acrylic resin crowns were fabricated for seven healthy adults age twenty-five to sixty-five. All margins were carried subgingivally for 1 mm. on all teeth. His conclusions were subgingival placement of any one of the three types of temporary crowns placed on twenty-eight posterior teeth of seven subjects caused no detectable change in the gingiva over a three week period. He also suggested further study of the influence of temporary crowns on different types of gingival tissues.

D. SUMMARY OF PERTINENT LITERATURE

AUTHOR	YEAR	EXPERIMENTAL SUBJECTS	INVESTIGATION	PARAMETERS OF MEASUREMENTS	FINDINGS
Waerhaug	1953	2 Dogs 17 Teeth Acrylic Crowns 10 PJC 5 Gold Crowns Human Autopsy	Study the reaction of gingiva to acrylic crowns with margins below the gingiva. 28-84 days.	Histological evaluation	1.)Crowns can be close to bottom of pocket without injury to periodontal fibers providing a perfectly fit crown is fabricated and thorough removal of all living and necrotic tissue is done before cementing.
Waerhaug	1956	3 Monkeys 10 Teeth 1 Tooth in 1 Dog	Effects of $ZNPO_4$ cement on gingival tissue Class V prep extended to bottom of pocket. 82-338 days.	Histological evaluation	1.)Normal epithelial cuff could be formed on cement in limited cases. 2.)$ZNPO_4$ caused irritation due to its chemical nature. 3.)Crevices formed between filling & tooth resulting in severe inflammation.
Waerhaug	1957	4 Monkeys 2 Dogs 23 Self Curing Class V Restoration extending below gingiva.	Reaction of gingival tissue to self curing acrylic restoration. 13-338 days.	Histological evaluation	1.)Self curing restoration causes chronic inflammatory reaction in gingival cuff. 2.)Crevice filled with plaque and necrotic material. 3.)This can cause deepening of clinical perio pocket.

AUTHOR	YEAR	EXPERIMENTAL SUBJECTS	INVESTIGATION	PARAMETERS OF MEASUREMENTS	FINDINGS
Koivumaa Wennstrom	1960	2 Males 6 Females Human subjects 9 normal shaped crowns 8 bulbous crowns	Histological investigation of changes in gingival margins adjacent to gold crown. Six month period.	Histological evaluation	1.) Normal shaped crown can be extended subgingivally without gingival damage. 2.)Bulbous contour crown causes severe inflammation 3.)Concluding, correct shape of crown is major factor.
Löe; Holm; Pedersen	1965	118 Adult Humans. Buccal aspect of gingiva.	To determine the presence or absence of fluid from normal and inflammed gingiva	Gingival Index Crevicular fluid collection	1.)Normal crevices do not have flow of fluid 2.)Inflammed gingiva - fluid present, amount varies 3.)crevicular fluid is inflammatory exudate.
Marcum	1967	6 Dogs	Effects of crown margin depth on gingival tissue. 66 gold crowns with margins 1/3 above crest, 1/3 even with crest, 1/3 below gingiva margin. 30-90 days	Histological evaluation	1.)Crowns with margin at or even with crest resulted in least inflammatory response. 2.)Crowns with margins above or below crest had most severe inflammatory response.

AUTHOR	YEAR	EXPERIMENTAL SUBJECTS	INVESTIGATION	PARAMETERS OF MEASUREMENTS	FINDINGS
Larato	1969	613 Male human Class V restoration subgingival margins 2,946 Class V Restoration.	Effects of cervical margins on gingiva. Duration not mentioned.	Clinical assessment: Localize redness of gingival tissue in relation to remainder of gingiva. Blunting of papilla assessed.	1.)Class V restoration had greatest inflammation with subgingival margins compared to above gingiva. 2.)Gold foil least inflammation response. 3.)Silicate cement & acrylic had high incident of inflammation regardless of margin placement.
Karlsen	1970	10 Adult Dogs 3 Monkeys	Effects of $ZNPO_4$ on gingival tissue. Class V prep extending to bottom of pockets. 82-338 days.	Histological evaluation	1.)Gingival inflamation is constant in subgingival restoration as compared to favorable response in supragingival cases. 2.)Gingival condition is related to marginal fit.
Perel	1971	6 Dogs	Effect of tooth contour on gingiva. Buccal & lingual convexities removed, resulting in undercontoured. Over contour axial surface of Class V with acrylic restoration. 9 weeks.	Clinical & Histological	Axial Tooth Surface altered 1.)Undercontoured - does not produce change in gingiva. 2.)Overcontoured - inflammation and hyperplastic changes in gingival margin.

AUTHOR	YEAR	EXPERIMENTAL SUBJECTS	INVESTIGATION	PARAMETERS OF MEASUREMENTS	FINDINGS
Sackett & Others	1976	12 human subjects 17-19 years of age.	Effects of axial crown over contour in adolescent. 42 test site/control. 42-49 days.	Gingival Index. Photographic technique Gingival fluid volume	1.)Of 42 test sites, 27 showed clinical signs of inflammation & alterations of tissue architecture. Gingival fluid - suggestive of some degredation of gingival tissue but no significant correlation found. 2.)Concluded: overcontouring predisposes gingival tissue to inflammatory disease.
MacEntee	1978	7 Adults 25-65 years of age. 28 acrylic crowns.	Histological evaluation of tissue response to acrylic crowns. 21 days.	Histological evaluation	1.)Subgingival placement of acrylic crown causes no change in gingiva in in 21 day period. 2.)Need for other study on treatment of crowns on different types of gingival tissue.

CHAPTER III

MATERIALS AND METHOD

Two adult female Rhesus monkeys were used in the experiment. The animals were anesthetized and weighed utilizing the following procedure:

Animal Number I was an adult female weighing 4.2 kilograms. Animal Number II was an adult female weighing 4.8 kilograms. Animal Number I was anesthetized using .6cc of Sernylan (20 mg/cc.) (Phencyclidine) IM. After anesthesia was achieved lcc. of Atropine Sulfate (1/120 gr./ml.) was given IM to control the salivary flow. Intra oral photographs were taken of the gingiva of all four quadrants. Acrylic trays were fabricated intraorally. Impressions were taken of both arches using Kerr polysulfide rubber base. These impressions were used to fabricate custom acrylic trays for final impressions after operative procedure and for polished diagnostic casts. The same sequence of events were done on female adult Animal Number II.

Animal Number I gingival tissue was excised:

1. Maxillary Right Second Molar: Buccal

   A block section was dissected from the buccal gingiva extending from the interproximal area of the mesial papilla to the distal including the papilla. The specimen was placed immediately in buffered formalin solution.

2. Maxillary Right Second Molar: Lingual

   A lingual biopsy including the distal papilla

was taken in the same manner.

3. Maxillary Right Second Bicuspid

   A block section extending from the buccal interproximal of mesial papilla to and including the distal papilla was taken.

4. Maxillary Right Bicuspid: Lingual

   A lingual biopsy in the same manner including the distal papilla was done. The animal was then placed back in her cage. No other medications were given.

Animal Number II was anesthetized in the same manner.

5. Mandibular Left Second Molar: Buccal

   A tissue biopsy was taken in the same manner extending from the mesial papilla along to and including the distal papilla.

6. Mandibular Left Second Molar: Lingual

   A lingual specimen, including the distal papilla, was taken.

7. Mandibular Left Second Bicuspid: Buccal

   A specimen was taken from the buccal which included the distal papilla.

8. Mandibular Left Second Bicuspid: Lingual

   A lingual specimen was taken in the same manner. Each of the animals were operated on for one hour duration.

Animal Number I

One week later the monkey was anesthetized using .6cc

of Sernylan IM followed by Sodium Pentobarbital IV (65mg./ml.) One cc. of Atropine Sulfate (1/120 gr./ml.) was given IM to control the salivary flow. The maxillary left first and second bicuspids along with the left maxillary first and second molars were prepared to receive cast crowns. The finished line terminated in a knife edge approximate at the gingival crest. Xylocaine two percent, Epinephrine 1:100,000 was used as a local anesthetic. The mandibular right first and second bicuspids along with the first and second molars were also prepared. The same type of finish line and gingival termination was used. The gingival bleeding was at a minimum.

The sequence of instruments was strictly adhered to.

1. High speed (Midwest) handpiece utilizing water throughout the preparations.
2. Bulk reduction occlusally was done using Star Diamond Wheel Number 110SP.
3. Bulk reduction on the buccal, lingual, distal and mesial was carried out with Star Diamond Number 769-5P.
4. The final finish was achieved using Star Number 769-5F (Super Fine Diamond).

Intra Oral Slides were taken of the prepared teeth. Gingipak was used to control the interproximal bleeding but was not packed subgingivally. No gingipak was used on the buccal or lingual of any of the preparations. The preparations were slightly dried with an air syringe and full arch

impressions were taken with light and heavy rubber base materials. Kerr Syringe was used for the light base. After eight minutes the impressions were removed and poured with hard white stone with gypsum hardener under vacuum mixing. Custom acrylic trays were utilized on both arches which had proper occlusal stops. Only one full arch impression of each arch was needed. All margins were clearly visible in the impression.

Temporary stainless steel crowns were cemented with Dycal. The crowns were checked to make sure that they did not extend subgingivally on the buccal and lingual. Occlusion was checked and the animal was placed back in her cage. No alterations were done in dietary pattern. Animals were routinely fed Purina Monkey Chow in biscuit form and water. (They generally consume about four percent of their body weight in food each day.)

The total time lapse from start of anesthetic to placing the animal in her cage was two and one half hours.

Lab Procedures For Animal Number I

Rubber base impressions were immediately poured using white Vel Mix with Gypsum hardener which was vacuum spatulated. A Pin Dex System was used for model preparation. Individual dies were prepared and wax patterns were fabricated. The maxillary left quadrant received undercontoured gold cast crowns. The mandibular right quadrant received overcontoured gold cast crowns. Lustercast investment with water bath technique was used and the burn out temperature

was 1000 degrees F. for one and one half hours. An electric casting machine at 1750 degrees F. was used with Mowrey Ultra Fine Grain Casting Gold. (W. E. Mowrey Company, St. Paul, Minnesota) The models were articulated using a hinge type articulator. The cast crowns were highly polished.

Animal Number I was anesthetized with .6cc. of Sernylan IM followed by one cc. of Atropine Sulfate (1/120 gr./ml.) IM. The cast crowns were adjusted for the maxillary left quadrant and for the mandibular right quadrant. The crowns were cemented using S. S. White Zinc Oxyphosphate cement. Cement was carefully removed around the gingiva of all crowns. Occlusal adjustments were performed. Attempts were made to remove all prematurities in centric and left and right excursions before the animal was placed in her cage.

Animal Number II was anesthetized using Sernylan .6 cc. followed by Atropine Sulfate 1 cc. IM. The animal was then given 1 cc. of Sodium Pentabarbital IV. The maxillary left first and second bicuspids, maxillary first and second molars were prepared for full gold crowns. Knife finish line terminated buccally and lingually and interproximally at the gingival crest. The mandibular right quadrant was also prepared in the same manner. Gingipak was placed in the interproximal areas but was not packed with any instrument. No packing was placed on the buccal or lingual of any of the preparations. Full arch rubber base impressions were taken using the injection technique with light and heavy Polysufide Rubber Base. Custom acrylic trays were

used. The mandibular impression was done in the exact manner. Stainless steel temporaries using Dycal were cemented. Care was taken to insure that the temporaries did not impinge on any gingival tissue.

Lab Procedure For Animal Number II

Impressions were poured and procedures did not differ from Animal Number I. The dies were waxed as follows:

Maxillary left quadrant received overcontoured gold crown. Clinically the teeth were extremely short occlusal-gingivally which limited the amount of excessive buccal and lingual contour as to not to interfer with occlusion. (Refer to Appendix B on page 116.) The wax patterns were then carried to completion using Mowrey Ultra Fine Grain casting gold (hard type III, number 7, Brinell hardness, number 210.) A high polish was achieved in the final castings.

ANIMAL NUMBER II

The monkey was anesthetized in the same manner with the exception that no Sodium Pentobarbital was administered. Temporary crowns were removed and all crowns were cemented after adjustments were made. Gold crowns were cemented with zinc phosphate cement (S. S. White). After fourteen days Monkey Number II was examined and the mouth assessed for

plaque accumulation and gingival irritation according to "The Gingival Index" and "Plaque Index System" of Loe (1967).

Criteria For The Gingival Index System

0 = Normal gingiva.

1 = Mild inflammation-slight change in color, slight edema. No bleeding on probing.

2 = Moderate inflammation-redness, edema and glazing. Bleeding on probing.

3 = Severe inflammation-marked redness and edema. Ulceration. Tendency to spontaneous bleeding.

Criteria For The Plaque Index System

0 = No plaque in the gingival area.

1 = A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may only be recognized by running a probe across the tooth surface.

2 = Moderate accumulation of soft deposits within the gingival margin and/or adjacent tooth surface, which can be seen by the naked eye.

3 = Abundance of soft matter within the gingival pocket and/or on the gingival margin and adjacent tooth surface.

After twenty-eight days gingival crevicular fluid was collected from the buccal crevices of all teeth. The collection technique followed the method suggested by the manufacturer (Harco Electronics Limited, Winnipeg, Canada) using the Periotron (clinical GCF meter).

Only the buccal crevice was measured due to the difficulty of reaching the lingual surface of the monkeys

and also the large width of the filter paper strips.

The collection technique was as follows:

1. Region to be examined was dried and isolated with sterile cotton rolls.
2. A sterile dry filter paper strip (Periopaper, Harco 1.5 mm. x 13 mm.) was placed at the entrance to the gingival sulcus orifice (Loe and Holm - Pedersen, 1965) for three seconds to empty the crevicular pool. This filter strip was removed and discarded.
3. After a twenty-seven second interval, another sterile dry filter paper strip was placed at the sulcus orifice for three seconds. The total elapsed time was thirty seconds.
4. The filter paper strip was immediately placed between the recording sensors so that the entire moistened area of the filter strip was in contact with the sensors.
5. With the switch on the no hold mode, the digital read-out value rises to a maximum and then decreases. The highest numerical reading was recorded. The digital numerical values were converted to fluid volume (microliters by dividing the readings by 200).
6. After each measurement, the sensors are dried with a sterile cotton roll. All measurements were taken by the same investigator. The animals

were anesthetized in the same manner except that no Atropine was administered on Animal Number II at twenty-eight or forty-five days. Atropine Sulfate was given to Animal Number I at twenty-eight days but discontinued at all other times.

Termination of Experiment on Animal Number I

The animal was anesthetized with .6 cc. Serylan IM followed by Atropine Sulfate 1 cc., IM. Custom acrylic trays using rubber base were used to secure the impression needed for polished diagnostic casts. The animal was given 800,000 units of Flo-cillin IM (Sterile Benzathine Penicillin G and Procaine Penicillin G in aqueous suspension: Division of Bristol-Myers Co., Syracuse, New York) prophylactically after completion of all biopsies to prevent infection.

Biopsy Specimen Collected

1. An incision was made along the mucogingival junction to the depth of the bone from maxillary left first bicuspid to the third molar. Relieving incisions were made at each interproximal area. Specimens were carefully removed and immediately placed in the formalin solution.
2. The same incision was performed on the lingual and careful dissection was made for the specimen collection.
3. An incision in the same manner was made for the mandibular right quadrant.
4. Control Specimen: Normal clinically appearing

gingiva of tooth number three and nineteen was used. The specimen was dissected from the buccal and the lingual. A total of twenty specimens were taken.

Specimen Preparation

The biopsy specimens were fixed in buffered formalin solution for twenty-four hours, after which they were washed in water for twenty-four hours. The tissue was then embedded in paraffin and cut at six micron thin. Every ten sections were mounted. The cut was made tangentially to the specimen. Five slides of each specimen were prepared. All specimens were stained with Hematoxylin and Eosin.

Impressions were taken for polished diagnostic casts prior to specimen collection on Animal Number II. Biopsy specimens were collected from Animal Number II in the exact manner as Animal Number I. Flo-cillin, 800,000 units IM, was given prophylactically after all biopsies to prevent infection. Twenty specimens were also taken from Animal Number II and the preparation of the specimen for histological slides was carried out in the same manner.

A total of two hundred slides were prepared for microscopic evaluation. Slides were selected at random and viewed under four hundred fifty magnification. A reticular eyepiece was used for cell counting. Inflammatory cells were counted using a hand counter.

The cell count was made along the basement cell level and the total number of inflammatory cells were noted per

100 u2 and recorded for each area. Ten readings per slide were recorded. Photo microscopic slides were taken using a Zeiss Photo Microscope using Kodak PCF 135 film.

All experimental data was then compiled and recorded using IMB System 1360 Assembler Coding for key punch cards. The cards were then used for Computer Statistical Analysis using an analysis of variance procedure.

SUMMARY OF THE PARAMETERS OF MEASUREMENTS

AT THE DIFFERENT TIME PERIODS

ANIMAL I AND II

		OVERCONTOURED			UNDERCONTOURED			CONTROL		
	DAY:	14	28	45	14	28	45	14	28	45
TESTS TAKEN	Plaque Index:	x	x	x	x	x	x	x	x	x
	Gingival Index:	x	x	x	x	x	x	x	x	x
	Crevicular Fluid Volume:		x	x		x	x		x	x
	Inflammatory Cell Density:			x			x			x

Animal I: Female Rhesus monkey, Weight: 4.2 kilograms

Animal II: Female Rhesus monkey, Weight: 4.8 kilograms

Anesthetic: Serylan 20 mg./cc (Phencyclidine) .6cc IM

Diet: Purina Monkey Chow (hard bisquit) and water.

No alteration in diet or oral hygiene.

CHAPTER IV

FINDINGS

The following outline will summarize the statistical analysis of the data collected. There was a total of twenty-seven tables of statistical analyses.

I. Control Versus Undercontoured

A. Fourteen Days

1. Plaque Index

Table 1. F value of .12. No significant difference between the control versus the undercontoured crowns.

2. Gingival Index

Table 2. F value of 0. No significant difference between the control versus the undercontoured crowns.

B. Twenty-eight Days

1. Plaque Index

Table 3. F value of 0. No significant difference between the controls and the undercontoured crowns.

2. Gingival Index

Table 4. F value of .16. No significant difference between the controls and the undercontoured crowns.

3. Periotron

Table 5. F value of 2.11. No significant difference between the controls and the undercontoured

crowns.

C. Forty-five Days

1. Plaque Index

Table 6. F value of .45. No significant difference between the controls and the undercontoured crowns.

2. Gingival Index

Table 7. F value of 27.51. A significant difference at the .0001 level between the controls versus undercontoured crowns.

3. Periotron

Table 8. F value of .24. No significant difference between the controls versus the undercontoured crowns.

II. Control Versus Overcontoured Crowns

A. Fourteen Days

1. Plaque Index

Table 9. F value of 18.91. A significant difference between the controls versus overcontoured crowns at the .0003 level.

2. Gingival Index

Table 10. F value of 21.18. A significant difference between the controls versus the overcontoured crowns at the .0001 level.

B. Twenty-eight Days

1. Plaque Index

Table 11. F value of 2.71. No significant

difference between the controls versus the overcontoured crowns.

2. Gingival Index

Table 12. F value of 6.81. A significant difference between the control versus overcontoured crowns at the .01 level.

3. Periotron

Table 13. F value of 6.22. A significant difference between the controls versus overcontoured crowns at the .02 level.

C. Forty-five Days

1. Plaque Index

Table 14. F value of 11.78. A significant difference between the controls versus the overcontoured crowns at the .0002 level.

2. Gingival Index

Table 15. F value of 43.50. A significant difference between the control versus the overcontoured crowns at the .0001 level.

3. Periotron

Table 16. F value of 25.56. A significant difference between the controls versus the overcontoured crowns at the .0001 level.

III. Undercontoured Crowns Versus Overcontoured Crowns

A. Fourteen Days

1. Plaque Index

Table 17. F value of 16.58. A significant

difference between undercontoured versus over-contoured crowns at the .001 level.

2. Gingival Index

Table 18. F value of 40.0. A significant difference between the undercontoured versus the over-contoured crowns at the .0001 level.

B. Twenty-eight Days

1. Plaque Index

Table 19. F value of 2.79. No significant difference between the undercontoured versus the over-contoured crowns.

2. Gingival Index

Table 20. F value of 6.66. A significant difference between the undercontoured versus the over-contoured crowns at the .02 level.

3. Periotron

Table 21. F value of 19.76. A significant difference between the undercontoured versus the over-contoured crown at the .0006 level.

C. Forty-five Days

1. Plaque Index

Table 22. F value of 4.67. A significant difference between the undercontoured versus over-contoured crowns at the .04 level.

2. Gingival Index

Table 23. F value of 3.19. No significant difference between undercontoured crowns and

overcontoured crowns.

3. Periotron

Table 24. F value of 11.97. A significant difference between undercontoured versus overcontoured crowns at the .003 level.

IV. Control Versus Undercontoured Crowns for Inflammatory Cell Density at Forty-five Days

Table 25. F value of 7.80. A significant difference between the controls versus the undercontoured crowns at the .01 level.

V. Control Versus Overcontoured Crowns for Inflammatory Cell Density at Forty-five Days.

Table 26. F value of 41.82. A significant difference between the controls versus the overcontoured crowns at the .0001 level.

VI. Undercontoured Versus Overcontoured Crown for Inflammatory Cell Density at Forty-five Days.

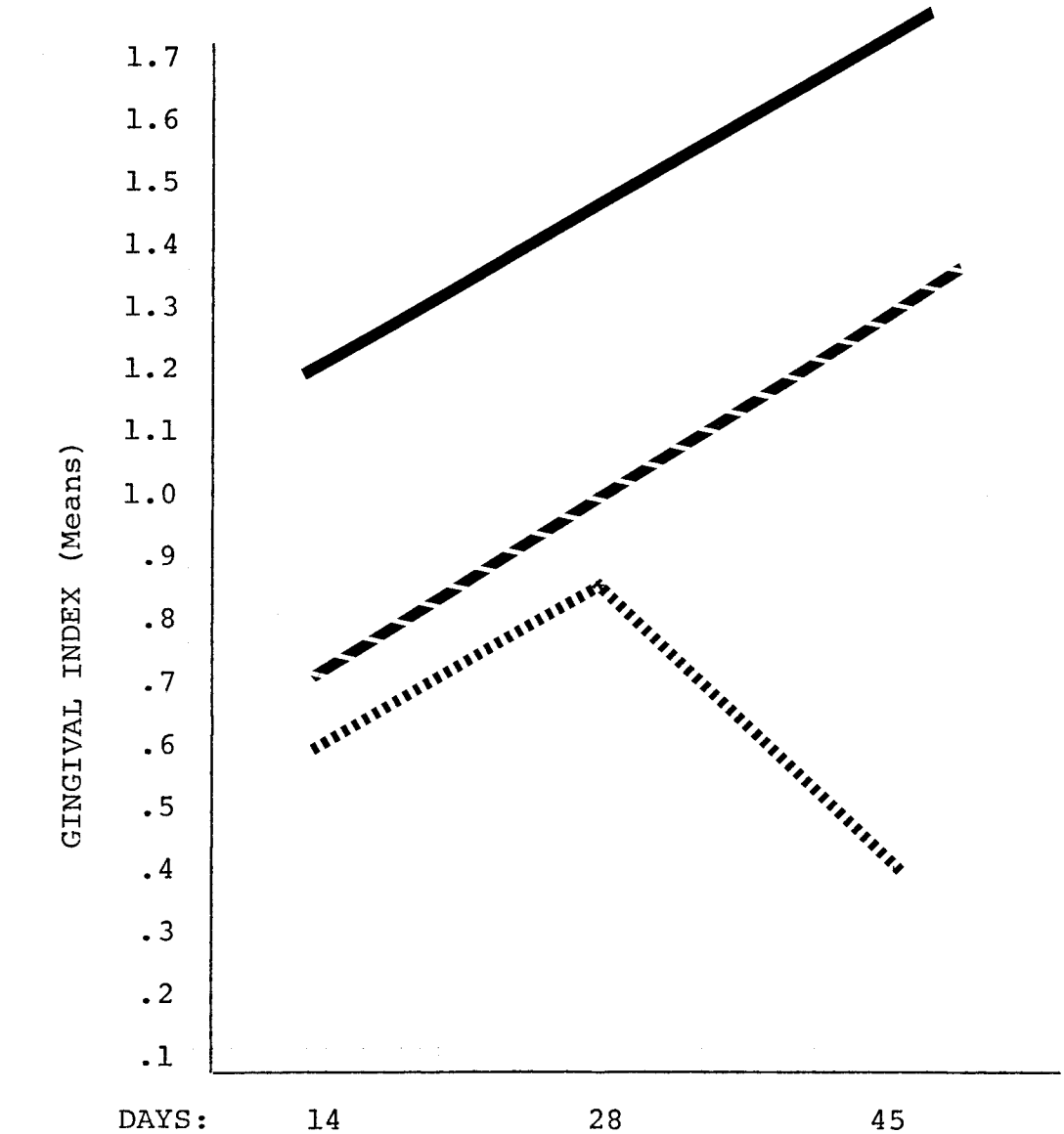
Table 27. F value of 28.38. A significant difference between the undercontoured versus the overcontoured crowns at the .0001 level.

SUMMARY OF ANALYSIS OF VARIANCES

CONDITIONS	CONTROL VS. UNDERCONTOURED			CONTROL VS. OVERCONTOURED			UNDERCONTOUR VS. OVERCONTOURED		
Time Period In Days:	14	28	45	14	28	45	14	28	45
Plaque Index	0	0	0	++	0	++	++	0	+
Gingival Index	0	0	++	++	+	++	++	+	0
Periotron	-	0	0	-	-	++	-	++	++
Inflammatory Cell Density	-	-	+	-	-	++	-	-	++

KEY: 0 = No significance
++ = Significant difference at less than .0001 level
+ = Significant difference at less than .01 level
- = No recordings

GINGIVAL INDEX (Means)



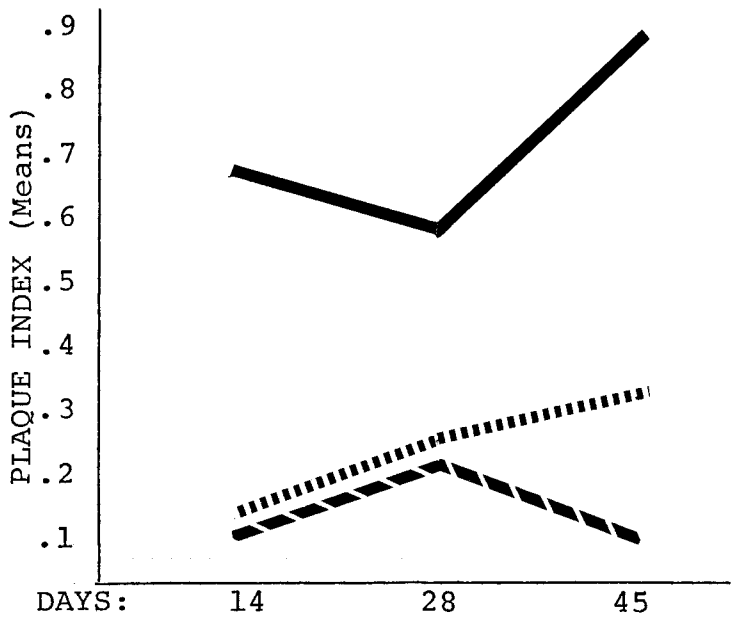
KEY:

CONTROLS:

OVERCONTOURED:

UNDERCONTOURED:

PLAQUE INDEX (Means)



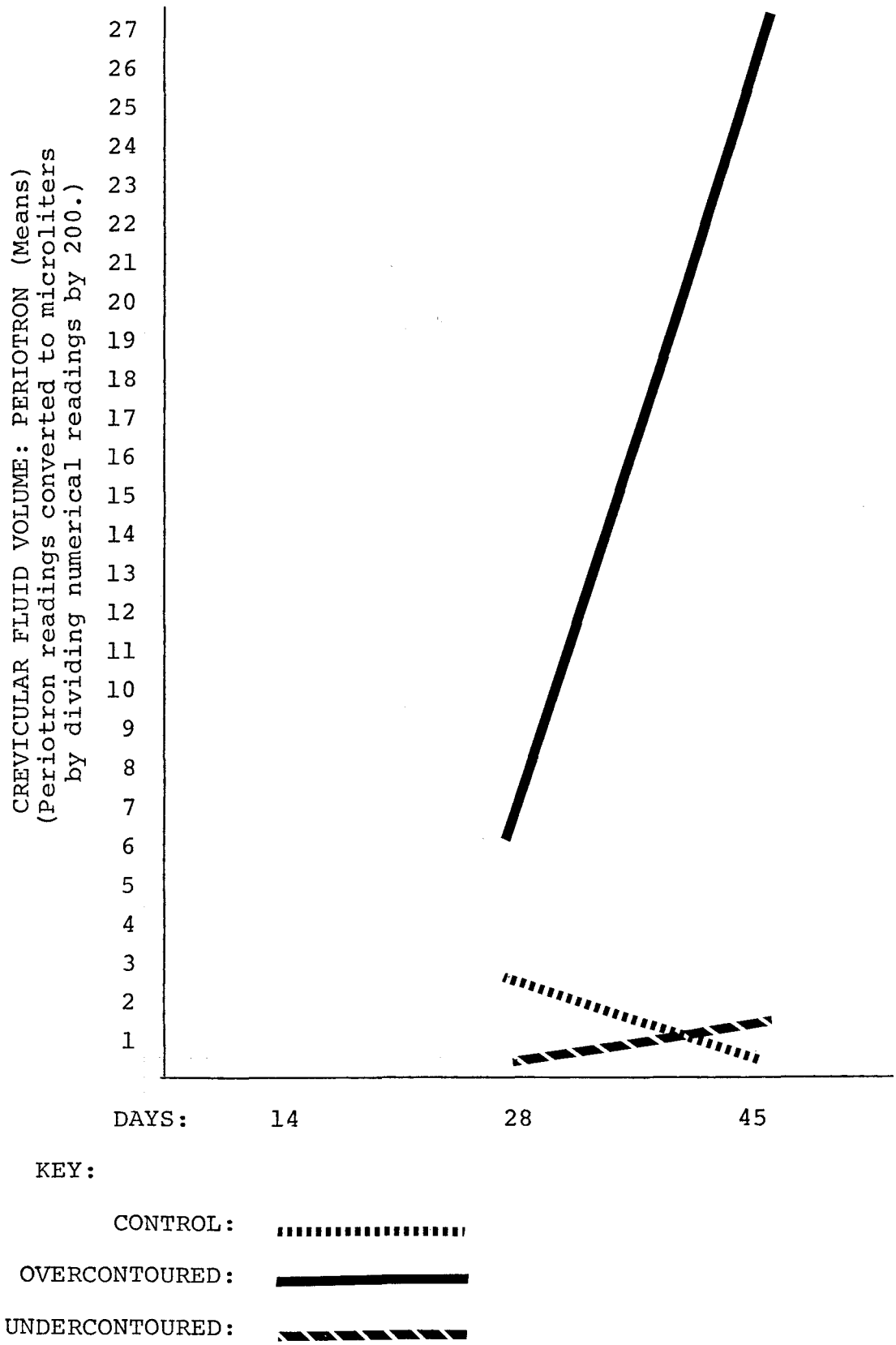
KEY:

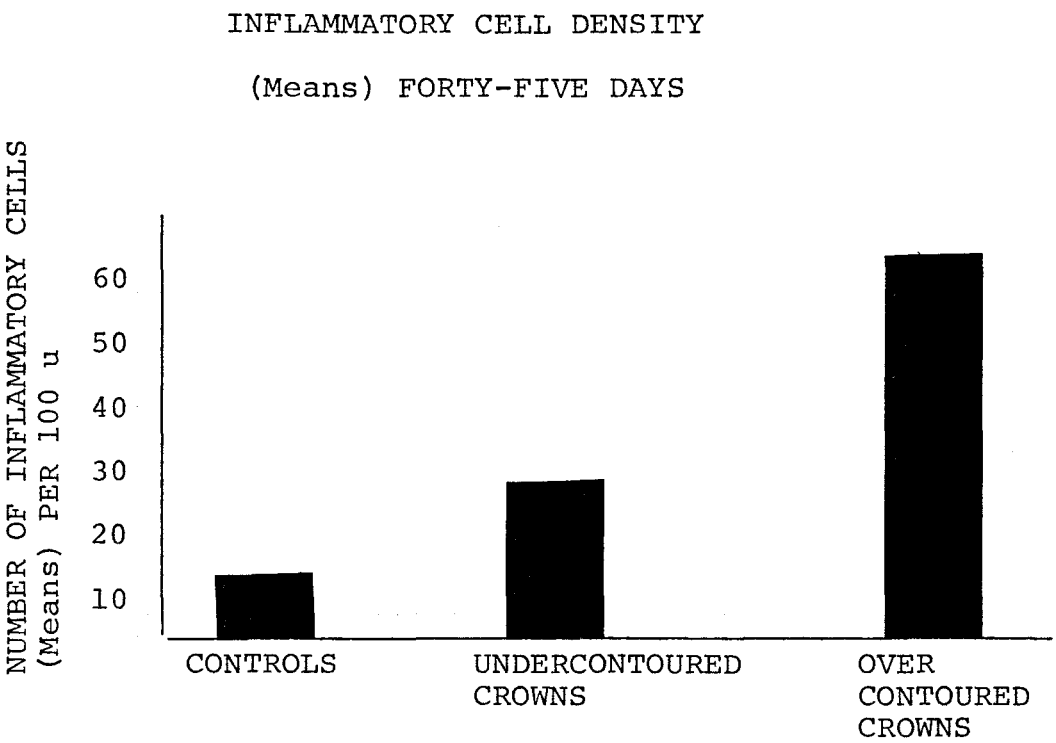
CONTROLS:

OVERCONTOURED:

UNDERCONTOURED:

CREVICULAR FLUID VOLUME:
PERIOTRON (Means)




INFLAMMATORY CELL DENSITY
(Means) FORTY-FIVE DAYS
NUMBER OF INFLAMMATORY CELLS
(Means) PER 100 u
60
50
40
30
20
10
CONTROLS
UNDERCONTOURED
CROWNS
OVER
CONTOURED
CROWNS

CHAPTER V

DISCUSSION

The main concern of the study was to determine the effects of varied axial contours of cast gold crowns on gingival tissue. The margins of these restorations terminated at or slightly above the gingival crest.

There has been much written on the subject of marginal termination of crown preparation and various schools of thought have emerged from these studies. After reviewing the literature on this subject one theme became evident. Preservation of teeth and prevention of dental disease were paramount. Because of the differences in each patient, perceptive clinical judgement was essential. The majority of studies agreed factors such as esthetics, age of patient, caries susceptibility, periodontal health, occlusal-gingival height and patient motivation had to be evaluated before deciding where to terminate the margins. Appropriate clinical judgement was critical for the success in dental therapy. From a periodontal point of view, it was best to avoid the gingival sulcus during crown preparation.

Silness (1970) found the gingiva around crowns with subgingival margins was more inflamed than the gingiva around crowns with supragingival margins. However, when clinical judgement dictates that margins should be below the gingiva, the perplexing question was just where to terminate the restoration.

Waerhaug (1960) attempted to answer that problem. He

noted if margins must be placed beneath the gingiva, they should not come close to the bottom of the pocket. Also, he decided the margin should be placed just below or beneath the gingival crest to avoid injuring the epithelium attachment. It had been established, the gingival pocket is not sterile. Since debris and plaque collects in this area, it became apparent a perfect fit or junction between casting and tooth preparation was of great importance.

Modern techniques such as the scanning electron microscope have given important information on marginal adaptation of cast crowns or restorations. Saltzberg (1976) used this instrument and noted a definite void occurred between margins of a restoration and the tooth preparation. These marginal defects permitted plaque formation. This demonstrated the "Perfect Clinical Union" does not exist and this void can provide a nidus for plaque accumulation. Ash and Gitlin, (1964) confirmed this when they found a high positive correlation between the degree of plaque and the degree of gingivitis.

It then can be inferred a restoration should avoid the distortion of the gingival crevice. The question then becomes what type and shape of restoration is best. Once again various opinions, concerning which biomechanical shape is needed to avoid and prevent injury to the gingival tissue, have emerged. Wheeler (1961) stated buccal and lingual curvature had great physiologic importance by deflecting food on to the keratinized gingiva. This was essentially the position of those who subscribed to a food impaction

theory as it related to axial crown curvatures. Herland and others (1962) found the rationale of muscular molding and cleansing rather than food impaction should be used as a guide for the construction of a restoration which would be well tolerated by the gingiva.

The literature was sparse as it related to axial contours of restorations. There had been more clinical or empirical description of establishing a criteria for a gingivally tolerated restoration. Perel (1971) and Sackett (1976) studied the effects of axial contour experimentally. Perel's work was conducted on six dogs. He altered the buccal and lingual convexities and created undercontoured teeth and overcontoured Class V acrylic restorations extending below the gingival crest. He concluded overcontouring produced inflammation and hyperplastic tissue changes. Sackett's study was done on human subjects and he attempted to determine the effects of axial crown overcontouring on the gingiva of adolescents. He concurred with Perel's findings: overcontouring predisposes gingival tissue to inflammatory disease. This study concurred with the findings of Perel and Sackett as to the effects of overcontouring on the gingival tissue. However, it was felt that no studies had been conducted to show what, if any, effects occurred when axial alterations were done when margins terminated at or slightly above the gingival crest. Great care was exercised in this experiment to avoid contacting the gingival tissue during instrumentation and impression technique.

Inflammatory response is the bodies reaction to noxious entity and the response can be recorded both subjectively and objectively. Oliver, Holm, Pedersen and Löe (1969) showed a definite correlation between clinical scoring, crevicular fluid volume measurement and histological evaluation of the gingiva. This present study which included these and other parameters of measurement suggested overcontouring can predispose gingival tissue to inflammatory change. However, the results of this experiment were confined to two animals, sixteen cast crowns and sixteen controls over a forty-five day period.

Since a positive correlation has been shown between bacterial plaque accumulation and gingival inflammation, this correlation becomes extremely important to biomechanical design. A restoration which either reduces plaque accumulation or provides accessibility for easy removal of plaque by the patient is desirable. This can be achieved by designing a restoration which reduces unphysiologic curvatures or contours. In order to achieve this adequate reduction of tooth structure is essential to achieve natural curvatures using various dental materials. This is especially important in the gingival third of the restoration. Excessive curvatures in this area aid bacterial plaque accumulation and can initiate gingivitis and predispose the caries or periodontal susceptible patient to further damage of dental structures. These factors can be controlled through constant awareness on the part of the clinician to these various entities. Transferring

this information in our dental prescription to the laboratory technician and seeing that it is carried out is the obligation of the dentist to the patient.

Further investigation is suggested:

1.) Longitudinal study to determine what effects axial alterations have on the epithelial attachment and osseous structure.

2.) At what point are the effects reversible?

3.) What other predisposing factors can influence the effects of axial alteration?

4.) Conduction of studies on human subjects.

5.) Duplication of these findings with more experimental animals and longer time period.

CHAPTER VI

SUMMARY

Two adult Rhesus female monkeys were used to investigate the effects of varied axial contours on the gingiva. Sixteen teeth were prepared to receive cast gold crown with margins terminating at or slightly above the gingival crest. Eight cast crowns were overcontoured and eight cast crowns were undercontoured. Each animal had four overcontoured and four undercontoured cast crowns. Eight teeth in each animal served as controls. Four parameters of measurements were employed, the Gingival Index, Plaque Index, crevicular fluid volume and inflammatory cell density. The periods of measurements were fourteen, twenty-eight and forty-five days.

The collected data of the four parameters was statistically evaluated by analysis of varience.

CHAPTER VII

CONCLUSIONS

1.) Parameters of measurements such as the Gingival Index, Plaque Index, crevicular fluid volume and inflammatory cell density were employed with consistent results.

2.) Overcontoured cast crowns with margins terminating at or slightly above the gingival crest had a deleterious effect on the gingival tissue.

3.) Undercontoured cast crowns with margins terminating at or slightly above the gingival crest did not effect the gingival tissue as much as overcontoured crowns.

4.) Undercontoured cast crowns were preferred to overcontoured cast crowns.

5.) Both overcontoured and undercontoured cast crowns had an adverse effect on the gingival tissue.

CHAPTER VIII

ILLUSTRATIONS

FIGURE 1: POLYSULFIDE RUBBER BASE IMPRESSION

FIGURE 2: PIN DEX MODEL PREPARATION WITH DIES MARKED

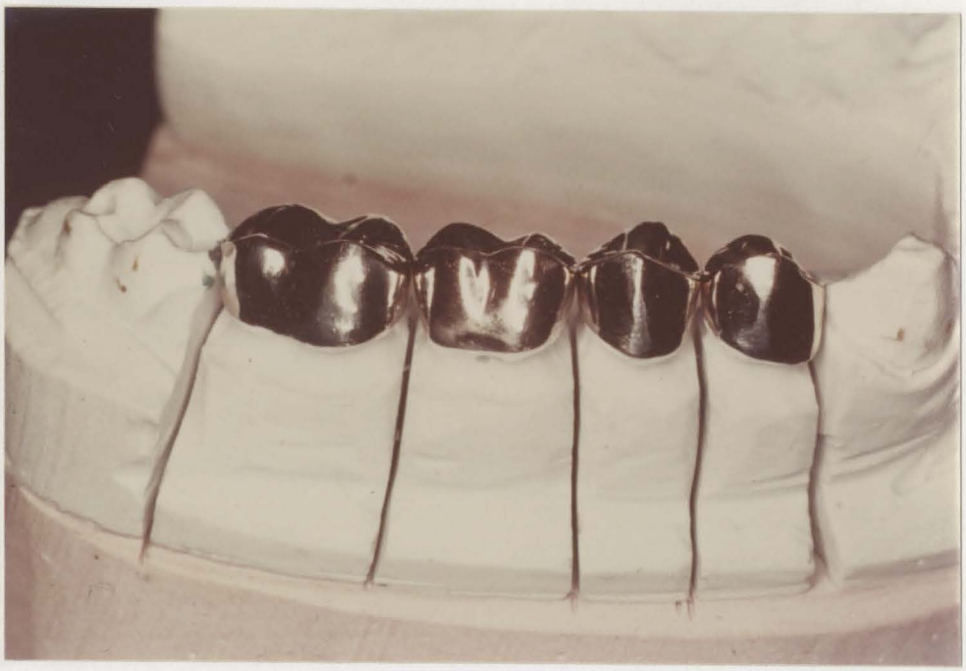


FIGURE 3: UNDERCONTOURED CAST GOLD CROWNS

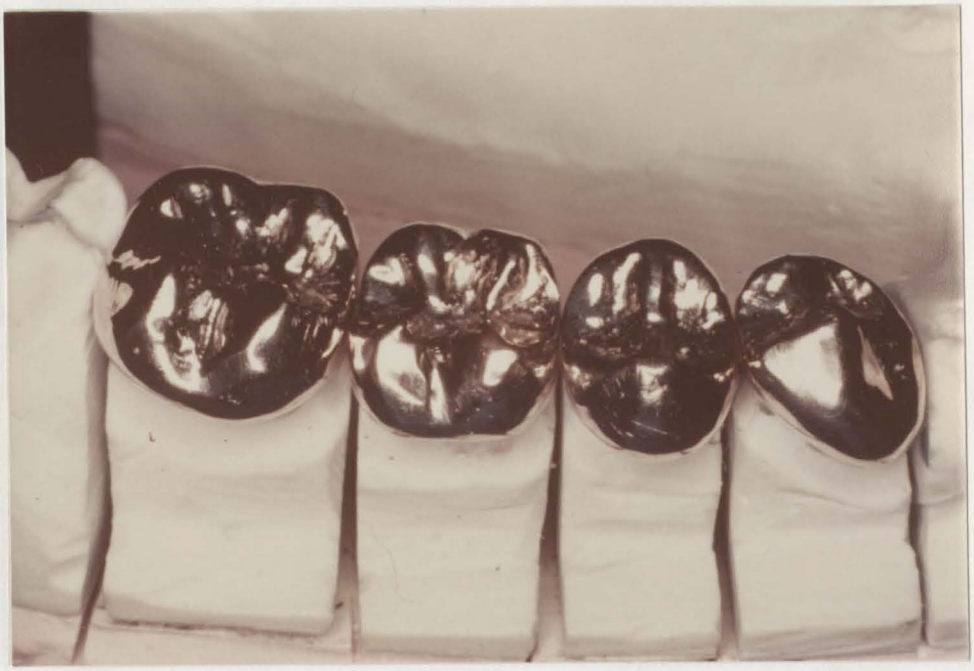


FIGURE 4: OVERCONTOURED CAST GOLD CROWNS

FIGURE 5: OVERCONTOURED GOLD CAST CROWNS FROM LINGUAL

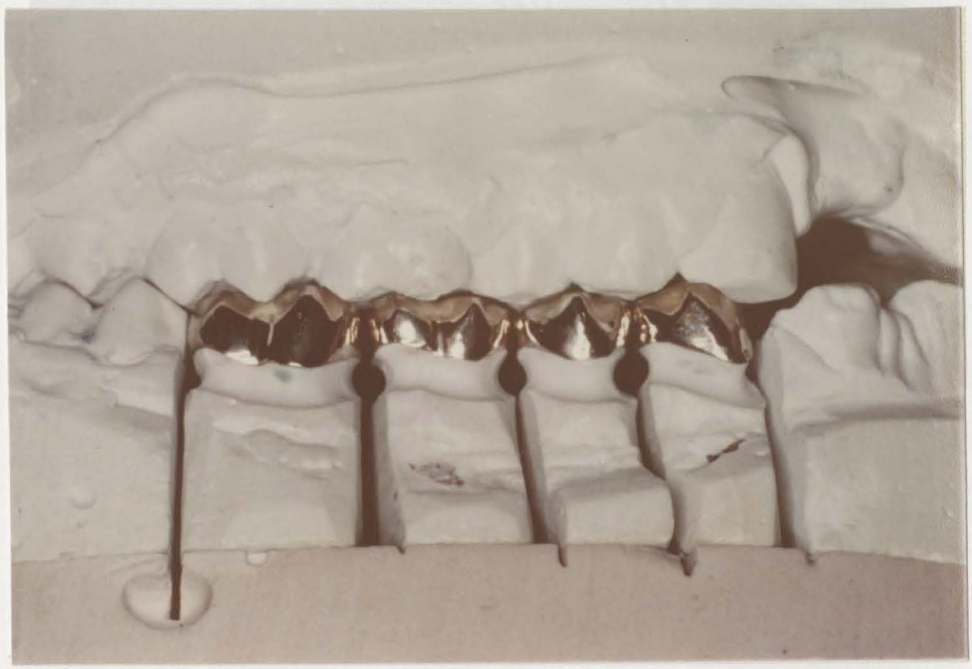


FIGURE 6: MODELS ARTICULATED

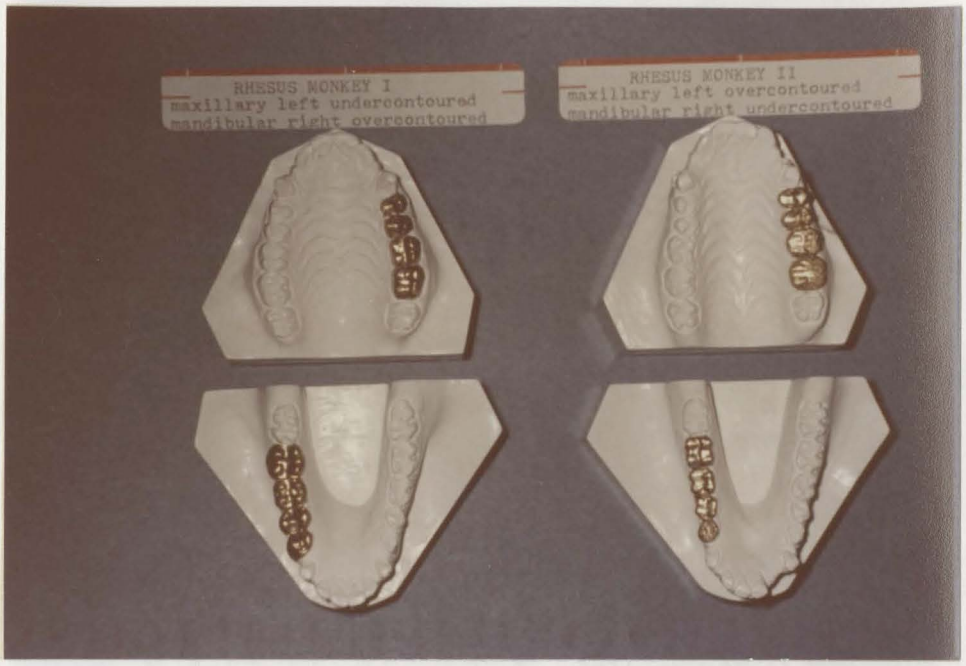


FIGURE 7: EXPERIMENTAL MODEL DESIGN

FIGURE 8: FORTY-FIVE DAYS
NORMAL APPEARING GINGIVA

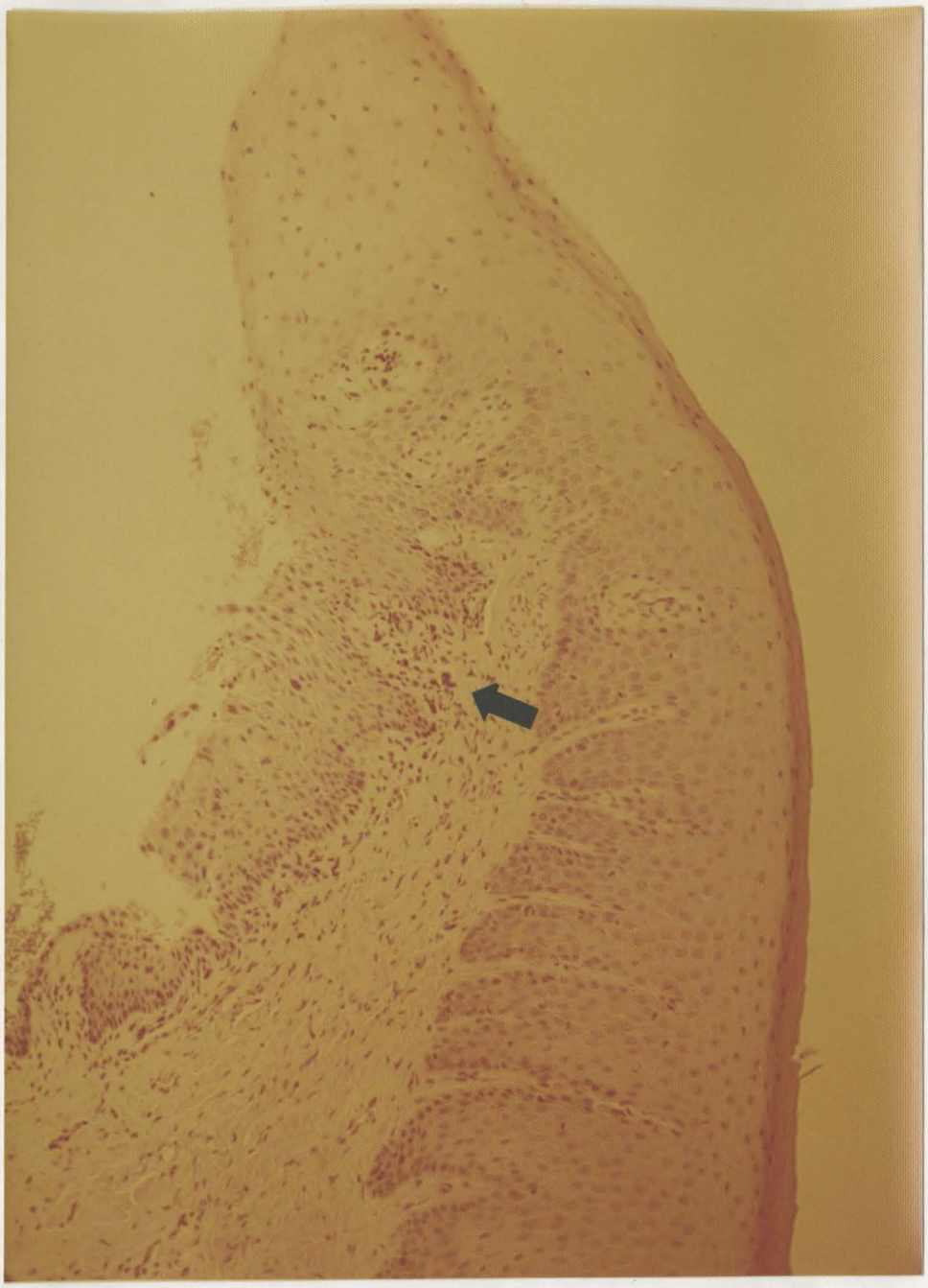


FIGURE 9: FORTY-FIVE DAYS

HISTOLOGICAL SECTION (45X)
NORMAL APPEARING GINGIVA

NOTE: INFLAMMATORY CELLS IN CONNECTIVE TISSUE (Arrow)

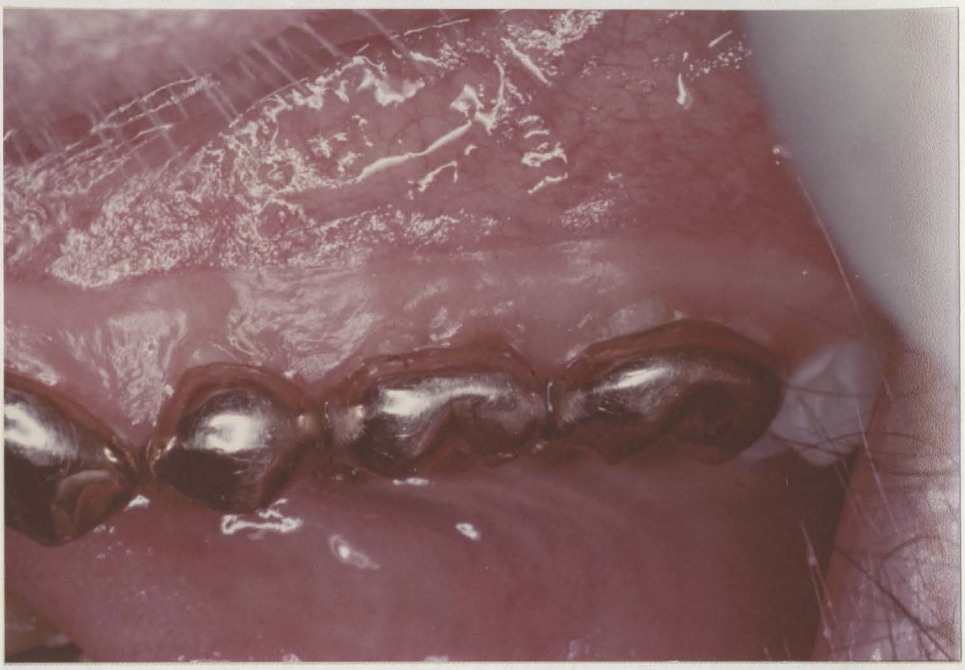


FIGURE 10: FORTY-FIVE DAYS

OVERCONTOURED CAST GOLD CROWNS

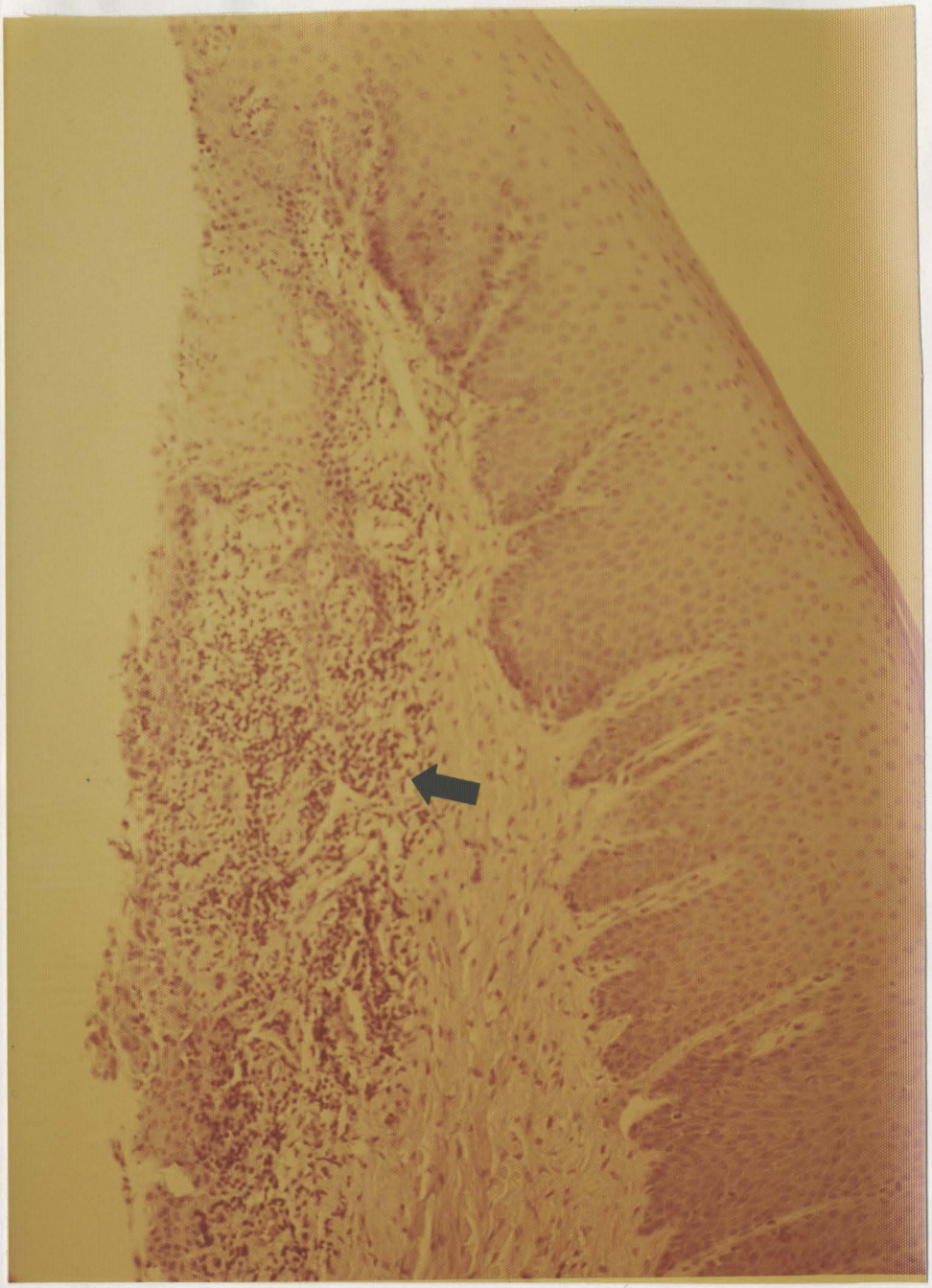


FIGURE 11: FORTY-FIVE DAYS

HISTOLOGICAL SECTION (45X)
GINGIVA ADJACENT TO OVERCONTOURED CAST GOLD CROWN

NOTE: SEVERE INFLAMMATORY RESPONSE
IN CONNECTIVE TISSUE (Arrow)

FIGURE 12: FORTY-FIVE DAYS

UNDERCONTOURED CAST GOLD CROWNS

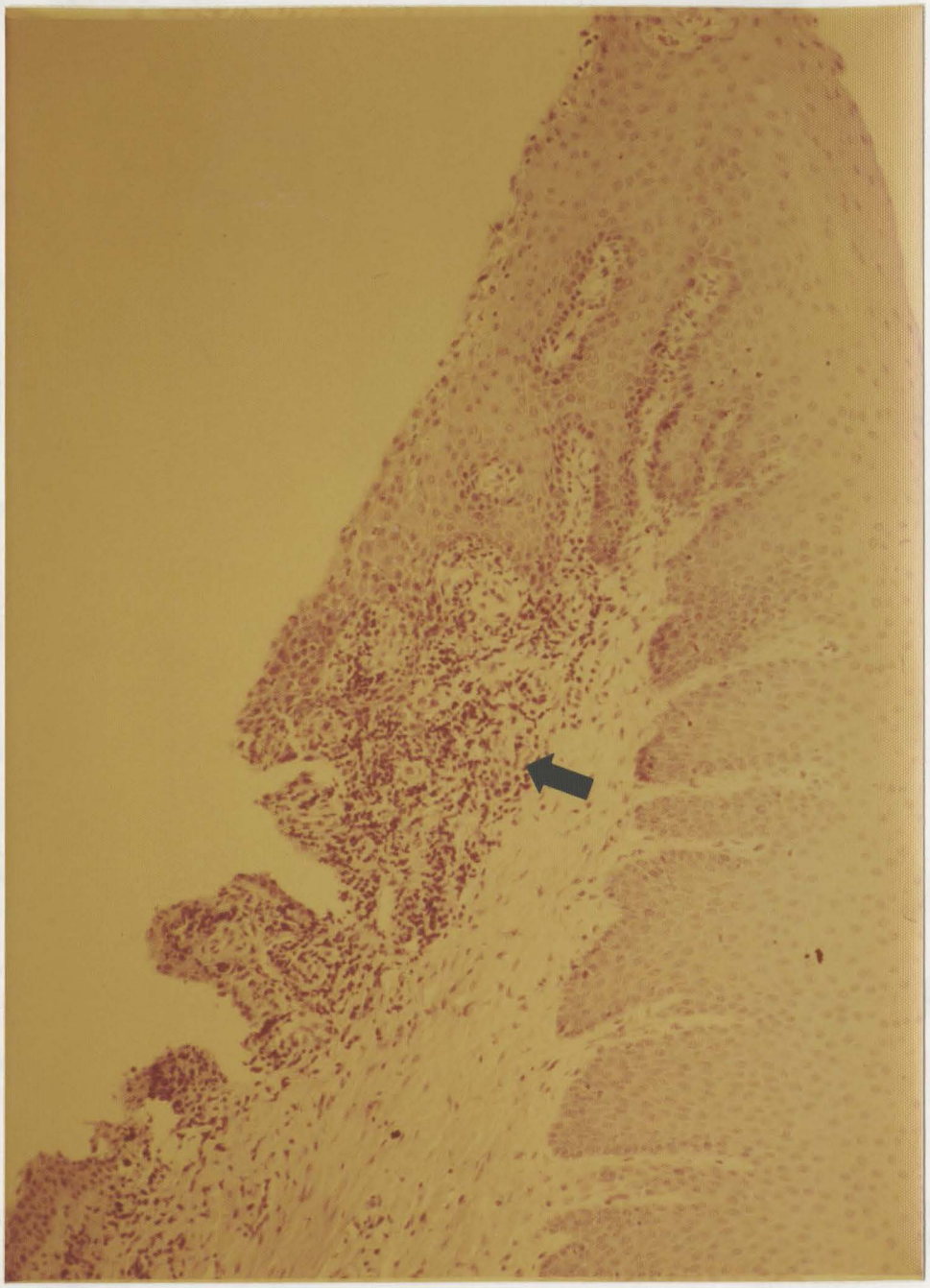


FIGURE 13: FORTY-FIVE DAYS

HISTOLOGICAL SECTION (45X)
GINGIVA ADJACENT TO UNDERCONTOURED CAST GOLD CROWN

NOTE: MODERATE INFLAMMATORY RESPONSE
IN CONNECTIVE TISSUE (Arrow)

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APPENDIX A

EXPERIMENTAL DATA:

PLAQUE INDEX, GINGIVAL INDEX AND PERIOTRON READINGS

ANIMALS I AND II

APPENDIX A

TABLE I

ANIMAL NUMBER I

Fourteen Days

TOOTH NUMBER:	2	3	4	5	12	13	14	15	18	19	20	21	28	29	30	31
PLAQUE INDEX																
Buccal	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
Mesial	1	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1
Lingual	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1
Distal	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1
Mean PI	.5	.25	0	.25	.25	0	0	0	.25	.5	.5	0	.25	.5	.75	1
GINGIVAL INDEX																
Buccal	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Mesial	1	1	0	1	1	1	1	1	0	1	0	0	2	2	2	2
Lingual	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
Distal	1	1	1	0	1	1	2	1	0	1	0	0	1	1	1	1
Mean GI	.5	.75	.25	.5	.5	.5	.75	.5	0	.5	.5	.25	1.25	1	1	1

APPENDIX A

TABLE II

ANIMAL NUMBER II

Fourteen Days

TOOTH NUMBER:	2	3	4	5	12	13	14	15	16	19	20	21	28	29	30	31
PLAQUE INDEX																
Buccal	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Mesial	0	0	0	0	2	1	1	1	0	0	0	0	0	0	0	0
Lingual	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
Distal	0	0	0	0	1	1	1	1	0	1	0	0	1	1	1	0
Mean PI.	.25	0	0	0	1	.5	.5	.5	0	.5	0	0	.25	.25	.5	0
GINGIVAL INDEX																
Buccal	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Mesial	1	1	1	0	2	2	2	2	2	1	0	1	1	1	1	1
Lingual	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Distal	1	1	1	1	2	2	2	2	1	1	2	1	1	1	1	1
Mean GI.	1	1	1	.5	1.5	1.5	1.5	1.5	1.25	1	.75	.75	.75	.75	.75	.75

APPENDIX A

TABLE III

ANIMAL NUMBER I

Twenty-eight Days

TOOTH NUMBER:	2	3	4	5	12	13	14	15	18	19	20	21	28	29	30	31
PLAQUE INDEX																
Buccal	1	0	0	2	0	0	0	2	0	0	1	0	0	0	1	1
Mesial	1	1	1	2	0	0	0	1	0	0	0	0	0	1	1	1
Lingual	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Distal	1	0	1	2	1	0	0	0	0	0	1	1	0	0	1	0
Mean PI.	.75	.25	.5	1.5	.25	0	0	.75	0	0	.5	.25	0	.25	1	.75
GINGIVAL INDEX																
Buccal	0	1	2	2	1	0	0	1	0	0	0	1	2	1	2	2
Mesial	1	2	3	2	2	1	1	1	1	1	1	1	2	2	2	2
Lingual	0	0	1	1	1	1	1	1	0	1	1	0	1	1	1	1
Distal	1	2	3	3	2	1	1	1	1	2	2	2	2	2	2	2
Mean GI.	.5	1.25	2.25	2	1.5	.75	.75	1	.5	1	1	1	1.75	1.5	1.75	1.75

APPENDIX A

TABLE IV

ANIMAL NUMBER II

Twenty-eight Days

TOOTH NUMBER	2	3	4	5	12	13	14	15	18	19	20	21	28	29	30	31
						PLAQUE INDEX										
Buccal	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1
Mesial	1	1	0	0	3	1	1	1	0	1	0	1	1	1	1	0
Lingual	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Distal	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
Mean PI	.25	.25	0	0	1	1	.5	.25	0	.25	0	.5	.5	.25	.25	.5
						GINGIVAL INDEX										
Buccal	0	1	0	1	1	1	1	0	1	1	1	1	1	1	0	0
Mesial	2	1	1	1	2	2	2	1	1	1	1	1	1	2	1	1
Lingual	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1
Distal	1	1	1	1	2	1	2	1	0	1	1	0	2	2	1	1
Mean GI	.75	.75	.5	.75	1.5	1.25	1.5	.75	.75	.75	.75	.75	1.25	1.5	.75	.75

APPENDIX A

TABLE V

ANIMAL NUMBER I

Twenty-eight Days

PERIOTRON READING

UNDERCONTOURED			OVERCONTOURED		
Tooth Number			Tooth Number		
12	1	(.005 ul.)	28	4	(.02ul.)
13	0	(0)	29	5	(.025 ul.)
14	0	(0)	30	3	(.015 ul.)
15	0	(0)	31	6	(.03 ul.)
CONTROL					CONTROL
18	0	(0)	2	0	
19	0	(0)	3	8	(.04 ul.)
20	1	(.005 ul.)	4	0	
21	0		5	1	(.005 ul.)

APPENDIX A

TABLE VI

ANIMAL NUMBER II

Twenty-eight Days

PERIOTRON READING

UNDERCONTOURED			OVERCONTOURED		
Tooth Number			Tooth Number		
2	4	(.02 ul.)	12	10	(.05 ul.)
3	1	(.005 ul.)	13	18	(.09 ul.)
4	1	(.005 ul.)	14	8	(.04 ul.)
5	8	(.04 ul.)	15	15	(.075 ul.)
CONTROL			CONTROL		
18	20	(.1 ul.)	28	0	
19	0		29	0	
20	0		30	0	
21	2	(.01 ul.)	31	0	

APPENDIX A

TABLE VII

ANIMAL NUMBER I

Forty-five Days

TOOTH NUMBER:	2	3	4	5	12	13	14	15	18	19	20	21	28	29	30	31
PLAQUE INDEX																
Buccal	1	1	0	1	0	0	1	1	0	0	0	0	0	0	1	1
Mesial	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1
Lingual	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Distal	1	0	1	1	0	0	1	1	0	0	0	0	0	1	1	0
Mean PI.	.75	.5	.5	.75	0	0	.5	.75	0	0	.25	0	.25	.75	.75	.5
GINGIVAL INDEX																
Buccal	0	0	1	1	1	1	1	2	0	1	0	0	2	1	1	1
Mesial	1	1	1	2	1	1	2	2	0	1	0	0	1	2	1	1
Lingual	1	0	0	0	1	1	1	1	1	0	0	0	1	1	1	1
Distal	1	1	1	2	1	2	2	3	0	0	1	0	2	2	2	1
Mean GI.	.75	.5	.75	1.25	1	1.25	1.50	2	.25	.5	.25	0	1.5	1.5	1.25	1

APPENDIX A

TABLE VIII

ANIMAL NUMBER II

Forty-five Days

TOOTH NUMBER	2	3	4	5	12	13	14	15	18	19	20	21	28	29	30	31
PLAQUE INDEX																
Buccal	0	0	0	1	1	1	2	1	0	1	0	1	0	0	0	1
Mesial	1	1	0	1	0	1	1	1	0	0	1	1	1	1	0	1
Lingual	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Distal	1	0	0	0	1	1	2	1	1	0	0	0	1	1	1	1
Mean PI	.5	.25	0	.5	.75	.75	1.25	.75	.25	.25	.25	.5	.5	.5	.25	.75
GINGIVAL INDEX																
Buccal	1	1	1	1	3*	2	2	1*	1	0	0	0	1	1	1*	1*
Mesial	0	2	1	1	3	3	3	2	0	1	1	1	1	2	1	1
Lingual	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1
Distal	1	1	1	1	3	3	3	2	1	1	1	1	2	2	1	1
Mean GI	.5	1	.75	.75	2.5	2.25	2.25	1.5	.5	.5	.5	.75	1.25	1.5	1	1

*Noted gingival recession of 2mm

APPENDIX A

TABLE IX

ANIMAL NUMBER I

Forty-five Days

PERIOTRON READING

UNDERCONTOURED			OVERCONTOURED		
Tooth Number			Tooth Number		
12	4	(.02 ul.)	28	10	(.05 ul.)
13	6	(.03 ul.)	29	12	(.06 ul.)
14	0		30	52	(.26 ul.)
15	0		31	49	(.245 ul.)
CONTROL			CONTROL		
18	1	9.005 ul.)	2	0	
19	0		3	0	
20	0		4	0	
21	0		5	1	9.005 ul.)

APPENDIX A

TABLE X

ANIMAL NUMBER II

Forty-five Days Termination

PERIOTRON READINGS

UNDERCONTOURED			OVERCONTOURED		
Tooth Number			Tooth Number		
2	1	(.005)	12	17	(.085)
3	6	(.03)	13	35	(.175)
4	1	(.005)	14	13	(.065)
5	1	(.005)	15	7	(.035)
CONTROL			CONTROL		
18	10	(.05)	28	4	(.02)
19	0		29	0	
20	0		30	0	
21	0		31	1	(.005)

APPENDIX B

BUCCAL-LINGUAL MEASUREMENTS AT HEIGHT OF GREATEST CURVATURE: ANIMALS I AND II

APPENDIX B

TABLE I

ANIMAL NUMBER I

BUCCAL-LINGUAL MEASUREMENTS AT HEIGHT OF GREATEST CURVATURE

Tooth Number	Before Preparation	Preparations	Cast Crown Measurement (Undercontoured)
12	6.2 mm.	5.5 mm.	6.2 mm.
13	6.4 mm.	5.5 mm.	6.2 mm.
14	6.6 mm.	6.5 mm.	6.4 mm.
15	7.0 mm.	6.8 mm.	6.5 mm.
			(Overcontoured)
28	5.0 mm.	4.5 mm.	6.5 mm.
29	5.0 mm.	4.6 mm.	6.5 mm.
30	5.9 mm.	5.5 mm.	7.5 mm.
31	6.6 mm.	5.7 mm.	9.0 mm.

APPENDIX B

TABLE II

ANIMAL NUMBER II

BUCCAL-LINGUAL MEASUREMENTS AT HEIGHT OF GREATEST CURVATURE

Tooth Number	Before Preparation	Preparation	Cast Crown Measurement (Overcontoured)
12	5.0 mm.	4.5 mm.	7.0 mm.
13	5.5 mm.	4.5 mm.	7.5 mm.
14	6.0 mm.	5.2 mm.	8.0 mm.
15	7.0 mm.	6.0 mm.	9.0 mm.
			(Undercontoured)
28	4.0 mm.	3.2 mm.	4.0 mm.
29	4.5 mm.	4.0 mm.	5.0 mm.
30	5.5 mm.	4.9 mm.	5.5 mm.
31	6.0 mm.	5.2 mm.	6.0 mm.

APPENDIX C

ANALYSIS OF VARIANCE

APPENDIX C

TABLE I

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS CONTROL VERSUS UNCERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0052	.0052	0.12	.72
Within	22	.9296	.0422		
Total	23	.9348			

APPENDIX C

TABLE II

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS CONTROLS VERSUS UNDERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.000	.000	.00	1.0
Within	22	1.851	0.084		
Total	23	1.851			

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TABLE III

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.000	.000	.00	1.0
Within	22	2.781	.1264		
Total	23	2.781			

APPENDIX C

TABLE IV

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0325	.0325	0.16	0.69
Within	22	4.582	.2082		
Total	23	4.614			

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TABLE V

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0010	.001	2.11	0.16
Within	22	.0105	.0004		
Total	23	.0115			

APPENDIX C

TABLE VI

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0325	.0325	0.45	0.50
Within	22	1.582	.0719		
Total	23	1.614			

APPENDIX C

TABLE VII

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	2.755	2.755	27.51	0.0001
Within	22	2.203	0.100		
Total	23	4.958			

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TABLE VIII

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.000042	.000042	.24	0.62
Within	22	.00385	.00017		
Total	23	.00390			

APPENDIX C

TABLE IX

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS CONTROL VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	1.020	1.020	18.91	.0003
Within	22	1.1875	0.0539		
Total	23	2.2083			

APPENDIX C

TABLE X

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS CONTROL VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	2.083	2.083	21.18	.0001
Within	22	2.164	.0983		
Total	23	4.247			

APPENDIX C

TABLE XI

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	0.4218	0.4218	2.71	0.11
Within	22	3.4296	0.1558		
Total	23	3.8515			

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TABLE XII

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	1.417	1.417	6.81	0.01
Within	22	4.582	0.208		
Total	23	6.00			

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TABLE XIII

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS CONTROL VERSUS OVERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0044	.0044	6.22	0.02
Within	22	.0155	.0007		
Total	23	.0199			

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TABLE XIV

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	0.8138	.8138	11.78	0.002
Within	22	1.519	.0690		
Total	23	2.33			

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TABLE XV

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	6.750	6.750	43.50	.0001
Within	22	3.414	0.155		
Total	23	10.164			

APPENDIX C

TABLE XVI

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS OVERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0709	.0709	25.56	.0001
Within	22	.0610	.0027		
Total	23	.1319			

APPENDIX C

TABLE XVII

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	V Prob
Between	1	0.878	0.878	16.58	.0011
Within	14	0.7421	.053		
Total	15	1.621			

APPENDIX C

TABLE XVIII

ANALYSIS OF VARIANCE TABLE

FOURTEEN DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	1.5625	1.5625	40.0	.0001
Within	14	0.5468	.0390		
Total	15	2.109			

APPENDIX C

TABLE XIX

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	0.316	0.316	2.79	0.11
Within	14	1.585	0.113		
Total	15	1.902			

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TABLE XX

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.7656	0.7656	6.66	.0218
Within	14	1.609	.1149		
Total	15	2.375			

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TABLE XXI

ANALYSIS OF VARIANCE TABLE

TWENTY-EIGHT DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.00722	.00722	19.76	.0006
Within	14	.00511	.00036		
Total	15	.01234			

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TABLE XXII

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

PLAQUE INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.3906	.3906	4.67	.048
Within	14	1.171	.0837		
Total	15	1.562			

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TABLE XXIII

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

GINGIVAL INDEX

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.6601	.6601	3.19	.09
Within	14	2.898	.2070		
Total	15	3.558			

APPENDIX C

TABLE XXIV

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS

PERIOTRON

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	.0506	.0506	11.97	.0038
Within	14	.0592	.0042		
Total	15	.1098			

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TABLE XXV

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS UNDERCONTOURED CROWNS

FOR INFLAMMATORY CELL DENSITY

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	1436.64	1436.64	7.80	0.010
Within	22	4049.47	184.06		
Total	23	5486.11			

APPENDIX C

TABLE XXVI

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS CONTROL VERSUS OVERCONTOURED CROWNS

FOR INFLAMMATORY CELL DENSITY

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	16030.83	16030.83	41.82	.0001
Within	22	8433.55	383.34		
Total	23				

APPENDIX C

TABLE XXVII

ANALYSIS OF VARIANCE TABLE

FORTY-FIVE DAYS UNDERCONTOURED VERSUS OVERCONTOURED CROWNS FOR INFLAMMATORY CELL DENSITY

Variance Source	DF	Sum of Squares	Mean Squares	F Value	F Prob
Between	1	11804.16	11804.16	28.38	.0001
Within	30	12476.91	415.897		
Total	31	24281.07			

APPROVAL SHEET

The thesis is submitted by Joseph L. Caruso, D.D.S., has been read and approved by the following Committee:

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

4/17/79
Date

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