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Effect of Self-Curing Acrylic Treatment Restorations on the Crevicular Fluid Volume

Patrick Harold Garvin
Loyola University Chicago

EFFECT OF SELF-CURING ACRYLIC TREATMENT RESTORATIONS ON THE CREVICULAR FLUID VOLUME

By

Patrick H. Garvin, D.D.S.

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DEDICATION

In loving memory of my Father

Harold J. Garvin

For the years of support and encouragement

To my wife, Regina, and my sons and daughters,

Jim, Joan, Karen, Patricia, John, and Paul

To my Mother, Marion

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I wish also to thank my Mother and Father for their encouragement and sacrifice that made my education possible.

A special thanks to my wife, Regina, for her untiring support and love; and to my family.

VITA

The author, Patrick Harold Garvin, is the son of Harold James Garvin and Marion (Fitzpatrick) Garvin. He was born April 7, 1933, in Bartlesville, Oklahoma.

His elementary education was obtained from Holy Family and Immaculate Conception parochial schools in Tulsa, Oklahoma. His secondary education was at St. Mary's School and Newton High School, Newton, Kansas, where he graduated in 1951.

In September, 1951, he entered the University of Kansas.

In the fall of 1954, he entered Northwestern University Dental School, and received his Doctor of Dental Surgery degree in 1958. He is a member of the Delta Sigma Delta dental fraternity.

He was a dental intern at the Veteran Administration Research Hospital, Chicago, Illinois, from the summer of 1958 to the summer of 1959.

In the summer of 1959, he entered private dental practice. He is a past member of the Board of Directors for the Fox River Valley Dental School.

In 1977, he entered the postgraduate clinical specialty training program in Fixed Prosthodontics and the graduate program in Oral Biology at Loyola University Dental School, Maywood, Illinois.

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INTRODUCTION

One of the prime goals of the dentist is to help maintain the oral health of the patient. And in his efforts to properly restore the dentition, the clinician needs to have a thorough understanding of the effects the procedures, techniques, materials, and final restorations have on the oral health of the patient. Such knowledge permits a more intelligent approach to the proper selection of material and the establishing of sound manipulative procedures. Strict and careful attention must be paid to the satisfactory placement of gingival margins and contouring of restorations. The maintenance of a healthy periodontium is a main objective of the clinician.

Treatment restorations are required to protect and maintain the vitality of the pulp, restore occlusal relationships, provide stability to the teeth, provide a satisfactory esthetic substitute and maintain the integrity of the periodontal tissues.

There are certain limitations, however, inherent to temporization. Namely, these limitations are: 1) lack of inherent strength, 2) poor marginal adaptation, 3) color instability, 4) poor wear properities, 5) detectable odor emission, 6) inadequate bonding characteristics, 7) poor tissue response, 8) difficult cement removal, and, 9) time needed for fabrication can be prohibitive.

It is understood that an increase in the gingival crevicular fluid is an early indication of gingival inflammation, even before

clinical signs become evident. (Loe and Holm-Pederson, 1965). Until recently, it was difficult to measure or guage this gingival crevicular fluid quantitatively. Now by means of a crevicular fluid master developed by Harco Electronics* which electronically measures minute fluid volume, this can be accomplished in a standardized manner.

The purpose of this investigation was to determine the effect of self-curing acrylic treatment restorations (temporization) on the gingival sulcus area after complete crown preparation by measuring the gingival crevicular fluid volume using the crevicular fluid meter.

* Harco Electronics Limited, Winnipeg, Canada

REVIEW OF THE LITERATURE

In G.V. Black's (1887) histological description of the periodontal membrane, he referred to a very peculiar system of cells resembling those of the lymphatics, which clustered about the principal fibers of the membrane. These cells, which he called salivary corpuscles, were found under the free border of the gingiva and they were "augmented" with every irritation of the membrane. He noted these cells were first affected in salivation with mercury. Black (1899) described loops of glands, running lengthwise to the root and anastomosing freely and ceasing in a rather thick mass before reaching the gingival border. He concluded from this study these glands were easily disturbed by certain drugs such as mercury and iodine and they were often disturbed by poisonous substances floating in the bloodstream. He felt "phagedenic pericementitis" had its beginning in these glands.

Bodecker (1933) in his investigation of dental erosion and its possible causes concluded the gingival fluid was acid in dentitions suffering from traumatic occlusion. He found there was more gingival fluid from the crevices around teeth with erosion.

Waerhaug (1953) noted after injecting India ink into gingival pockets, that within one hour transudation of fluid and the emigration of leucocytes through the pocket epithelium took place. Within three hours the leucocytes took up the grans of ink; and after three

days all the ink had disappeared. Waerhaug differed from Gottlieb's theory of the presence of an organic connection between the epithelium and tooth surface. He felt this was a histologic concept and that it did not coincide with the clinical observations. Waerbaug agreed with G.V. Black's concept, the gingiva was closely fitted around the tooth and preferred the term epithelial cuff to epithelial attachment. He felt it was possible for the gingiva to defend itself against injury such as a temporary ingress of bacteria on a matrix band.

Waerhaug (1952) concluded the flow of gingival fluid in the pocket was in a coronal direction, and the gingival fluid originated from the blood serum. In healthy gingival tissues the flow of gingival fluid was very slight. His investigation showed pockets without calculus or deposits were as a rule sterile. He also felt it possible to obtain bacteria free pockets around artificial crowns where no bacterial retention possibilities existed.

Hagerman (1955) described the connective tissue fibers of the free gingiva as a "dynamic, living, responsive tissue functioning as a protective cover for the underlying periodontium."

Jensen and Zanders (1958) believed the effects of cementing material on the gingival tissue showed the poor marginal seal of a restoration contributed to gingival irritation. With poor adaptation there developed plaque and bacterial accumulation which caused gingival irritation.

Brill and Bjorn (1959) administered fluorescein orally to

humans and by collection on filger paper strips were able to detect it in the gingival-sulcular fluid. They found the quantity of fluorescein recovered on the strips increased with an increase in the severity of gingival inflammation. Also, patients with extensive dental restorations showed more fluorescein in the gingival sulcus than clinically healthy gingiva adjacent to non-restored teeth. Their study showed the fluid in the gingival pocket originated from interstitial fluid and increased with gingival irritation and disease.

Brill (1959) injected dogs with Evan's Blue, a dye that binds to plasma proteins; and concluded plasma proteins passed through capillary walls and entered the gingival sulcus in increased amounts as a result of gingival irritation and inflammation and mechanical stimulation.

In a separate study, Brill and Krasse (1959) again working with dogs, showed brief mechanical stimulation of clinically healthy pockets provoked and increased flow of tissue fluid through pocket epithelium.

Brill (1959) demonstrated chewing paraffin produced an increase in gingival tissue flow.

In a study involving dogs, Brill (1959) concluded gingival tissue fluid washed away particulate matter and bacteria from pockets.

Brill (1960) performing an immuno-electrophoretic study of

tissue fluid from gingival pockets found the fluid which ordinarily flows through the epithelial cuff into human gingival pockets contains at least seven different proteins, corresponding to those of normal human serum. He, therefore, believed the source of this gingival fluid was tissue fluid. Ordinarily the fluid was confined within the body by epithelium and drains away as lymph. This study indicated the gingival fluid drained through the epithelial cuff into the gingival pockets. This observation supported the contention gingival fluid, 1) arose from the bloodstream, 2) passed through connective tissue, and 3) entered the gingival pockets through the epithelium.

Krasse (1960) demonstrated a marked flow of gingival fluid from gingival pockets with marginal gingivitis. This investigation was performed on dogs, in which the consistency of the diet was also altered. He noted a harder consistency produced an increase in the gingival flow.

Waerhaug (1960) demonstrated the remarkable healing capacity of the epithelial attachments. He noted there was a certain leakage of fluid constantly going on. He viewed this as a defense mechanism. Again he emphasized the epithelial attachment was actually an epithelial cuff that envelops the tooth by the circular collagenous ribers and the blood pressure within the capillaries. He stated emphatically "the normal gingival pocket is only a potential pocket. It opened up when instruments were inserted, but it closed again when they were

taken out." In the histologic section the potential pocket was not experienced as an open space.

Orban (1960) refuted Waerhaug's conception of the lack of attachment. He preferred to use the term attached epithelial cuff.

Lie (1961) in describing the physiological aspects of the gingival pocket, believed there was a continuous transudation of tissue fluid into the clinically normal gingival pocket. This was in agreement with the observation made by Brill. Loe also agreed it originated from blood. No glands could be demonstrated in the area so the fluid can not be a product of secretion. He noted mitotic figures along the entire length of the non-keratinized epithelial lining of the pocket and the desquamation of the surface cells supported the view that the epithelial cuff was constantly renewed.

Krasse and Egelberg (1962) analyzed the Na/K ratio of human gingival fluid and from their results concluded the gluid in the gingival crevice was an inflammatory exudate.

Egelberg (1963) in this study applied histamine (an inflammatory mediator) to the gingiva of humans and dogs and found there was an increased permeability and the flow of fluid in the sulcus increased.

Egelberg (1963) concluded fluid from healthy pockets could be considered an inflammatory exudate and not a simple filtration product.

Mann (1963) collected gingival fluid from human subjects on

filter paper strips and concluded severity of gingival inflammation was the main factor determining the rate of fluid flow.

Loe and Holm-Pederson (1965) concluded: 1) healthy gingival crevices did not exhibit fluid flow, 2) crevicular fluid began prior to the appearance of any clinical changes, and 3) monitoring fluid flow provided the clinician with a more sensitive technique for detecting early gingivitis than waiting for clinical signs to develop.

Nagao (1967) studied the influence of prosthetic appliances upon the flow of crevicular tissue fluid and concluded the insertion of crowns increased crevicular fluid flow and poor fitting crowns resulted in more crevicular fluid than crowns that fit well.

Listgarten (1967) demonstrated the oral epithelium had the ability to reconstitute an attachment apparatus after gingival surgery similar to the one in the normal state. There were hemidesmosomes and basement lamina and cuticular structure present in the newly formed epithelial attachment. To achieve this, no reduced enamel epithelium was needed.

Gavin (1968) studying the ultrastructure of the crevicular epithelium of cat gingiva concluded there existed a peculiar permeability of the gingival crevice region of the oral mucosa to tissue fluid and leucocytes. He found the intercellular spaces were wide and extended as a continuous network from the basal lamina to the epithelial surface. One important difference of this epithelium

in comparison with other epithelium was the continuity of its intercellular spaces with the oral cavity and the presence within it of large numbers of leucocytes. He theorized the wide intercellular spaces could be a route for the inward passage of materials through the epithelium.

Sandalli and Wade (1969) concluded scaling, polishing and supervised oral hygiene reduced gingival fluid flow. In addition, they also found there was a considerable reduction in gingival fluid flow four weeks after periodontal surgery, at which time the crevicular epithelium has had a chance to become re-established.

Schwartz (1971) studied gingival reaction to different types of tooth accumulated materials and found the most severe reaction occured with plaque on calculus, followed by bacterial plaque.

Alfano (1974) performed an interesting and detailed study on the origin of gingival fluid. He contended plaque and bacterial by-products establish a osmotic gradient which initiated gingival exudation. This was a pre-inflammatory exudate, which could progress from osmotically-modulated exudate to a secondary inflammatory exudate. A change in composition occured with this. Some of Alfano's conclusions were (and these were in agreement with other workers), "1) gingival fluid may be recovered from clinically and histologically healthy tissues, 2) the intercellular spaces in the sulcular epithelium dilated during inflammatory exudation, 3) gingival fluid-flow increased several days prior to clinical inflammation, 4) the

Na/K ratio of the pre-inflammatory gingival fluid was comparable to an inflammatory exudate but the protein composition of this fluid was lower than an inflammatory exudate, 5) gingival inflammatory exudation was associated with interruption in the basement membrane, 6) the protein/Ca ratio increased in the gingival fluid from increasingly inflammed tissues, and 7) the flow of gingival fluid increased concurrently with the accumulation of dental plaque."

Cimasoni (1974) concluded his monograph with the following statement: "measuring the intensity of gingival fluid flow was probably the most reliable and sensitive procedure for a quantitative evaluation of gingival inflammation. The measurements should, however, always be made using standardized techniques."

Waerhaug (1978) noted the junctional epithelium becomes readapted to the tooth surface in areas that had been previously covered with subgingival calculus and plaque.

Demetrion (1978) found a similar composition between gingival and mixed and parotid salivary IGA content. The presence of immunoglobulins in the crevicular fluid tended to support the contention the fluid played a role in a defense mechanism.

In more clinically related literature, in regard to crown restoration and gingival reactions, we found Wheeler (1931) expressed a strong awareness of the function of the cervical tissue and the importance of proper management of this area in complete crown restorations. He recognized the cervical margin was the most difficult

and perhaps the most important part of crown preparation. He recommended leaving 1mm of enamel above the normal attachment if possible.

Ewing (1954) stressed the point temporary cements should be chosen for their ability to be insoluble in oral fluids. Patients must practice exceptionally good hygiene while wearing treatment restorations.

Chestner (1954) emphasized the margins of self-curing acrylic resin treatment restorations should be trimmed carefully, and that the interproximal spaces should be relieved to allow for proper hygiene and to prevent irritation to the gingival tissues. He advocated using zinc oxide eugenol resin cement for cementing temporarily.

Amsterdam (1959) stated "treatment restorations should not only protect and maintain the integrity of the pulpal and periodontal tissues, but in addition, should restore occlusal relationships, provide stability to the teeth, and afford the patient maximum comfort and function." An important characteristic of a treatment restoration was it should protect the cervical areas from irritation.

Morris (1962) developed the muscle action theory or muscular molding. He felt the flow of serum was increased by heavy muscular action and hard foods. He stressed trying to duplicate the natural contours of the cervical region, especially in the area one-half millimeter above the gingival crest. His concepts agreed with those of Wheeler. He emphasized also the importance of embrasure

contours, proper development and placement of the contact point.

Herlands (1964) advocated the clinician wait six to eight weeks after the completion of periodontal surgery before proceeding with the fixed restoration procedures. This was to allow for the epithelization of the gingival tissue. In regard to treatment restorations, he felt it was important to keep the margin away from the gingiva and with the embrasure sufficiently open to allow for cleaning and stimulation.

Marcum (1967) found the margins of crown restorations that were even with the gingival crest produced the least inflammatory response from the gingival tissues. Margins that were located above and below caused the most inflammation.

Klecinic (1968) stressed the need to eliminate all irritants to the gingiva, to restore tooth form deformities, the proper patient care and hygiene in preparation of restorative dentistry for periodontally comprised dentitions.

Perel (1971) in studying the periodontal considerations of crown contours, concluded deflective contours are not desirable. Deflective contours resulted in lack of stimulation of the gingiva along with food and plaque accumulation. This resulted in an inflammation of the gingiva.

Skurow (1971) stressed the importance of minimizing the irritation to gingival tissues.

Berman (1973) concluded the success or failure of complete

crown restorations was determined by how well a clinician handled the soft tissues. He noted two basic requirements for successful tissue retraction. One, the tissue should be normal, and two, it should be capable of repair. He described a beveled shoulder preparation technique which provided the proper space for a gold collar marginal termination without infringing on the soft tissues. He concluded generally normal gingiva creeps over and covers the thin walled gold collars of complete crowns. Whereas, abnormal tissue fails to respond to preparation, retraction and impression making. When the abnormal tissue heals, recession and exposure of terminal margins of the preparation results.

Trivedi (1973) concluded most gingival inflammation adjacent to restorative materials was possibly due to imperceptible roughness, debris, defective margins or chemical injury.

Richter (1973) concluded from his study involving margin placement the fit and finish of full crown restorations was more important than whether the margin was supra or sub-gingival.

Nemetz (1974) emphasized the need to condition the soft tissues prior to final preparations. He stressed the importance of proper instrumentation and proper tissue retraction.

Borden (1974) measured human crevicular fluid flow using the Harco fluid meter to compare extracrevicular and intracrevicular collection techniques. Their results showed: 1) repeated intracrevicular measurements gave similar gingival fluid flow rates,

2) the three seconds intracrevicular measurement of crevicular fluid flow was more sensitive than the extracrevicular technique, 3) repeated intracrevicular measurements did not significantly stimulate fluid flow, 4) the recommended technique for measuring crevicular fluid with GCF meter involves initially emptying the crevicular pool with a paper strip followed by a thirty seconds interval and three seconds placement of a fresh filter paper strip for measurement, and 5) measuring gingival crevicular fluid flow was an objective method for monotiring gingival inflammation. They stated the intracrevicular measurement was a more satisfactory technique."

Volchansky (1974) using a scanning electron microscope studied surface roughness of enamel, cementum, amalgam, gold inlay, porcelain fused to gold and calculus. The conclusion was, "enamel is probably the smoothest and most acceptable surface in the mouth, and all natural and restored surfaces should be compared to it."

Jameson (1976) in comparing the crevicular fluid volumes of restored and non-restored teeth, found a statistically significant difference between them. He concluded the placement of subgingival margins resulted in a predictable degree of inflammation. This degree of inflammation was considered indigenous to complete crown restorations placed subgingivally.

Mac Entee, Bartlett, and Loadholt (1978) studied the gingival tissue response to three currently used temporary acrylic resin crown. The three types of crowns were the cold cure acrylic con-

structed on a cast and polymerized in a pressure cooker and relined with acrylic in the mouth after the completion of the preparation. The second type was fabricated on a cast, but not relined with acrylic in the mouth. And the third type was constructed directly on the prepared tooth in the mouth, using an al alginite impression as a matrix. They measured sulcus depth, noted the gingival index and performed a biopsy. Their investigation showed no detectable change in the gingiva over a three week period from any of the three temporary crowns.

METHODS AND MATERIALS

Thirty-one patients requiring full crowns were randomly selected ranging in age from seventeen years to sixty-three years of age. Nineteen of the thirty-one patients were females.

Before the crown preparation was performed, the tooth was isolated with cotton rolls and gently dried with a warm air syringe. A crevicular fluid reading was taken at the mesial-buccal and distal-buccal surface near the papilla of the tooth to be prepared.

The gingival sulcus was emptied first by using a sterile moisture absorbent filter paper strip (Periopaper - Harco) and inserted with cotton forceps into the gingival sulcus for three seconds. A period of twenty-seven seconds was allowed to elapse. Then another filter strip was inserted into the evacuated crevice for three seconds. This 'exposed' filter strip was then carefully placed between the fluid sensors of the Periotron instrument. The filter paper strip is inserted to the line marked on each filter strip. A read out screen on the instrument would indicate electronically a quantitative measurement of the fluid collected. By taking this value from the screen and dividing by 200, the amount of fluid collected could be transposed into micro-liters. Pocket depth was also noted for each reading location. A gingival index determination was made using a Loe and Silness gingival index.

Loe and Silness

Criteria for the Gingival Index System

0 = Absence of inflammation.

1 = Mild inflammation -- slight change in color and little change in texture.

2 = Moderate inflammation -- moderate glazing, redness, edema, and hypertrophy. Bleeding on pressure.

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

After recording the data, the crown preparation was completed. The treatment restoration was fabricated using a self-curing acrylic (ethyl methacrylate) material and was cemented using a zinc-oxide-eugenol type of cement (Fynal) or (Opotow).

At approximately two weeks later, the treatment restoration was carefully removed and the crevicular fluid was again measured, duplicating the procedure used before. The pocket depth and gingival index was also noted.

Two weeks after final cementation of the crown, a third set of crevicular fluid readings were taken. The pocket depth and gingival index was again noted.

All readings were performed by the investigator. All the preparations and procedures were performed by the investigator except for one patient. No previous restoration existed at the site the crevicular fluid reading was taken.

Figure 1. Periotron (Clinical GCF Meter - Harco Electronics LTD, Winnipeg, Canada.)

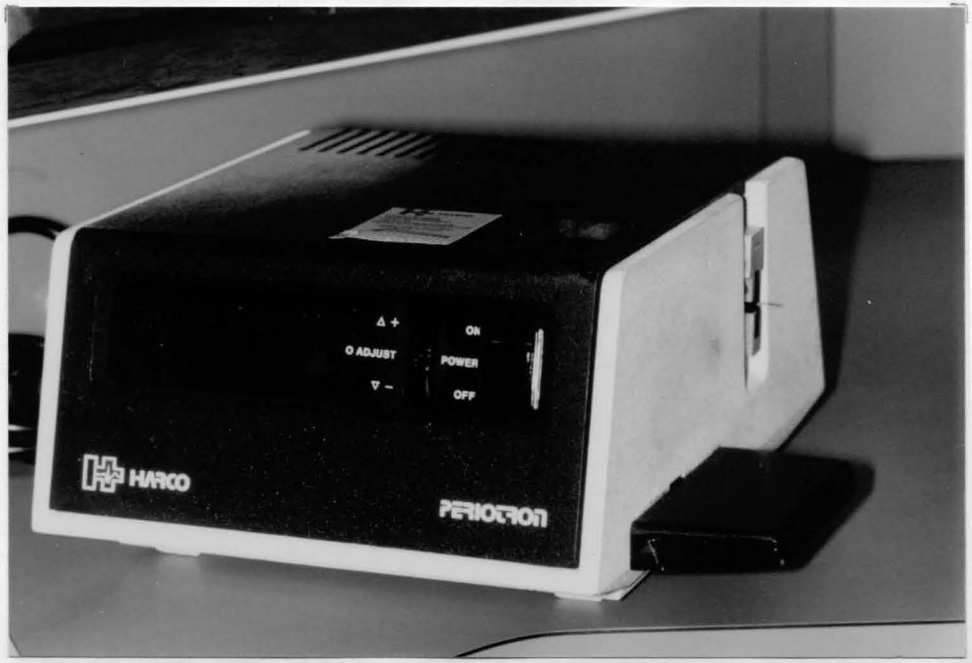

Figure 2. Periotion (Clinical GCF Meter - Harco Electronic LTD, Winnipeg, Canada.)

Figure 3. Sterile Filter Paper Strips (Periopaper - Harco Electronics LTD, Winnipeg, Canada.)

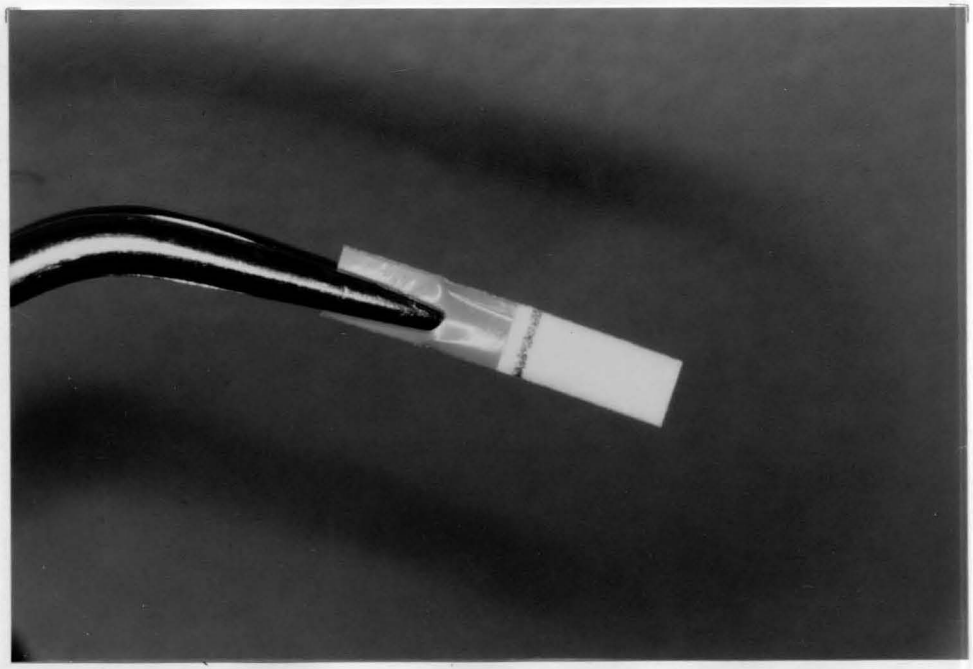

Figure 4. Filter Paper Strip Prior to Collection of Crevicular Fluid.

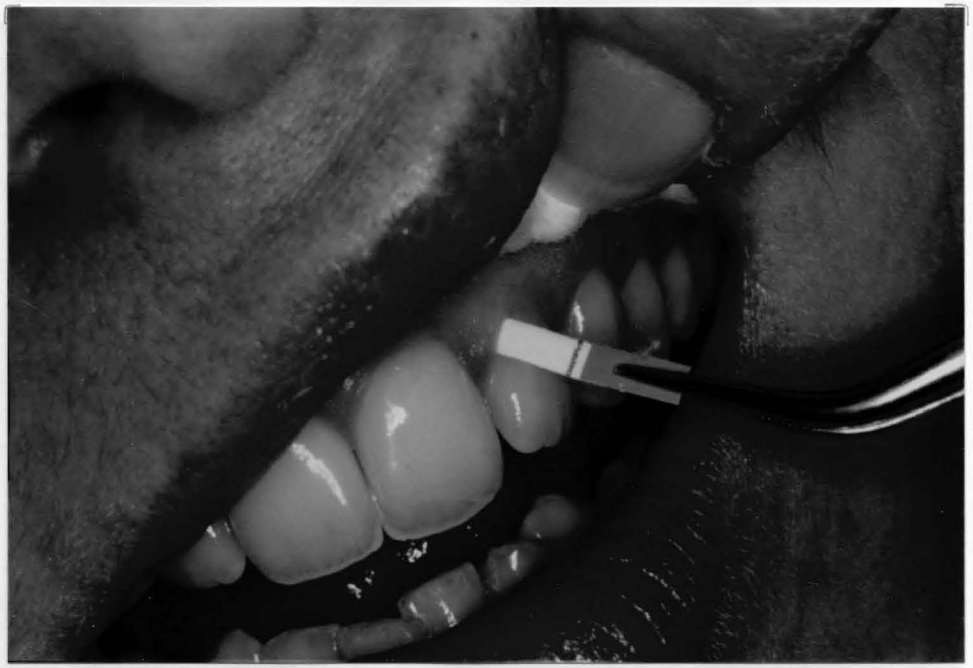

Figure 5. Gingival Fluid Collection Technique From a Patient Before Preparation.

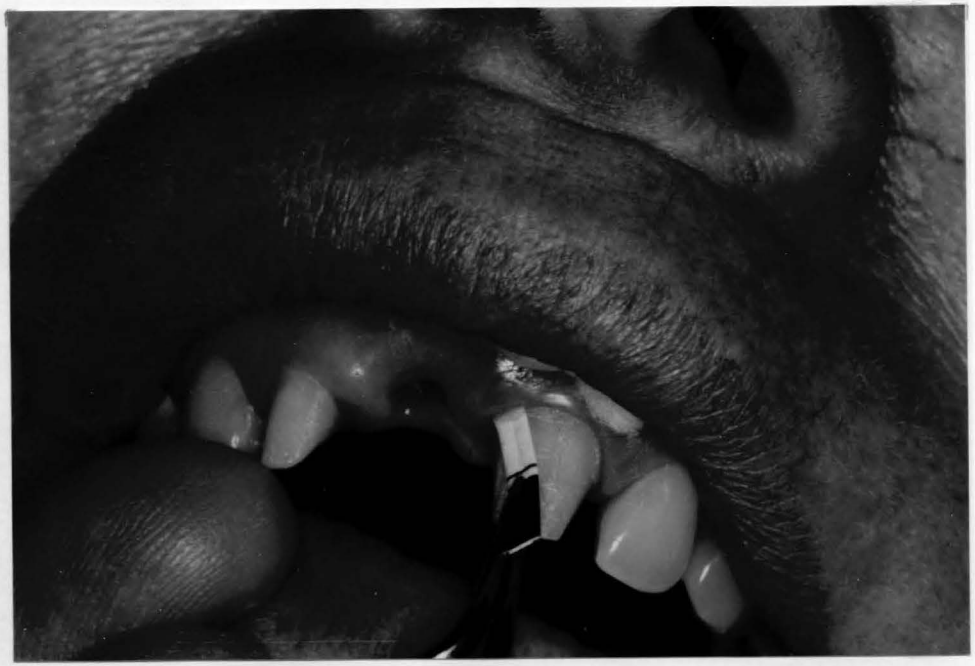

Figure 6. Gingival Fluid Collection Technique From a Patient With Treatment Restoration Removed.

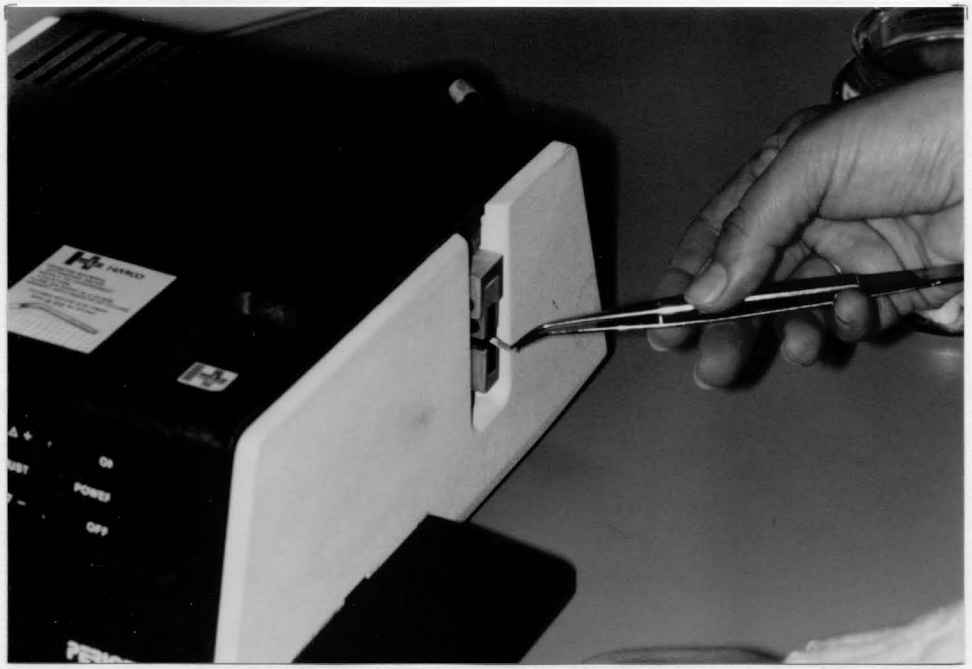

Figure 7. Placing Filter Paper Between Recording Sensors.

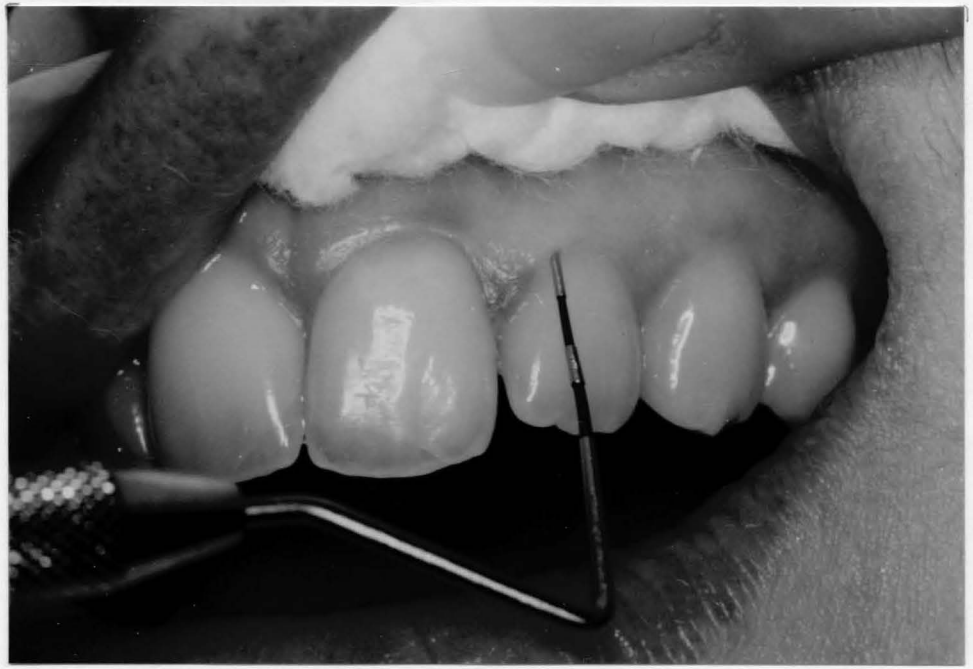

Figure 8. Measuring Sulcus Depth (After Collecting GCF).

Formula for Ethyl Methacrylate: $H_2C = \underset{\underset{CH_3}{|}}{C} - C = O - OC_2H_5$

RESULTS

Table one is the compiled data before treatment listing the patient's number, age, sex, tooth number, the restorative material, mesial fluid volume, mesial gingival index, mesial pocket depth, distal fluid volume, distal gingival index, distal pocket depth, fluid volume average, (average of the mesial and distal measures), and fluid volume average expressed in micro-litres.

Table two is the corresponding compiled data at the time the treatment restoration was removed.

Table three is the compiled data taken approximately two weeks after final cementation.

Table four is the analysis of variance table for the average crevicular fluid volume and time, showing a highly significant F value of 30.75 between the different times.

Table five lists the means for the average fluid volumes for each time, together with their standard deviations.

Table six shows the follow-up t-tests comparing time 1 to time 2, time 2 to time 3, and time 1 to time 3. There was a highly significant difference between time 1 and time 2 ($P < .01$), and between time 2 and time 3 ($P < .01$), but no significant difference between time 1 and time 3.

Average pocket depth and average fluid volume showed very little correlation (Pearson correlation coefficient, $r = .046$). The F

value for this correlation was 0.19 which is not significant.

The depth measurements were stable over time and showed no direction. This was demonstrated by an analysis of variance for average depth and time. This analysis produced a F value of 1.88 which is not significant.

It would seem the treatment restoration was a significant factor in causing gingival irritation. However, gingival irritation and inflammation was considered a reversible process in this study.

This investigation was designed using only one particular kind of material (a self-curing acrylic resin, ethyl methacrylate*) for the fabrication of the treatment restoration. The margins were placed either at the crest of the gingiva or slightly subgingivally.

* Parkell Company

TABLE I

Before Treatment

COMPILED DATA

Patient#	Age	Sex	Tooth#	Rest've Material	Mes. Fl.Vol.	Ging. Index	Pocket Depth	Dist. Fl.Vol.	Ging. Index	Pocket Depth	Fl.Vol. Aver.	u/litres
1	46	F	21	P/M	7	0	2	10	0	2	8.5	.042
2	51	F	12	P/M	5	0	1	0	0	1	2.5	.012
3	37	F	19	FCC	1	0	.5	9	0	1	5	.025
4	41	F	30	FCC	3	0	1	3	0	1	3	.015
5	42	F	20	P/M	1	0	.5	13	0	2	7	.035
6	36	M	19	FCC	10	0	2	4	0	1.5	7	.035
7	55	F	28	P/M	2	0	1	8	0	1	5	.025
8	52	F	7	P/M	2	0	1.5	3	0	1.5	2.5	.012
9	52	F	9	P/M	5	0	1	7	0	1.5	6	.03
10	45	M	29	FCC	5	0	1	14	0	3	9.5	.047
11	45	F	13	P/M	3	0	2	4	0	1	3.5	.017
12	52	M	13	P/M	6	0	1.5	13	0	2	9.5	.047
13	55	F	20	P/M	6	0	2	11	1	3	8.5	.042
14	39	M	19	FCC	7	0	2.5	5	0	3	6	.03
15	45	F	21	AVC	1	0	1	5	0	1	3	.015
16	37	F	31	FCC	4	0	1.5	7	1	3	5.5	.027
17	37	F	28	AVC	2	0	1	10	0	0	6	.03
18	63	F	10	P/M	6	0	1.5	6	0	2	6	.03
19	40	M	19	FCC	11	0	3	12	0	3	11.5	.057
20	32	F	13	P/M	10	0	2.5	4	0	2	7	.035
21	26	M	30	FCC	10	0	2.5	11	0	2.5	10.5	.052
22	37	M	2	FCC	13	2	3	14	2	3	13.5	.067
23	17	M	14	FCC	5	0	.5	9	0	.5	7	.035
24	46	M	18	FCC	9	0	2	6	0	2	7.5	.037
25	31	F	18	FCC	4	1	2	6	1	2	5	.025
26	55	M	10	P/M	9	1	3	10	1	3	9.5	.047
27	49	F	8	P/M	7	1	1	6	0	1	6.5	.032
28	49	F	9	P/M	4	0	1	5	0	1	4.5	.022
29	48	F	19	FCC	3	0	1	3	0	1	3	.015
30	42	M	3	P/M	5	0	.5	14	1	3	9.5	.047
31	42	M	5	P/M	1	0	.5	7	0	1	4	.02

TABLE II

Treatment Restoration

COMPILED DATA

Patient#	Age	Sex	Tooth#	Rest've Material	Mes. Fl.Vol.	Ging. Index	Pocket Depth	Dist. Fl.Vol.	Ging. Index	Pocket Depth	Fl.Vol. Aver.	u/litres
1	46	F	21	Snap	5	0	2	8	0	2	6.5	.032
2	51	F	12	Snap	1	0	1	8	0	1	4.5	.022
3	37	F	19	Snap	11	0	.5	21	0	1	16	.08
4	41	F	30	Snap	23	1	1	14	1	1	18.5	.092
5	42	F	20	Snap	31	1	1.5	27	1	1.5	29	.145
6	36	M	19	Snap	6	0	2	23	1	1.5	14.5	.072
7	55	F	28	Snap	11	0	1	13	0	1	12	.06
8	52	F	7	Snap	4	0	1.5	7	0	1.5	5.5	.027
9	52	F	9	Snap	6	0	1	2	0	1.5	4	.02
10	45	M	29	Snap	3	0	2	15	0	2.5	9	.045
11	45	F	13	Snap	7	2	3	3	1	2.5	5	.025
12	52	M	13	Snap	12	0	1.5	23	1	2	17.5	.087
13	55	F	20	Snap	15	1	2	16	1	2	15.5	.077
14	39	M	19	Snap	19	1	1.5	16	1	1	17.5	.087
15	45	F	21	Snap	8	0	1	12	0	1	10	.05
16	37	F	31	Snap	6	0	1	16	0	1	11	.055
17	37	F	28	Snap	16	0	1	10	0	1	13	.065
18	63	F	10	Snap	10	0	1	28	1	1	19	.095
19	40	M	19	Snap	26	0	1	36	1	1.5	31	.155
20	32	F	13	Snap	31	2	1	25	1	1.5	28	.14
21	26	M	30	Snap	16	1	1.5	40	2	2	28	.14
22	37	M	2	Snap	18	1	1.5	20	1	1.5	19	.095
23	17	M	14	Snap	8	0	.5	34	1	2	21	.105
24	46	M	18	Snap	17	1	1	29	0	1	23	.115
25	31	F	18	Snap	37	1	1	16	1	1	26.5	.132
26	55	M	10	Snap	9	0	3	20	1	3	14.5	.072
27	49	F	8	Snap	6	1	1	4	0	1	5	.025
28	49	F	9	Snap	1	0	1	5	0	1	3	.015
29	48	F	19	Snap	32	1	3	8	0	1	20	.1
30	42	M	3	Snap	10	2	.5	22	1	2	16	.08
31	42	M	5	Snap	28	2	2	24	1	1	26	.13

TABLE III

Two Weeks After Final Cementation — COMPILED DATA

Patient#	Age	Sex	Tooth#	Rest've Material	Mes. Fl.Vol.	Ging. Index	Pocket Depth	Dist. Fl.Vol.	Ging. Index	Pocket Depth	Fl.Vol. Aver.	u/litres
1	46	F	21	P/M	8	0	2	23	0	2	15.5	.077
2	51	F	12	P/M	5	0	1	2	0	1	3.5	.017
3	37	F	19	FCC	2	0	.5	4	0	1	3	.015
4	41	F	30	FCC	6	1	1	8	1	1	7	.035
5	42	F	20	P/M	5	0	1	2	0	1.5	3.5	.017
6	36	M	19	FCC	3	0	1	6	1	3	4.5	.022
7	55	F	28	P/M	1	0	1	10	0	1	5.5	.027
8	52	F	7	P/M	6	0	1.5	6	0	1.5	6	.03
9	52	F	9	P/M	3	0	1	7	0	1.5	5	.025
10	45	M	29	FCC	9	1	2.5	20	1	3	14.5	.072
11	45	F	13	P/M	5	0	2	7	0	2	6	.03
12	52	M	13	P/M	10	0	2	9	0	1	9.5	.047
13	55	F	20	P/M	3	1	1	12	1	2	7.5	.037
14	39	M	19	FCC	10	0	2.5	11	0	3	10.5	.052
15	45	F	21	AVC	11	0	1	23	2	1.5	17	.085
16	37	F	31	FCC	5	0	1	5	0	1	5	.025
17	37	F	28	AVC	13	0	1.5	7	0	2	10	.05
18	63	F	10	P/M	3	0	2	3	0	1.5	3	.015
19	40	M	19	FCC	17	0	1.5	6	0	3	11.5	.057
20	32	F	13	P/M	8	0	1	7	0	2	7.5	.037
21	26	M	30	FCC	7	1	2	8	0	2	7.5	.037
22	37	M	2	FCC	9	0	1.5	9	0	1.5	9	.045
23	17	M	14	FCC	7	0	1	9	0	1.5	8	.04
24	46	M	18	FCC	3	0	1	7	0	1	5	.025
25	31	F	18	FCC	13	2	3	9	2	1.5	11	.055
26	55	M	10	P/M	5	0	3	9	0	3	7	.035
27	49	F	8	P/M	0	0	1.5	2	0	1	1	.005
28	49	F	9	P/M	1	0	1.5	5	0	1.5	3	.015
29	48	F	19	FCC	5	0	2	8	0	1	6.5	.032
30	42	M	3	P/M	7	1	.5	18	1	1	12.5	.062
31	42	M	5	P/M	16	1	1	14	1	1	15	.075

TABLE IV

ANALYSIS OF VARIANCE

	DF	SS	MS	F
Subjects	30	.0314	.001	
Time	2	.0389	.019	30.75
Error (Subjects x Time)	60	.0380	.0006	

TABLE V

AVERAGE FLUID VOLUMES AND STANDARD DEVIATIONS

Means - Fluid Volume Average in u/litres

Time 1 = .03274 Standard Deviation .044

Time 2 = .07887 Standard Deviation .046

Time 3 = .03887 Standard Deviation .020

$H_o = u_1 = u_2 = u_3$

TABLE VI

T-TEST

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\frac{2}{N} \times \text{MS error}} = \frac{2x(.0006)}{31} = .00639$$

$$t_{1-2} = \frac{.046}{.00639} = 7.196 \qquad P < .01$$

$$t_{2-3} = \frac{.040}{.00639} = 6.258 \qquad P < .01$$

$$t_{1-3} = \frac{.006}{.00639} = .94 \qquad \text{No significance}$$

DISCUSSION

The clinician in this study fabricated the treatment restoration using a self-curing acrylic (ethyl methacrylate) material. A stiff wax impression was taken before the start of the preparation. The acrylic was adapted to the preparation directly in the mouth using the wax impression as a matrix. After the final set of the acrylic, the margins were refined, and the restoration was polished. Zinc oxide-eugenol cement was used to cement the treatment restoration.

In this investigation, the crevicular fluid volume showed a highly significant difference $P < .01$ in comparing readings taken before preparation and the readings taken at the time the treatment restoration was removed. There was no significant difference in comparing readings taken before preparation and the readings taken approximately two weeks after final cementation. It would seem the treatment restoration was a significant factor in causing gingival irritation, and the gingival irritation and inflammation was a reversible process.

Since one of the prime goals in treatment was to establish and maintain a healthy periodontal environment, the clinician should endeavor to minimize gingival irritation. Adequate instrumentation and adherence to the principles of sound tooth preparation were considered fundamental in achieving a successful final result. Obviously the treatment restoration is a vital link in the chain of procedures.

The goal of the clinician should be to minimize the amount of gingival irritation brought on by the instrumentation, retraction and materials; and keep the response within the perimeter of healing and adaptation.

In regard to treatment restorations, the requirements and functions are:

1. protect and maintain the vitality of the pulp.
2. should maintain and stabilize the tooth's position in the dental arch.
3. should not cause undue irritation to the gingival tissue.
4. should be functional in occlusion.
5. should be reasonably esthetic.
6. should be constructed so the patient can maintain proper hygiene.
7. should be strong enough to withstand reasonable forces and function.
8. should be able to be constructed within a reasonable amount of time.
9. should be able to be polished sufficiently to minimize plaque formation and retention.
10. should resist thermal conductivity.

The limitations of treatment restorations were discussed in the Introduction. There are several different types of materials that can be used for temporization. Namely, they are: (taken from Tylman's)

1. cast metal (precious and nonprecious)
2. aluminum shell and copper band temporization
3. preformed commercially processed metal crowns
4. cellulose acetate crown matrix and polycarbonate crown forms
5. heat-cured acrylic
6. cold-cured acrylic
7. template (Omnivac)
8. post-crown technique

Various techniques can be utilized to fabricate short-term biologically acceptable interim restorations.

The clinician in fabricating a treatment restoration should allow enough time in the procedure to properly fit, adapt, and contour the restoration. Care should be taken to minimize irritation to the gingival tissues by making sure no excess cement is left in the crevice. The interval of time the patient wears the treatment restoration should be as short as possible.

The gingival sulcus area and the dento-epithelial junction comprise a zone that is vital, active and is a functional unit.

The gingival sulcus is the shallow groove around the tooth, bounded by the surface of the tooth and the epithelium lining the free margin of the gingiva. The average depth of the normal healthy sulcus is approximately .5mm.

The epithelial lining of the sulcus is a thin, nonkeratinized, stratified squamous epithelium. There are no rete pegs; therefore

the various components of the vascular beds, arterioles, capillaries and venules are located in a more superficial position in relation to the surface of the epithelium. The epithelial lining acts as a semi-permeable membrane; allowing the fluid to pass from the connective tissue to the sulcus. This is a characteristic of non-keratinized epithelium where the shifting of fluids from one compartment to a-nother takes place. Brill and Bjorn demonstrated this passage of tissue fluid in human gingiva using fluorescein in 1959. They found the passage of fluid took place whether there was inflammation present or not. Loe's findings in 1961 supported this also; prin-cipally there is a continuous transudation of tissue fluid into a clinically normal gingival pocket. It has been shown the volume of fluid increased with an increase in inflammation, however. This quantitative flow into the sulcus took place before clinical signs were evident. The origin of the fluid was from blood. There were no glands in the area as was originally thought.

This increase and disturbance of local fluid exchange was due to an increase in capillary blood pressure and local vasodilation, open capillaries, increased permeability of the endothelial wall and a change in the osmotic pressure due to the escape of plasma proteins. This was substantiated by work of Brill (1959) and Alfano (1974) in separate investigations.

The dynamics of the gingival sulcus was interesting and is basically one of defense. The gingival fluid helped to cleanse

noxious and foreign material from the sulcus, possessed antimicrobal properties, seemed to exert an antibody defense, and the sticky plasma proteins apparently improved adhesion of the epithelial attachment to the tooth.

Investigations performed by Waerhaug, seemed to indicate there was no firm organic union between the tooth and the free gingiva. When foreign substances were introduced into the free gingival pocket, they were removed by an increased transudation of fluid and an emigration of leucocytes. Anytime, anything is placed in the gingival sulcus there is distinct change in the vascular permeability of the sulcular epithelium. Complete healing of the free gingiva followed.

When other irritants such as calculus were removed, satisfactory healing with readherence of epithelial cells and gingival readaption took place.

The gingival sulcus is an adaptative, vital and functional area. With proper insight, it will work in our behalf. O. Stuteville used to teach, "be kind to the tissues and they will be kind to you."

SUMMARY

Crevicular fluid volume measurements were taken from thirty-one patients randomly selected from private practice during complete crown preparations.

A significant difference was observed in the volume measurements taken before preparation and those taken when the treatment restoration was removed. No significant difference, however, was noted between the volume measurements taken before preparation and those taken two weeks after final cementation.

It seems reasonable to conclude from the results of this study that treatment restorations caused a significant increase in the crevicular fluid volume. This would indicate an inflammatory process was underway.

Part of this response could certainly be attributed to the instrumentation during preparation and the retraction of the gingival tissues.

However, if the clinician exercised care in his preparation, retraction methods and in the fabrication of the treatment restoration, as well as providing an acceptable final restoration this initial inflammatory response will and can be a reversible one. The gingival sulcus is an adaptative, vital and functional area.

In order to keep irritation at a minimum, the dentist should endeavor to refine the marginal adaptation, avoid overhands, contour

the restoration properly and establish a functional occlusion. The time the patient is wearing the treatment restoration should be kept at a minimum.

It is imperative the periodontal health of the patient be satisfactory before starting tooth preparations and proper daily hygiene be instituted.

In order for this inflammatory reaction to be reversible, the final restoration should meet the requirements necessary to maintain gingival health. It is important for the final restoration to:

1. have well adapted margins.
2. should be highly polished.
3. should not possess deflective contours in the gingival third area, nor be overcontoured.
4. should possess adequate embrasure space.
5. should supply occlusion.

It would be recommended that the gingival margins of the treatment restoration be terminated at the crest of the gingiva or very slightly below the crest of the gingiva. Care should be taken to remove any excess cement.

This study involved using only one material (a self-curing acrylic resin) for the treatment restorations. Further studies could be done comparing different temporary materials and their effect on crevicular fluid volume. Longitudinal studies observing changes in crevicular fluid volume around crown restorations would also be interesting.

CONCLUSIONS

1. Treatment restorations in combination with the preparation procedures elicited an increase in crevicular fluid volume around the prepared teeth.

2. The periodontal inflammatory process can be expected to be a reversible process.

3. Crevicular fluid volume can be measured and an increase indicates an inflammatory condition.

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APPROVAL SHEET

The thesis submitted by Doctor Patrick H. Garvin has been read and approved by the following committee:

Doctor William Malone, Director
Professor of Fixed Prosthodontics

Doctor Patrick Toto
Professor and Chairman
Oral and General Pathology

Doctor Boleslaw Mazur
Professor of Fixed Prosthodontics

The final copies have been examined by the director of the thesis/dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis/dissertation 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.

4/11/79
Date

William J. Malone
Director's Signature