CHAPTER 7

METHOD

7.1 Experimental procedure

A large number of premolar teeth extracted in the Exodontia Clinic at the United Dental Hospital of Sydney were collected over a period of nine months. The teeth were fixed in 10% buffered formo-saline. From this group 88 teeth, which had been extracted from adolescents for orthodontic reasons, were selected on the basis of having sound enamel. A further five teeth, which had been extracted for apparently periodontal reasons, were selected on the basis of displaying what appeared to be an average amount of natural proximal attrition for an elderly person who had lived on a so-called average modern refined diet.

The teeth were then washed in water and cleaned with a gauze square, and stored at room temperature, in an open container which was suspended inside a closed container which contained water at its base (Craig 1982). From this point on, unless being used or studied, the teeth were always stored under these conditions.

Of the 88 teeth selected, 78 teeth were randomly selected and set up into six arch forms made of acrylic. The teeth were secured into the acrylic moulds by an approximately 3 millimetre thick layer of denture soft liner material (Total. Denture Reline Material. Soft. Stratford-Cookson Company). This soft liner was found in a pilot study of a number of materials, to hold the teeth tightly enough to allow them to be stripped and polished without dislodging them, yet allow them to be removed from the mould without great difficulty and without damaging the teeth.

The 78 teeth were then used to provide 150 proximal surfaces for the proximal stripping and polishing procedures; the remaining six proximal surfaces, with the 10 teeth not mounted, provided 10 proximal surfaces which were not to be mechanically stripped or polished, and another 10 surfaces which were polished with prophylaxis paste only.

In all, 180 proximal surfaces were utilised in the study, 10 proximal surfaces for each of the following 18 categories or preparation groups.

1. No proximal stripping or polishing procedures carried out. Untreated (UT)
2. Polished with prophylaxis paste only. (P)
3. Natural proximal attrition. (AT)
4. Ultrasonic stripping only. (U/S)
5. Ultrasonic stripping and polishing with a medium polishing disc. (U/S M/D)
6. Ultrasonic stripping and polishing with a medium and then fine polishing disc. (U/S M/D F/D)
7. Ultrasonic stripping and polishing with a medium polishing strip (U/S M/S)
8. Ultrasonic stripping and polishing with a medium and then fine polishing strip (U/S M/S F/S)
9. Metal-backed interproximal strip only. Dome Stripper (D/S)
10. Metal-backed interproximal stripping and polishing with a medium polishing disc (D/S M/D)
11. Metal-backed interproximal strip and polishing with a medium and then fine polishing disc (D/S M/D F/D)
12. Metal-backed interproximal strip and polishing with a medium polishing strip (D/S M/S)
13. Metal-backed interproximal strip and polishing with a medium and then fine polishing strip (D/S M/S F/S)
14. Diamond disc only (D/D)

15. Diamond disc and polishing with a medium polishing disc (D/D M/D)
16. Diamond disc and polishing with a medium and then fine polishing disc (D/D M/D F/D)
17. Diamond disc and polishing with a medium polishing strip (D/D M/S)
18. Diamond disc and polishing with a medium and then fine polishing strip (D/D M/S F/S)

During the various proximal stripping and polishing procedures the acrylic moulds containing the teeth, were securely attached to the bracket table of a dental unit by means of a small G-clamp.

The 10 surfaces which were polished with the prophylaxis paste only, were polished each for approximately 60 seconds using Zircate Prophy Paste (L.D. Caulk Company) with an Ash Alpine Bristle Brush (Amalgamated Dental) revolving at approximately 3,000 R.P.Ms. The revolutions of the bristle brush, and later, the stripping and polishing discs, were measured on a Strobotac Type 1531-B apparatus (General Radio Company).

The ultrasonic stripping procedure was carried out on each proximal surface for approximately 60 seconds. A Dentsply Cavitron, model 700-2A, with a P-21 tip (Dentsply International Inc.) was used with Cavipaste (Dentsply International Inc.), which has as an abrasive agent, aluminium dioxide of 280 to 320 grit.

The metal-backed interproximal strips used were coarse 7 millimetre wide single sided Horico strips (Hopf, Ringlel & Co., Berlin, West Germany), with synthetic ruby abrasive particles of approximately 120 microns diameter. These strips, already mounted in their frames, were supplied by the Dome Company. They were used in a "Dome Interproximal Stripper"(Dome, Tarzana, U.S.A.) for approximately 60 seconds. Each strip was used on a maximum of four surfaces and was kept moist during the stripping procedure with a periodic spray of water. Fig. 9.

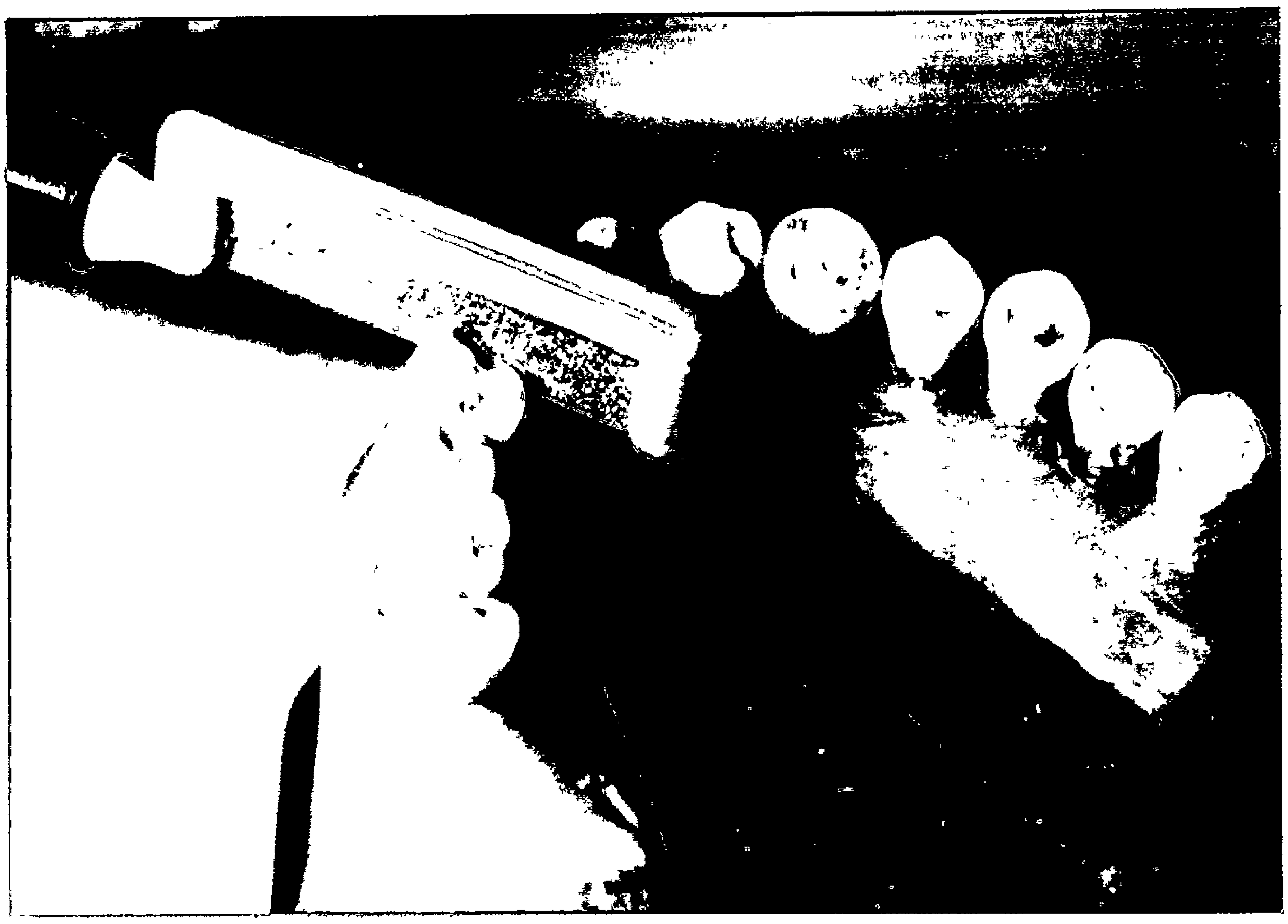


Fig. 9 An example of the metal-backed polishing strip (Dome Stripper) being used to reduce a proximal surface of a tooth mounted in one of the acrylic moulds.

The diamond disc used for stripping was a single sided Horico Diaflex of 19 millimetres diameter (Hopf, Ringleb & Co., Berlin, West Germany). The disc uses diamond abrasive particles of approximately 75 microns diameter. Each disc was used on a maximum of 25 proximal surfaces at a constant speed of 2,400 R.P.M. Each proximal surface was stripped for only 5-10 seconds with the disc, and the disc was kept moist with a spray of water at the commencement of the procedure. Fig. 10.

An Ash, double-bow separator (Amalgamated Dental), was used to provide separation between the teeth to carry out the ultrasonic and diamond disc stripping.

The polishing discs used were the 3M 16 millimetre polishing discs no. 1952 medium and no. 1953 fine (3M Company). They use aluminium oxide and zirconium silicate abrasive particles respectively and have approximately 240 and 400 grit respectively. They were used

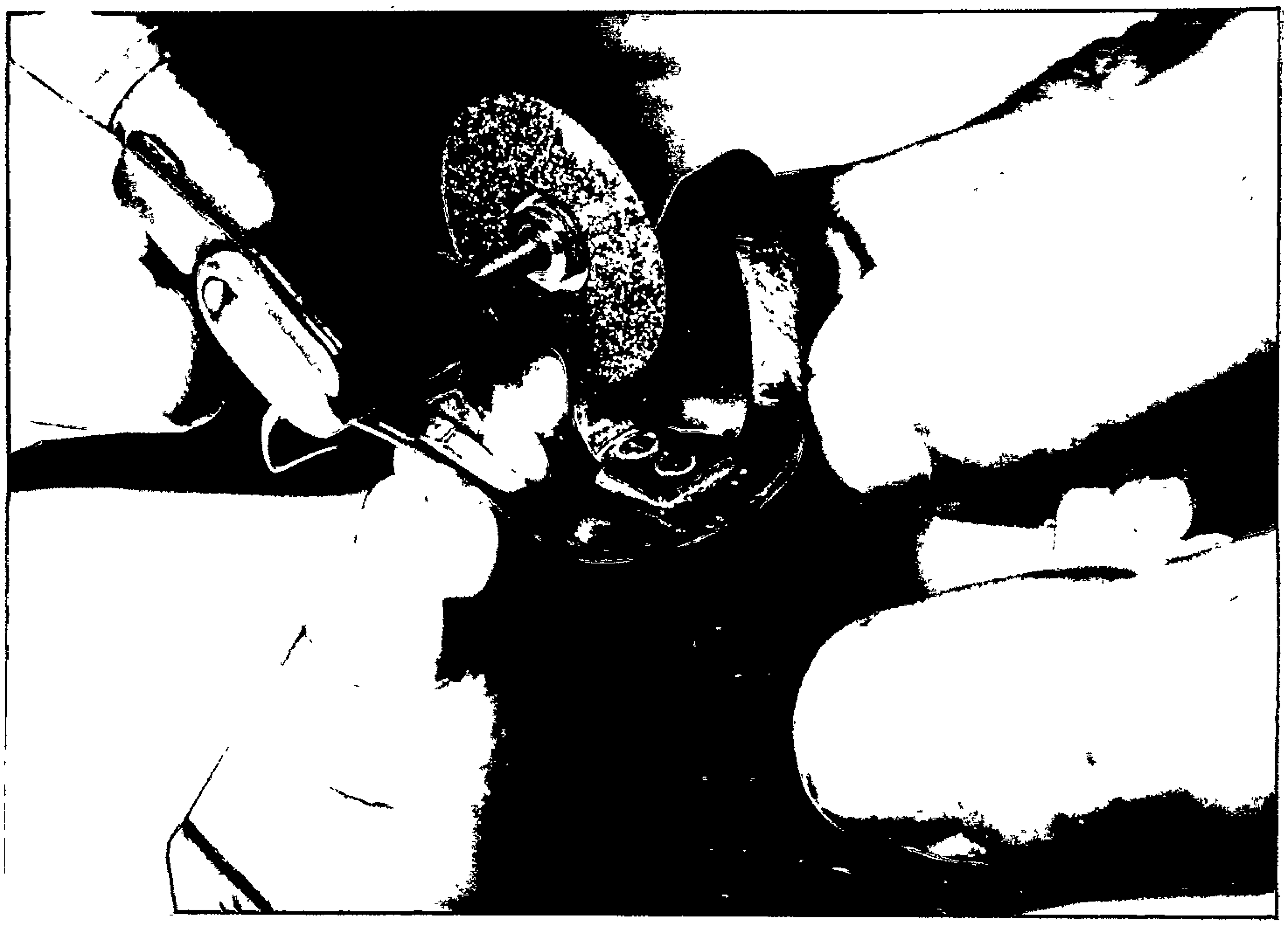


Fig. 10 An example of a diamond disc being used to carry out the procedure of proximal stripping. An Ash double bow separator is being used to create space for the diamond disc.

for approximately 15 seconds at 3,000 R.P.Ms, and each disc was used on a maximum of four proximal surfaces. The discs were kept moist by an initial spray of water. Fig. 11.

Fig. 11 A polishing disc being used to polish the proximal surface of a tooth after it has been reduced by a proximal stripping procedure.

The polishing strips used were the 3M Sof-lex 17.5 centimetre by 3.9 millimetre polishing strips, no. 1954 double ended coarse and medium (3M Company), designated in this study as medium and fine respectively. They use aluminium oxide abrasive particles and have a grit of 240 and 400 respectively. Each strip was used for approximately 60 seconds to polish only one proximal surface, and was kept moist by a periodic spray of water. Fig. 12.

Fig. 12 A polishing strip being used to polish the proximal surface of a tooth after it has been reduced by a proximal stripping procedure.

Throughout the experiment an effort was made to keep a constant pressure on the instruments used in the various stripping and polishing procedures. An effort was also made to keep these pressures, and the techniques used, close to what it was considered would be carried out on average in the clinical situation.

In Figures 13 and 14 are displayed the acrylic moulds, teeth, and a number of the proximal stripping and polishing instruments used in the study.

Fig. 13 The acrylic moulds and teeth used in the study.

After completion of the proximal stripping and polishing procedures the teeth were washed, while still seated in the mould, with a few seconds spray of water and dried with a quick blast of compressed air. After removal from the mould a few of the teeth still retained some debris, and where necessary, this was wiped gently with a clean fresh piece of gauze.

The other surfaces polished with the prophylaxis paste only, those kept untreated and those representing natural attrition, were similarly washed and dried after the initial washing process.

Care was taken not to touch or contaminate any of the proximal surfaces during the remainder of the experimental procedure.

The proximal surfaces were each then photographed at a magnification of 25 times on Ilford PAN F, ASA 50, 35 millimetre Black and White Print film, using a stereomicroscope and camera (Heerbrugg Wild Photomicroscope M400 and Wild Photoautomat MP5-55 assembly). The subject surfaces were

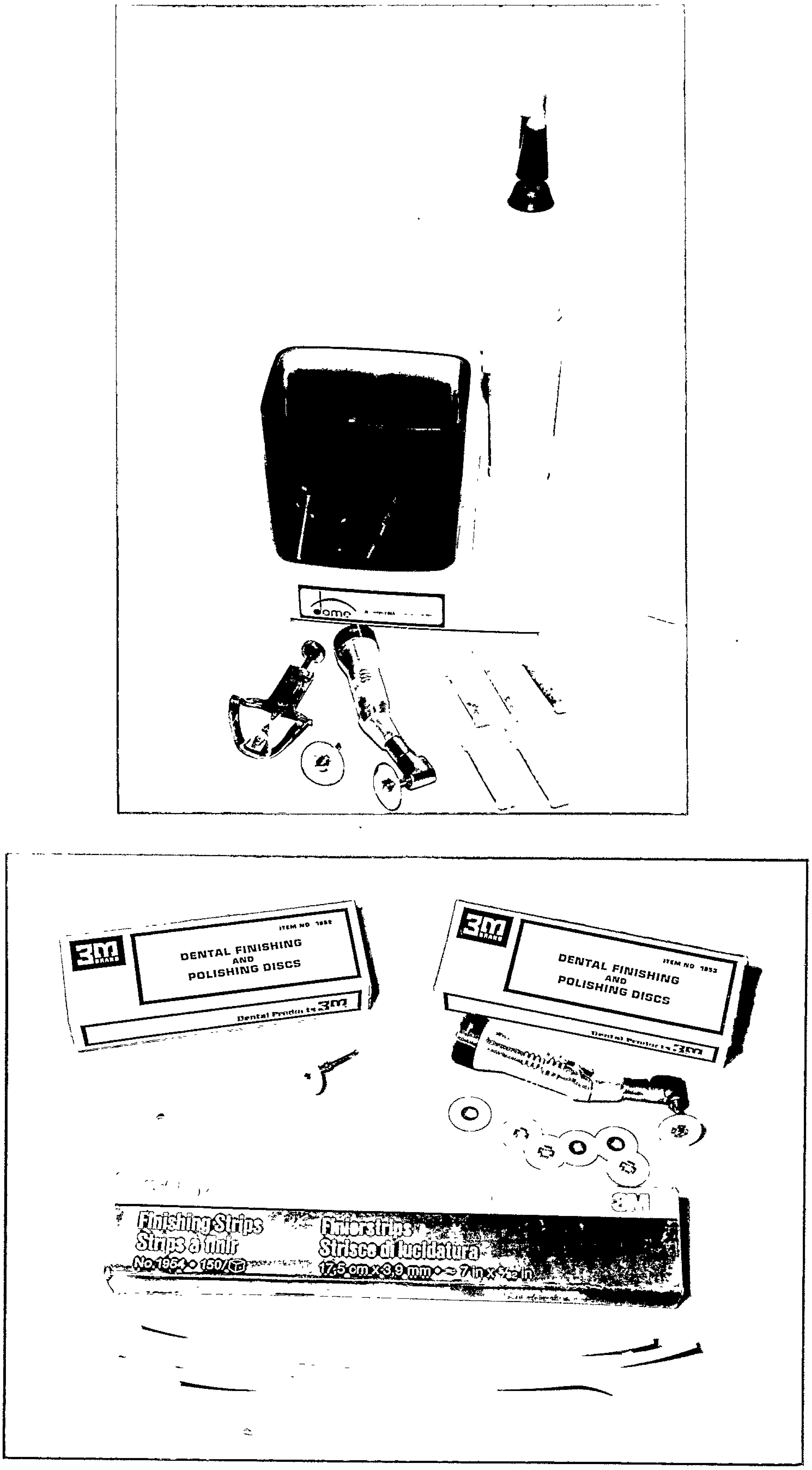


Fig. 14 A and B. Some of the proximal stripping and polishing instruments used in the study.

lighted with two fibre optic lights (Intralux 150H, Volpi) which were positioned by trial and error to produce the best possible photographic results, as seen through the microscope.

The photomicrographs, approximately 175 x 120 millimetres, were produced in Ilfospeed (Ilford) grade 4 paper.

7.2 Assessment Procedure

Assessment 1

The photomicrographs were scored by four independent evaluators who had no knowledge of which photomicrographs represented the various surfaces studied, and who had been calibrated using similar specimen photomicrographs taken during a pilot study. The evaluators were calibrated 28 hours and 4 hours before the assessment took place. The photographed surfaces were scored according to the following criteria in the "Enamel Roughness Index". (E.R.I.). (Modification of E.S.I. Index of Zachrisson and Arthun, 1979).

0 - Extremely smooth surface; with very few fine scratches or imperfections.

1 - Very smooth surface; with many fine scratches or imperfections and possibly a few deeper scratches or imperfections.

2 - Smooth surface; with both many fine and many deeper scratches or imperfections.

3 - Rough surface; with predominately deep scratches or imperfections, and perhaps some very deep and uneven scratches or imperfections.

4 - Very rough surface; with extremely deep scratches or imperfections giving a very rugged appearance.

It was decided, after a pilot run with one other independent observer that the scoring of 180 photomicrographs in one session could lead to evaluator fatigue and produce scoring error, so, five instead of ten photographed surfaces for each group were selected, leaving 90 photographed surfaces in total to be scored. The photomicrographs were taken by automatic exposure which provided consistency in the exposure of the photomicrographs. However, there were some inconsistencies with the printing of the photomicrographs from the negatives, and slight differences in contrast could be observed. Most of these inconsistencies were selected out, retaining the five best photomicrographs to be assessed in each category. The photomicrographs were selected on the basis of the exposure and clarity of the photographic images, and otherwise were randomly selected, by an independent observer, in an effort to avoid bias in the selection. The selected photmicrographs were then arranged in a random order by shuffling.

The calibration of the evaluators, the shuffling of the photomicrographs, and the assessment procedure of the 90 photomicrographs was carried out twice, five days apart.

Assessment 2

In the second method of assessment, a rank-ordering technique was used. Thirty photomicrographs were used, five from each of the following preparation groups (the same photomicrographs used in the first assessment).

1. Ultrasonic stripping and polishing with a medium polishing disc (U/S M/D).
2. Ultrasonic stripping and polishing with medium and fine polishing discs (U/S M/D F/D).
3. Metal-backed polishing strips and polishing with a medium polishing disc (D/S M/D).

4. Metal-backed polishing strips and polishing with medium and fine polishing discs. (D/S M/D F/D)
5. Diamond disc and polishing with a medium polishing disc (D/D M/D).
6. Diamond disc and polishing with medium and fine polishing discs (D/D M/D F/D).

The thirty photomicrographs, randomly stacked, were arranged on a large table from "most smooth" to "most rough" in appearance, by each of the four evaluators at separate sessions. Each evaluator was allowed between ten and fifteen minutes to perform the rank-ordering.

In this way each photomicrograph was assigned a rank from 1 to 30, 1 being the smoothest in appearance. These ranks were then regrouped according to the preparation groups, and the sum of the ranks were then also used to test for differences among the evaluators and between the preparation groups.

7.3 Background to Experimental Method

Surface roughness of both the crown and root surfaces of teeth have been studied in the past by a number of researchers. These researchers have usually used one or both of two methods to investigate these surface roughnesses.

The first method is by the use of a surface roughness meter or profilometer to quantitatively measure the actual roughness. This technique has been used by Green and Ramfjord (1966), Kerry (1967), Rosenberg and Ash (1974), Meyer and Lie (1977) and Pearlman (1981) to study the surface roughness after various methods of scaling and root planeing; by Clayton and Green (1970) and Heath and Wilson (1976), to investigate the roughness of restorative material in its relationship to plaque accumulation; and by Lammie (1957) who investigated the surface roughness of tooth surfaces resulting from various rotary dental instruments.

Earlier this year a pilot study, using a profilometer, was carried out by this author on a number of tooth surfaces which had undergone various proximal stripping and polishing procedures. The best available profilometer, a Talysurf IV (Rank Taylor and Hobson, England), did not have available a datum attachment, which would have allowed curved surfaces to be measured. Consequently only those tooth surfaces which were almost perfectly flat for an area of almost 3 millimetres by 3 millimetres could be surveyed with the profilometer. Although many of the flattened surfaces of the proximally stripped and polished premolar teeth measured at least 3 millimetres in a bucco-lingual direction, few had the required 3 millimetre flat surface occluso-gingivally to allow a roughness measurement to be made; and, as many of the scratches produced by the proximal stripping and polishing technique exhibited a characteristic bucco-lingual parallel pattern, measurement of the roughness in this occluso-gingival direction would have been critical. Also it was not possible to attain reliable readings for natural untouched tooth surfaces, natural attritional surfaces, surfaces polished with prophylaxis paste only, and surfaces subjected to ultrasonic stripping, because of the lack of this flat surface area. For this reason the measurement of the roughness of the proximal surfaces by the use of a profilometer technique was not further pursued.

The second common method used by various researchers to assess the roughness of tooth surfaces is by qualitative visual assessment. Photomicrograph examinations of root surface roughness after various periodontal scaling procedures has been carried out by Jones, Lozdan and Boyde (1972), Meyer and Lie (1977) and Pearlman (1981) using a Scanning Electron Microscope. The Scanning Electron Microscope has also been used by authors (Gwinnet and Gorelick 1977, Burapavong et al 1978, Retief and Denys 1979, Zachrisson and Arthun 1979, Pus and Way 1980 and Rouleau et al 1982) to examine the effects on the enamel surface of debonding orthodontic attachments with various instruments. Gorelick and Tascher (1966) have also used Scanning Electron Micrographs specifically to assess the roughness of the enamel surface after various proximal stripping and polishing procedures.

The particular advantage of the Scanning Electron Microscope in studying the enamel surface, is its resolution and large depth of field, which provides an excellent means of topographic assessment (Saxton 1973, Boyde 1976 and Gwinnet & Gorelick 1977). However, the use of the Scanning Electron Microscope and preparation of the specimen beforehand, requires considerable expertise, and is an expensive and time consuming procedure for the Scanning Electron Microscopy Unit; also access to the Scanning Electron Microscope was limited, making it impossible to obtain the more than two hundred photomicrographs needed for the study.

Zachrisson and Arthun (1979) successfully used a stereomicroscope, at 50 times magnification, in their study to examine and score the enamel surface appearance after various abrasive debonding techniques.

This author carried out a pilot study using various stereomicroscopes at various magnifications, and finally selected the stereomicroscope, noting that the pilot study photomicrographs showed very good definition, and good depth of field. The 25 times magnification used in the study was selected because it gave a very good coverage of most of the experimental area, reducing the possibility of bias in the selection of the field to be photographed; also it was selected because in the pilot study assessment, the observers all indicated that they felt this magnification was the most useful for assessment of the enamel surface.

7.4 Background to Assessment Method

The type of "0-4" scoring procedure used in this study has been used very successfully by various researches, clinicians and authors. It has been used by Russel (1956), Loe and Silness (1963), Loe (1967), Rosenberg and Ash (1974) and Tsamtsouris et al (1980) in assessing plaque accumulation and gingival health; by Duperon, Nevile and Kasloff (1971), Mahler, Terkla and Van Eysden (1973) and Osborne et al (1976) in assessing marginal breakdown and corrosion resistance of amalgam restorations; and by Meyer and Lie (1977) and Zachrisson and Arthun (1979) in specifically assessing the tooth surface roughness after various abrasive procedures.

The criteria used in this study in the "Enamel Roughness Index" (E.R.I.) are modifications of the "Enamel Surface Index" (E.S.I.) system used by Zachrisson and Arthun.

The criteria were also formulated from the results of the pilot study, with the knowledge that various abrasion and polishing procedures leave scratches and/or imperfections of varying depths and number, producing different grades of smoothness, with the progressively smoother surfaces showing many more finer scratches or imperfections, leading to extremely smooth surfaces, which at low magnification, show few scratches or imperfections. (Skinner and Phillips, 1967; Greener, Harcourt and Lautenschlager, 1972; and Coombe, 1977).

The rank-ordering technique used in the second method of assessment of the photomicrographs in this study, is somewhat similar to the assessment technique used by Richter and Mahler (1973) in studying gold restorations, and the technique used by Osborne et al (1976) and Rouleau et al (1976) who studied the marginal breakdown of amalgam restorations, and the roughness of the enamel surface after debonding orthodontic brackets respectively.

Osborne et al used five different methods of assessment, and concluded that the rank-ordering technique proved to be the most useful assessment technique of the five they used. According to Osborne et al the particular advantage of the rank-ordering technique is that "each photograph can be compared with the photographs surrounding it and thus can be more correctly categorised. There is a consistent rechecking of the placement of the photograph in the total order, which makes it possible to observe minute differences".

The rank-ordering assessment in this study would also allow the results of the Enamel Roughness Index scoring assessment to be further explored, as it would be ascertained whether different surface preparations obtaining similar or the same Enamel Roughness Index scores, could possibly be further separated on the basis of relative roughness.

The total number of photomicrographs used in the rank ordering assessment was kept to thirty to avert possible difficulties and inaccuracies that might be encountered by trying to assess greater numbers. In addition, this allowed a comparison to be made of only the six categories which consistently scored "very smooth" (E.R.I. no. 1) in the first assessment, and were similar in appearance.

CHAPTER 8

RESULTS

The typical appearance of the photomicrographed proximal surfaces from the teeth from each of the 18 preparation groups is shown in Figs. 15 to 32.

8.1 Assessment 1

The condition of the enamel surfaces of the 18 preparation groups, which consist of untreated, natural attrition and various proximally stripped and polished proximal surfaces, as scored according to the E.R.I. rating system is shown in Table 3. Each preparation group received a total of 40 E.R.I. scores and the break-up of the number of photomicrographs receiving specific E.R.I. scores is shown. The results are a compilation of the rating procedures carried out on two occasions by four evaluators on the same five different photomicrographs from each preparation group. (Appendix 1, tables 6 to 9).

A chi-square test (Appendix 2), used to compare the reproducibility of the two evaluations, performed five days apart, showed that there was very little variation between the two sets of evaluations, (x^2 = 1.00, P = 0.70) indicating very little variation with reproducibility for the evaluations.

No surfaces were rated with scores 0 or 4, and only a small number received scores of 2. The majority of the surfaces were scored either 1 or 3.

All the gross stripping procedures (ultra sonic, metal-backed polishing strip and diamond disc) consistently were scored as producing a 'rough' enamel surface (E.R.I.3). The medium, and medium and fine polishing strip polishing procedure did not appear to effectively reduce this roughness as they also were consistently scored as leaving a 'rough' enamel surface (E.R.I. 3). In contrast the medium, and medium and fine polishing disc polishing procedures did consistently produce a very marked improvement in the enamel surface roughness, being scored consistently as 'very smooth' (E.R.I. 1). The untreated and attritional tooth surfaces were consistently scored as 'rough' (E.R.I. 3), while the surface polished with prophylaxis paste only, consistently appeared 'very smooth' (E.R.I. 1).

There was a statistically significant difference ($x^2 = 636.52$, $P < 0.001$) between the groups that were consistently scored 'very smooth' (E.R.I. 1) and those that were consistently scored as 'rough' (E.R.I. 3). (Appendix 2).

8.2 Assessment 2

Table 4, compiled from tables 10 and 11 (Appendix 1), shows the sum of the ranks found by the evaluators for each of the preparation groups used in the rank-ordering assessment.

Spearman rank-order correlations were carried out between the four evaluators (multiple correlations), and these ranged from a low of + 0.78 to a high of + 0.88, giving very consistent relationships ($P < 0.0005$) with a high level of correlation, indicating that there was no significant difference in the way the evaluators rated the photomicrographs (Appendix 2).

Table 3 Quality of the enamel surface of 18 preparation groups rated according to the E.R.I. system. (UT-untreated, P-polished with prophyloxis paste only, AT-attritional tooth surface, U/S-ultrasonic stripping, D/S-motorised 'Dome Stripper' utilizing metal-backed polishing strips, D/D-diamond disc, M/D-medium grade polishing disc, F/D-fine grade polishing disc, M/S-medium grade polishing strip, F/S-fine grade polishing strip.)

Preparation Groups	E.R.I. Scores				
	Extremely Smooth 0	Very Smooth 1	Smooth 2	Rough 3	Very Rough 4
1. UT				40	
2. P		35	4	1	
3. AT		7	1	32	
4. U/S				40	
5. U/S M/D		34	5	1	
6. U/S M/D F/D		38	2		
7. U/S M/S				40	
8. U/S M/S F/S				40	
9. D/S				40	
10. D/S M/D		38	2		
11. D/S M/D F/D		38	2		
12. D/S M/S			1	39	
13. D/S M/S F/S				40	
14. D/D		1	1	38	
15. D/D M/D		30	8	2	
16. D/D M/D F/D		26	10	4	
17. D/D M/S		1	1	38	
18. D/D M/S F/S			1	39	

Table 4 Total of ranks and mean ranks of six proximal stripping and polishing groups as judged by evaluators from photomicrographs on the basis of surface roughness

Preparation group	Sum of ranks	Mean	S.D.
1. U/S M/D	333	16.50	1.01
2. U/S M/D F/D	189	9.45	1.55
3. D/S M/D	148	7.40	0.82
4. D/S M/D F/D	198	9.90	1.18
5. D/D M/D	530	26.50	0.70
6. D/D M/D F/D	462	23.10	1.07

A two-way nonparametric Friedman test was carried out also indicating that there was no significant difference in the way the evaluators rated the photomicrographs, but there was a significant difference between the preparation groups ($P < 0.01$) (Appendix 2).

Therefore multiple comparisons were made between the preparation groups using the t-test at $P < 0.003$ level of significance (Appendix 2). These results are shown in table 5, and it was shown that the differences in roughness between the individual preparation groups 3. D/S M/D, 2. U/S M/D F/D and 4. D/S M/D F/D, were not significant; whereas the differences between each of these three smoothest groups, and each of the remaining three rougher groups were clearly significant. Preparation groups 5. D/D M/D and 6. D/D M/D F/D were not detectably different at $P < 0.003$ from each other, but were clearly rougher than the other four preparation groups.

There was no detectable difference in surface roughness at $P < 0.003$, between the combined group polished with the medium polishing discs only, after the various proximal stripping procedures (1. U/S M/D, 3. D/S M/D,

Table 5 The preparation groups are ranked in order of their mean ranks, from smoothest (3. D/S M/D) to roughest (5. D/D M/D). The differences in roughness between those groups not bracketed are clearly significant ($P < 0.003$), while the differences in roughness between those groups that are bracketed are not clearly significant.

3.	D/S M/D
2.	U/S M/D F/D
4.	D/S M/D F/D
1.	U/S M/D
6.	D/D M/D F/D
5.	D/D M/D

5. D/D M/D) and the combined group polished with the medium and then fine polishing discs, after the various proximal stripping procedures (2. U/S M/D F/D, 4. D/S M/D F/D, 6. D/D M/D F/D).

The following 18 photomicrographs are representative photomicrographs, one from each preparation group, of those used in the assessment procedures. The photomicrographs are the actual size used in the assessment procedures and are approximately 45 times magnification of the proximal tooth surface. The quality of the photomicrographs reproduced here is not as high as that of the photomicrographs actually used in the assessment procedure, due to the unavailability of the same grade of photographic paper originally used, and because of contamination at the developing stage.

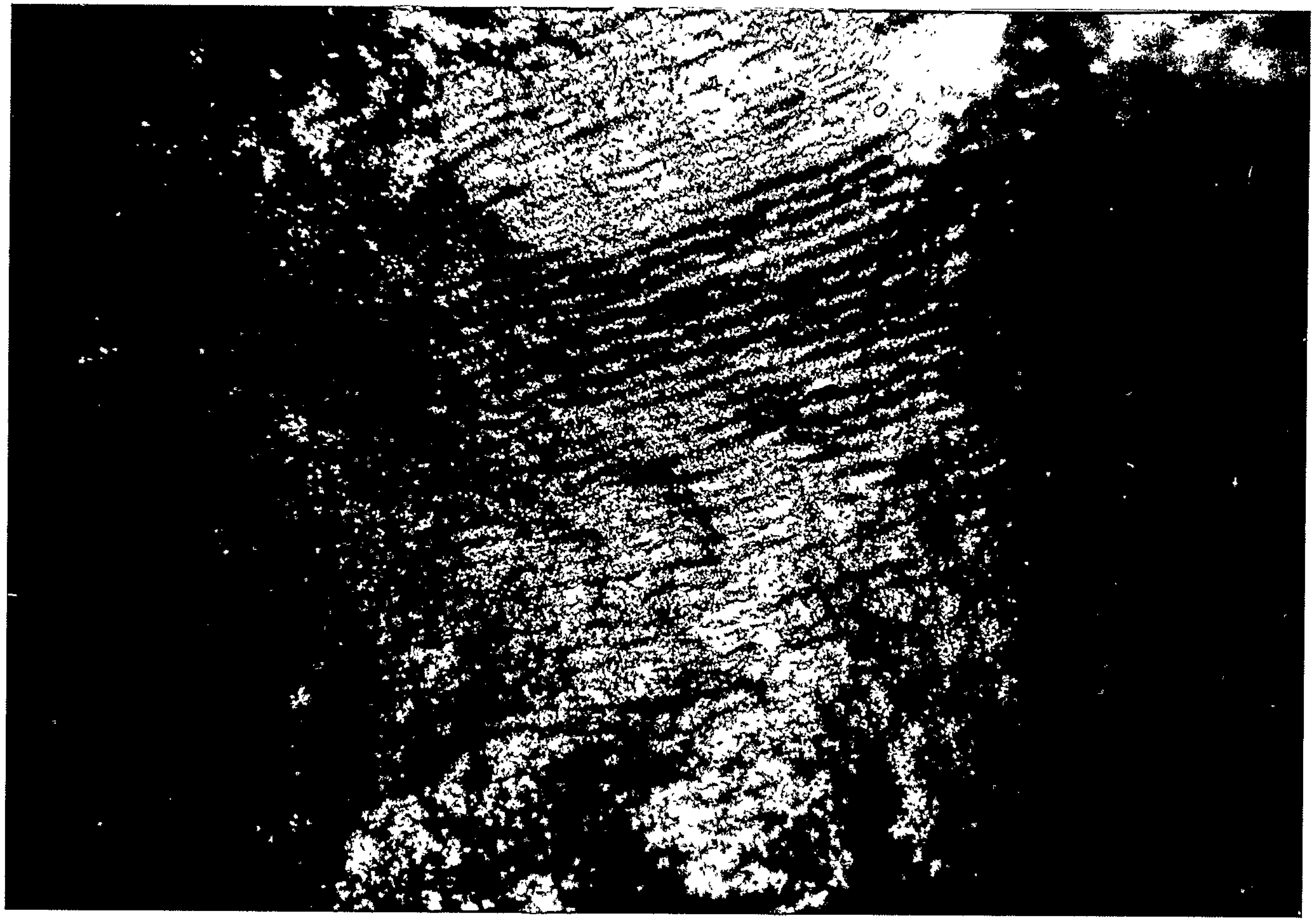


Fig. 15 A representative photomicrograph of a typical untreated proximal surface showing the perikymata. (UT).

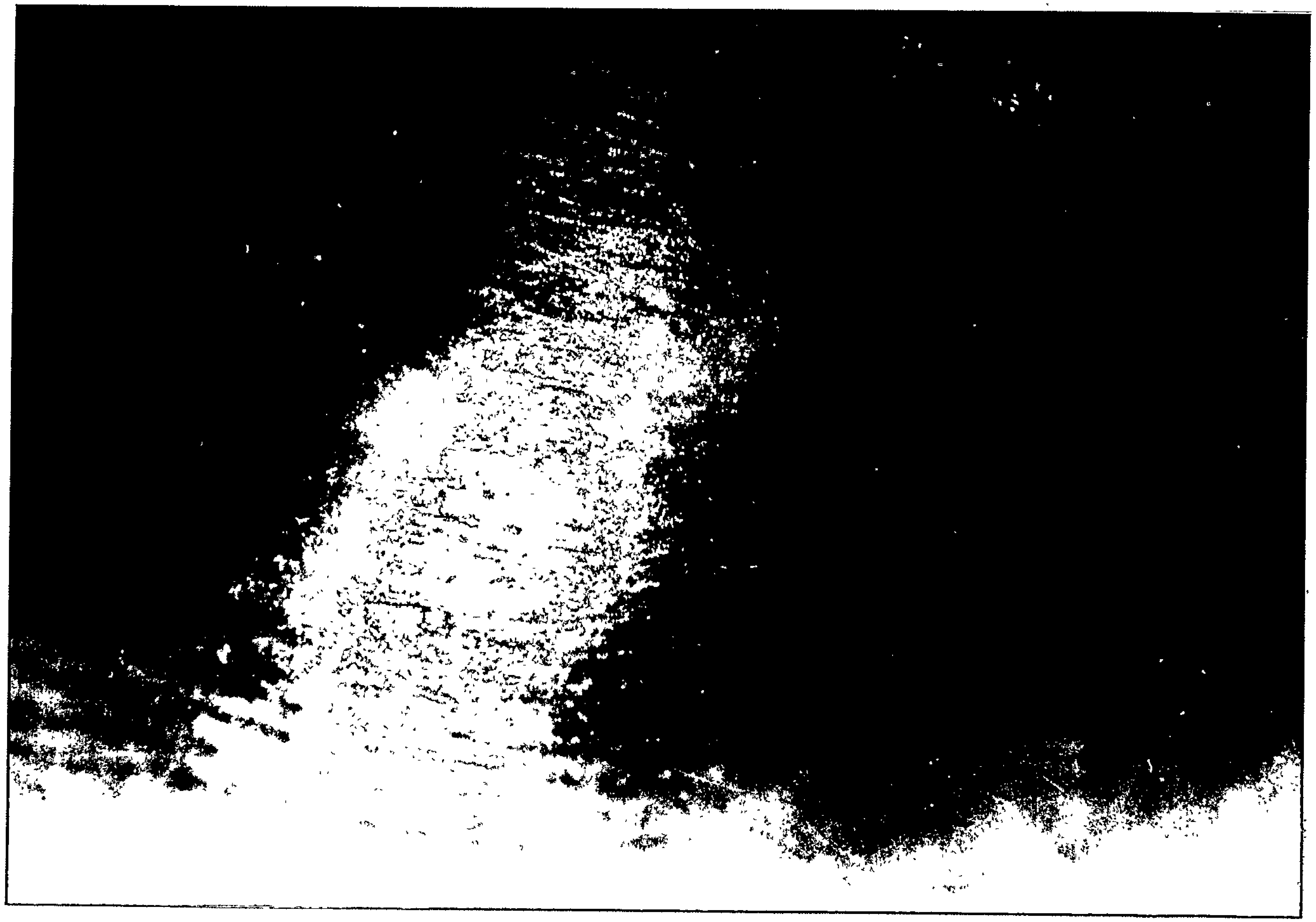


Fig. 16 A representative photmicrograph of a typical enamel surface which has been polished with prophylaxis paste only. (P).

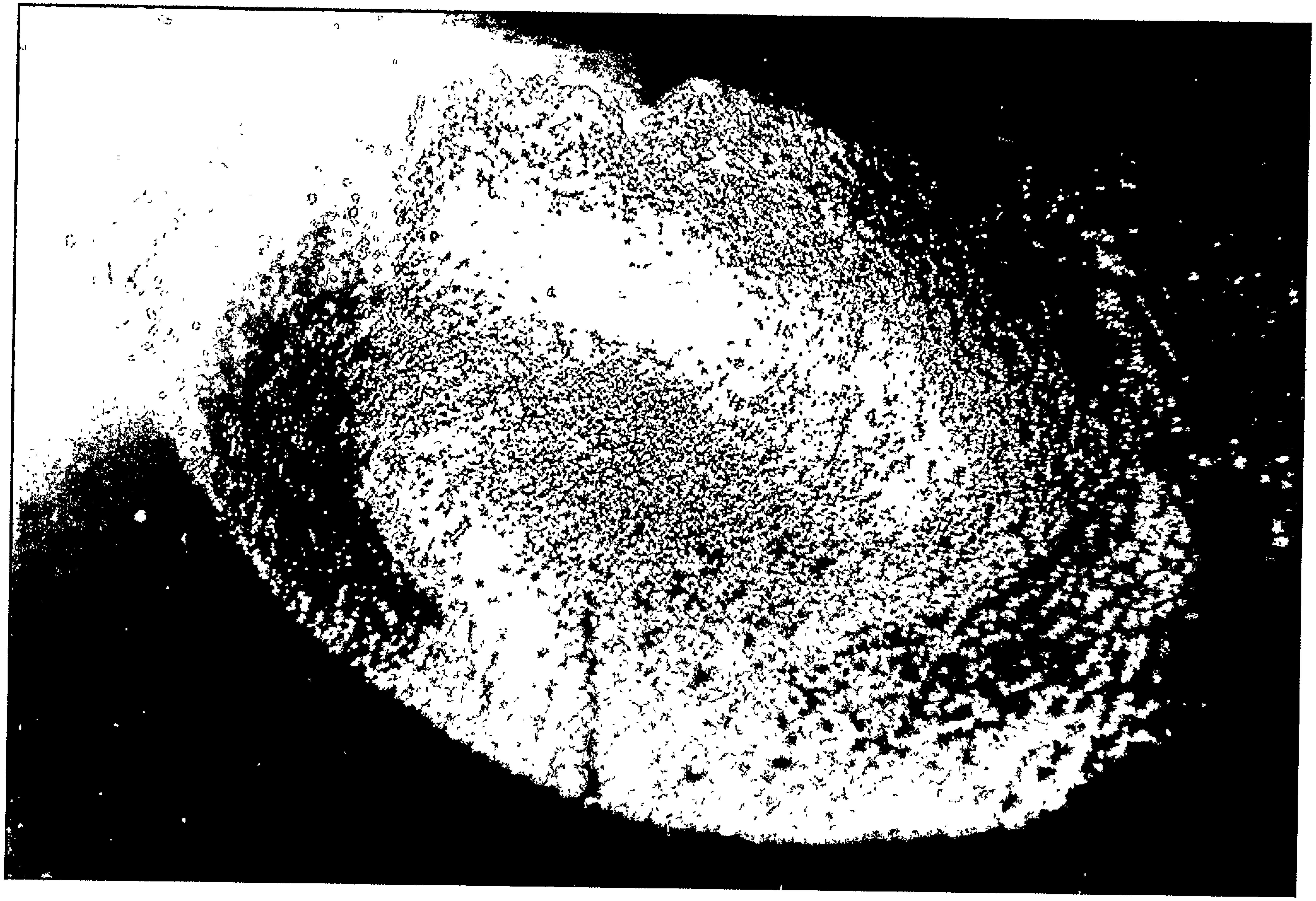


Fig. 17 A photomicrograph representing the most common appearance of an enamel surface which has been subjected to natural proximal attrition. (AT).

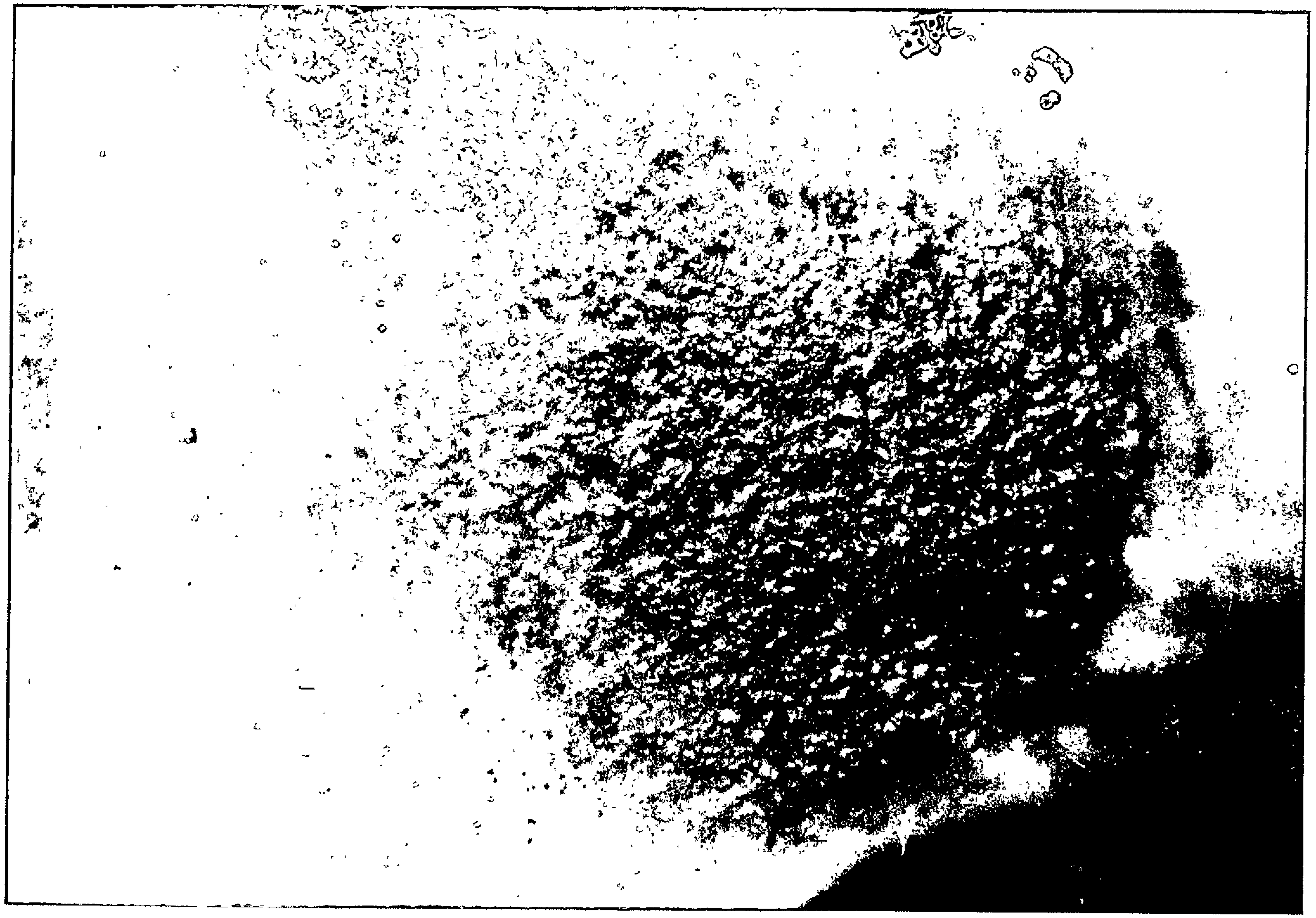


Fig. 18 A representative photomicrograph of a typical enamel surface which has been subjected to ultrasonic proximal stripping. A stainless steel smear from the tip of the instrument is apparent. (U/S).

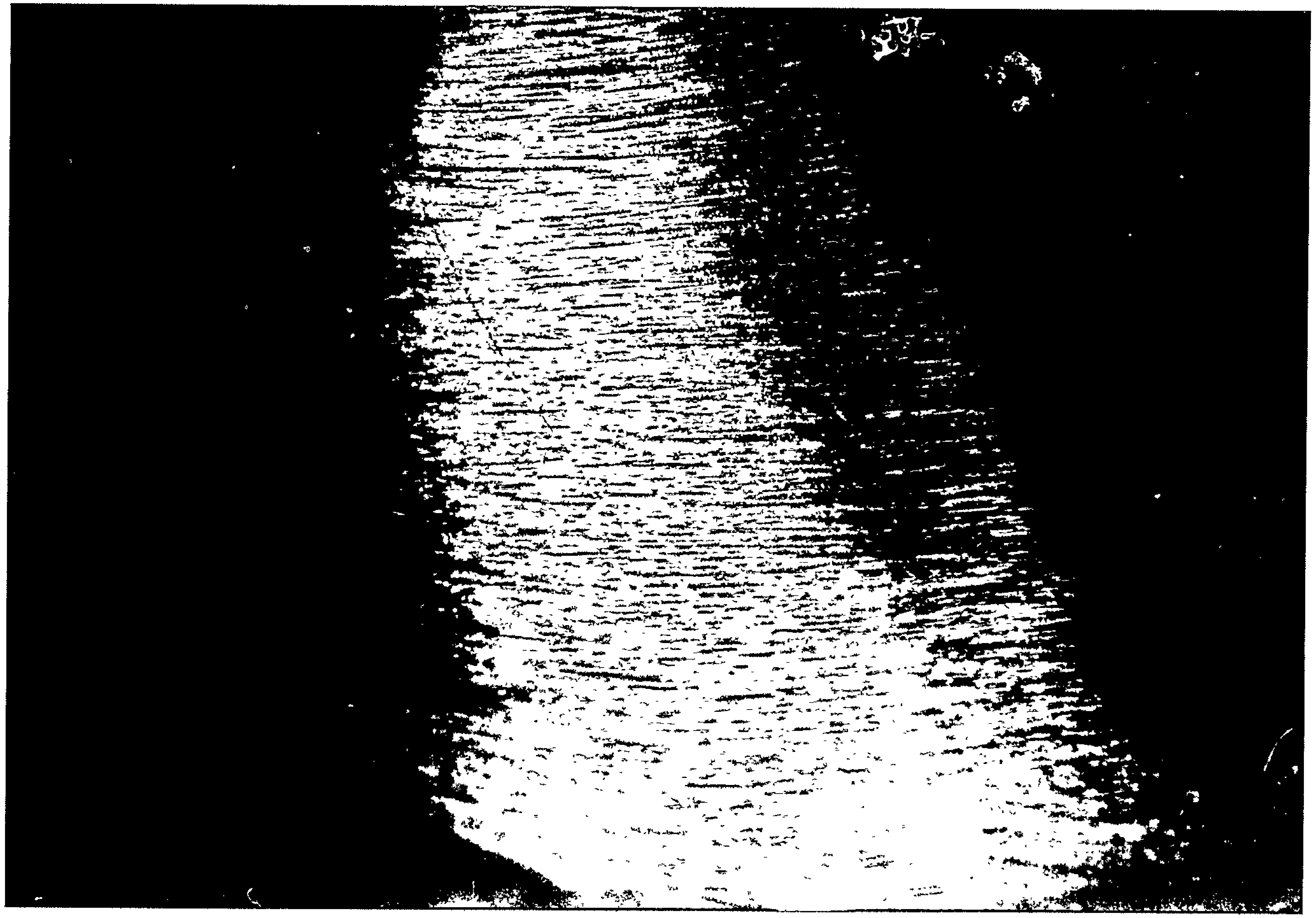


Fig. 19 A representative photomicrograph of a typical enamel surface which has been subjected to ultrasonic proximal stripping and has subsequently been polished with a medium polishing disc. (U/S M/D).

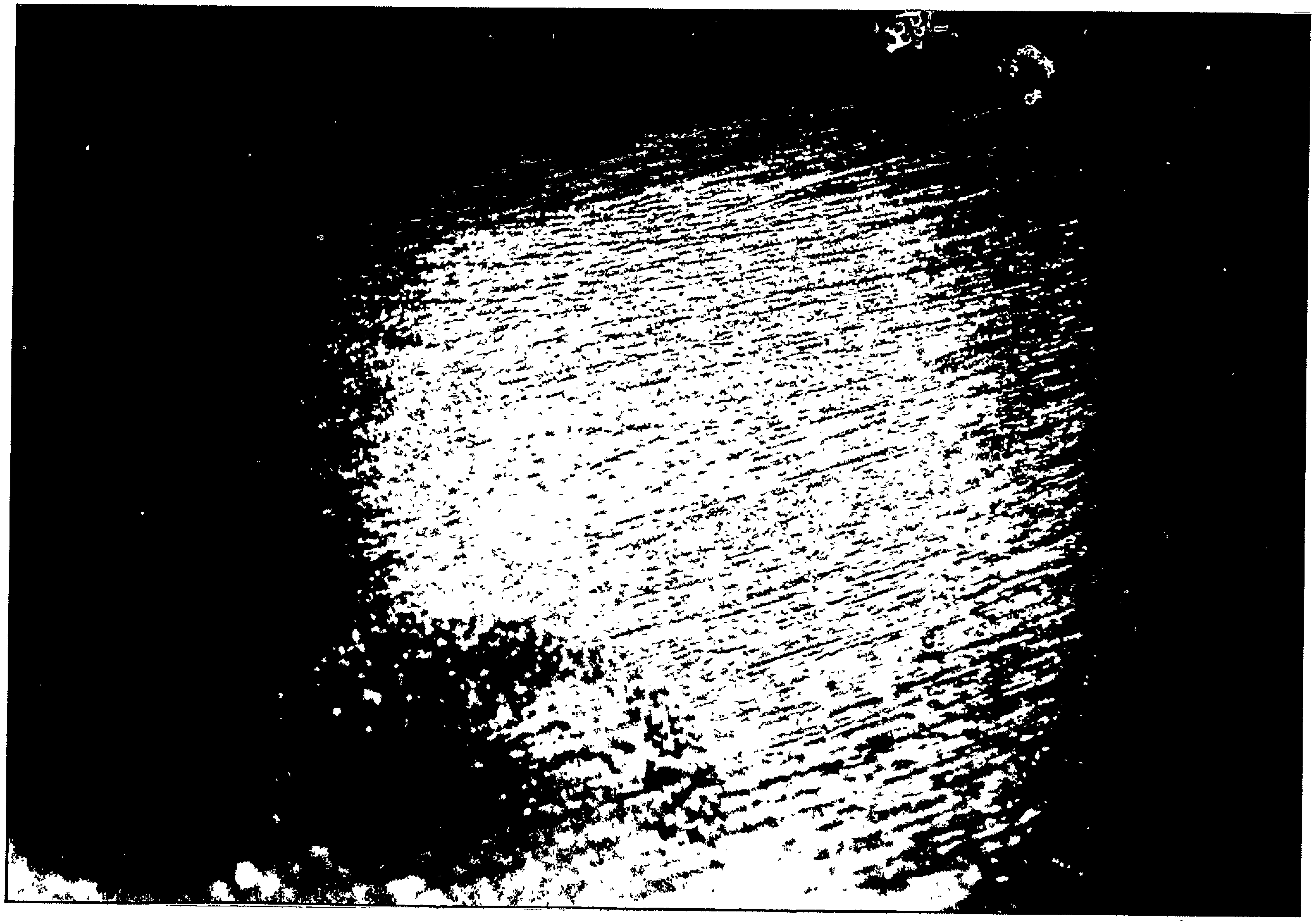


Fig. 20 A representative photomicrograph of a typical enamel surface which has been subjected to ultrasonic proximal stripping and has subsequently been polished with a medium and then fine polishing disc. (U/S M/D F/D).

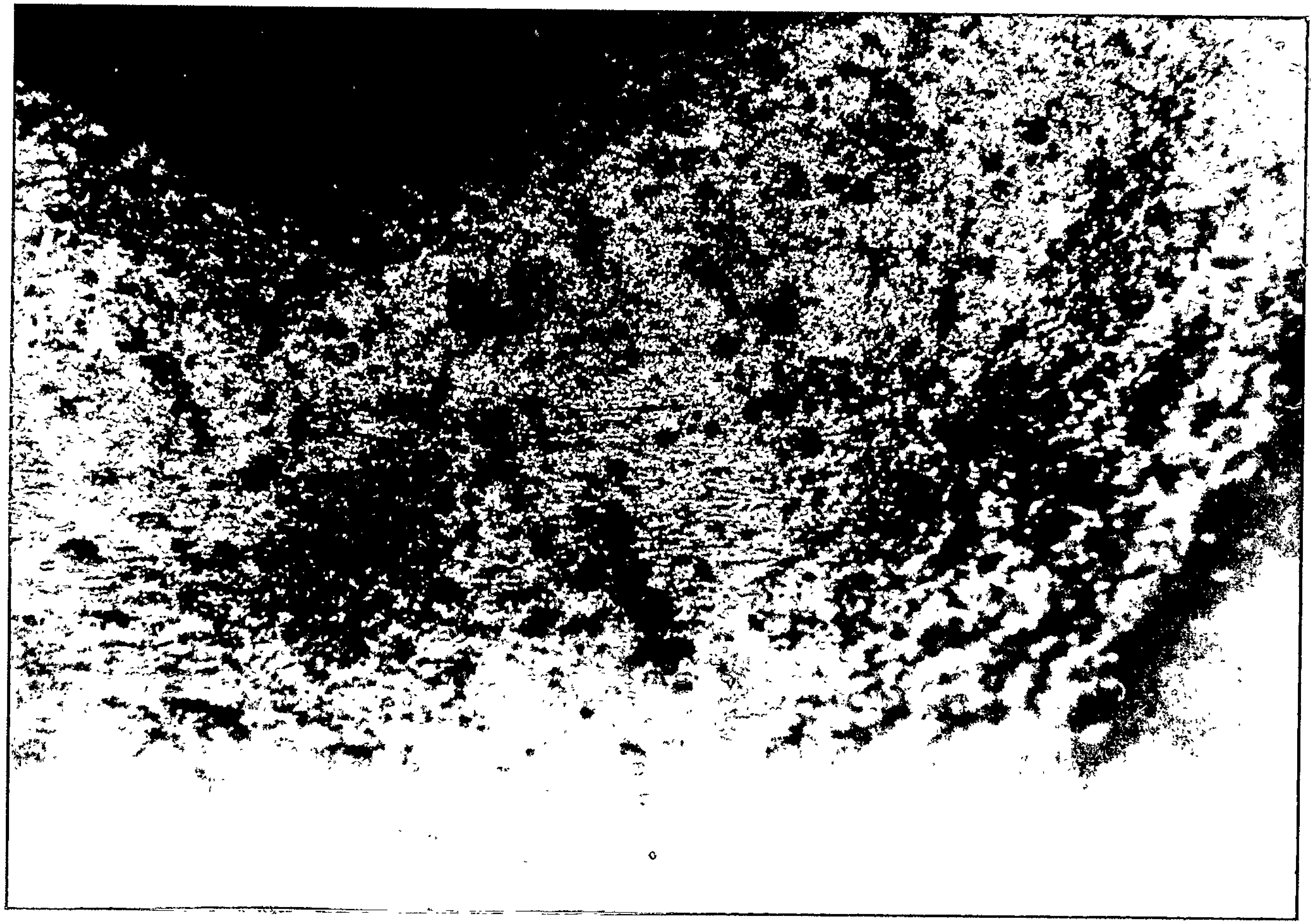


Fig. 21 A representative photomicrograph of a typical enamel surface which has been subjected to ultrasonic proximal stripping and has subsequently been polished with a medium polishing strip. (U/S M/S).

Fig. 22 A representative photomicrograph of a typical enamel surface which has been subjected to ultrasonic proximal stripping and has subsequently been polished with a medium and then fine polishing strip. (U/S M/S F/S).

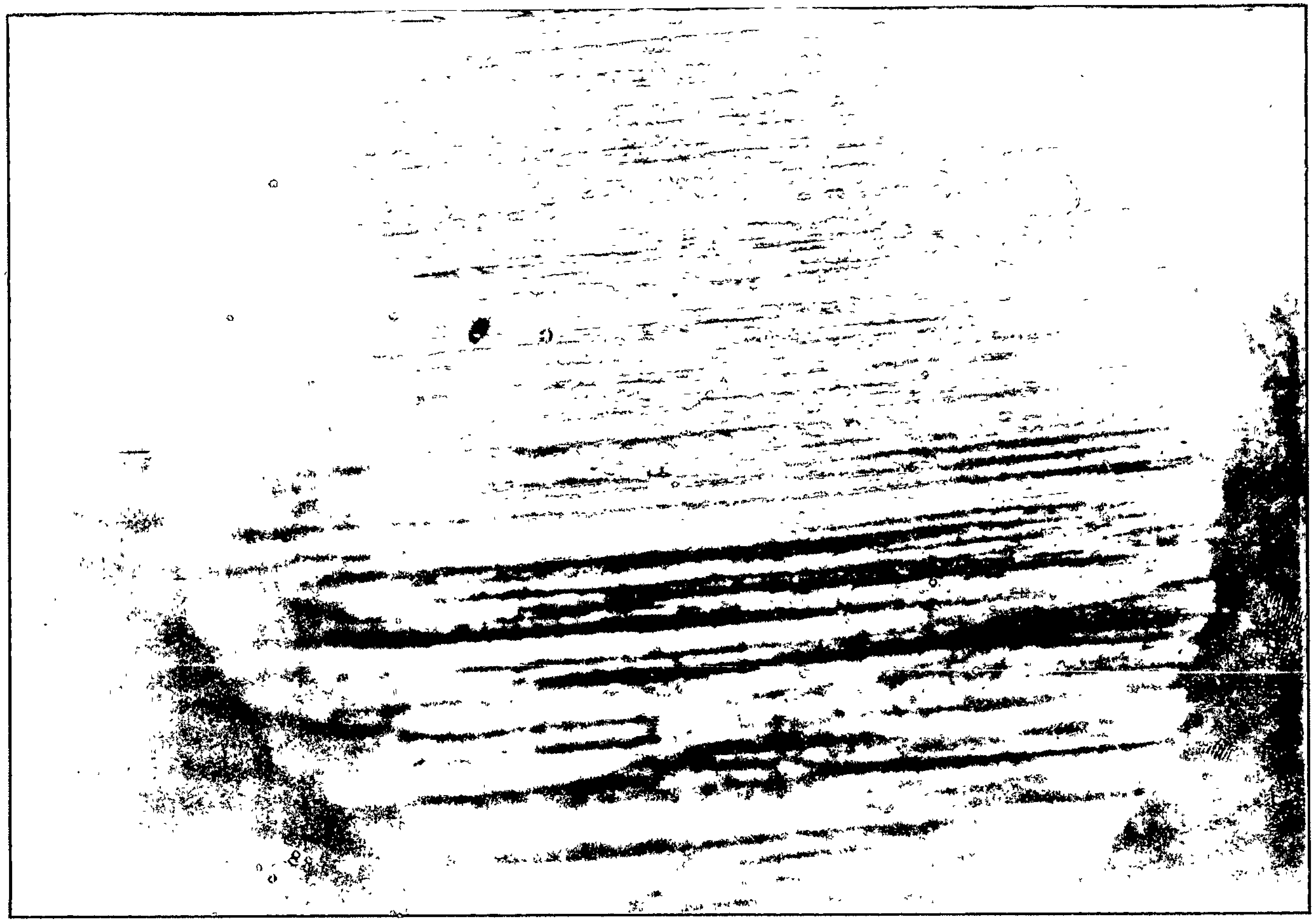


Fig. 23 A representative photomicrograph of a typical enamel surface which has been subjected to metal-backed polishing strip proximal stripping. (D/S).

Fig. 24 A representative photomicrograph of a typical enamel surface which has been subjected to metal-backed polishing strip proximal stripping and has subsequently been polished with a medium polishing disc. (D/S M/D).

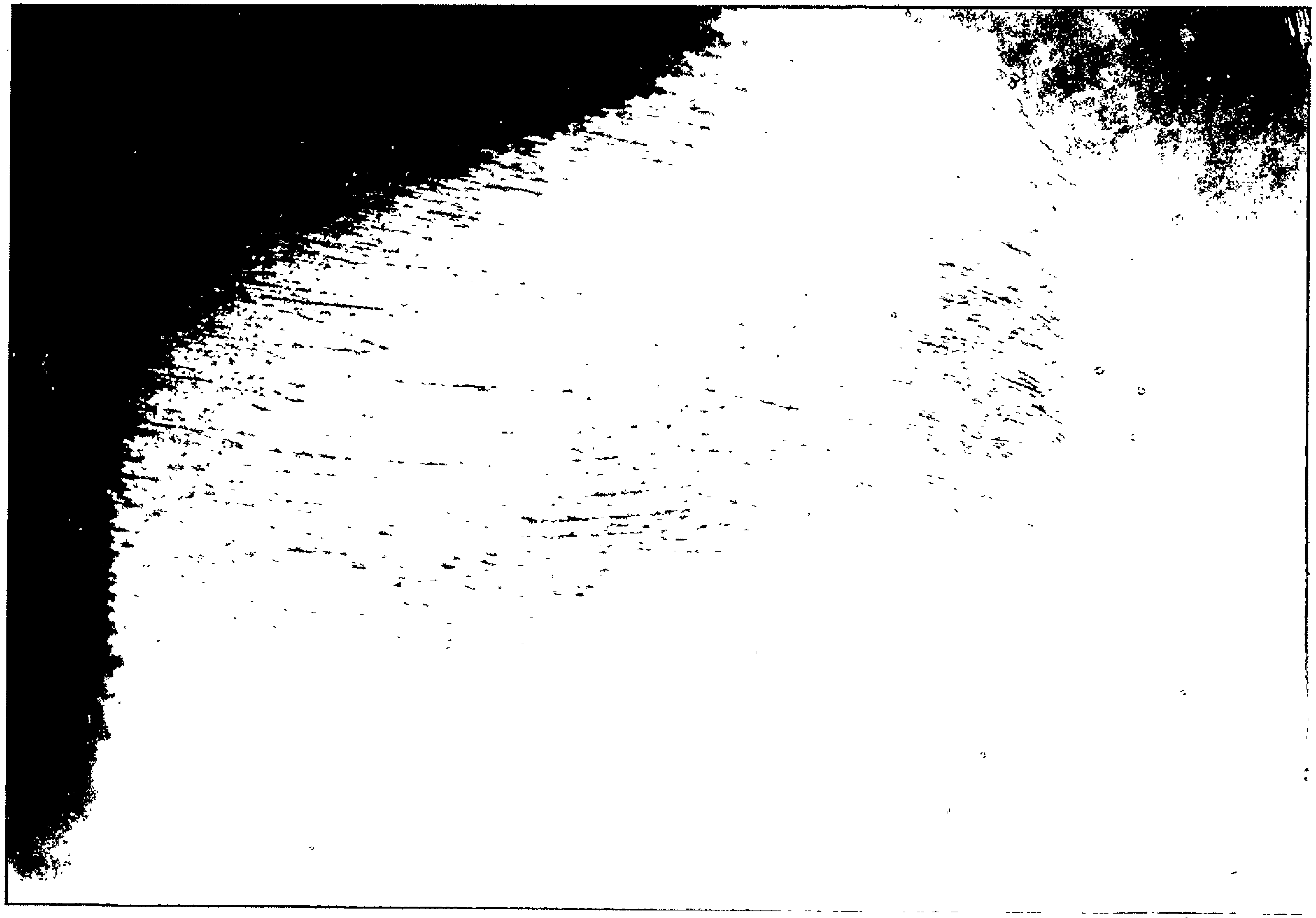


Fig. 25 A representative photomicrograph of a typical enamel surface which has been subjected to metal-backed polishing strip proximal stripping and has subsequently been polished with a medium and then fine polishing disc. (D/S M/D F/D).

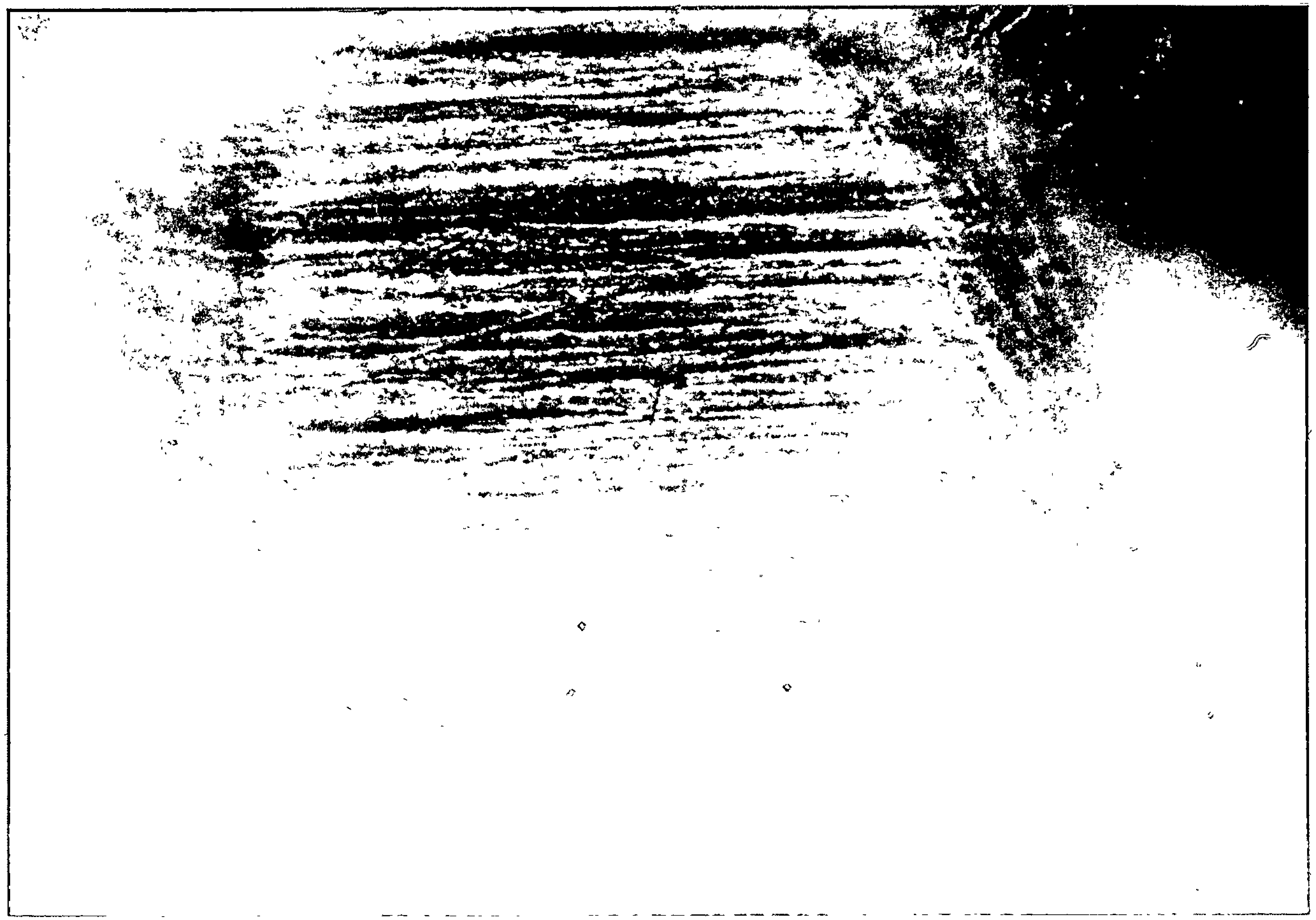


Fig. 26 A representative photomicrograph of a typical enamel surface which has been subjected to metal-backed polishing strip proximal stripping and has subsequently been polished with a medium polishing strip. (D/S M/S).

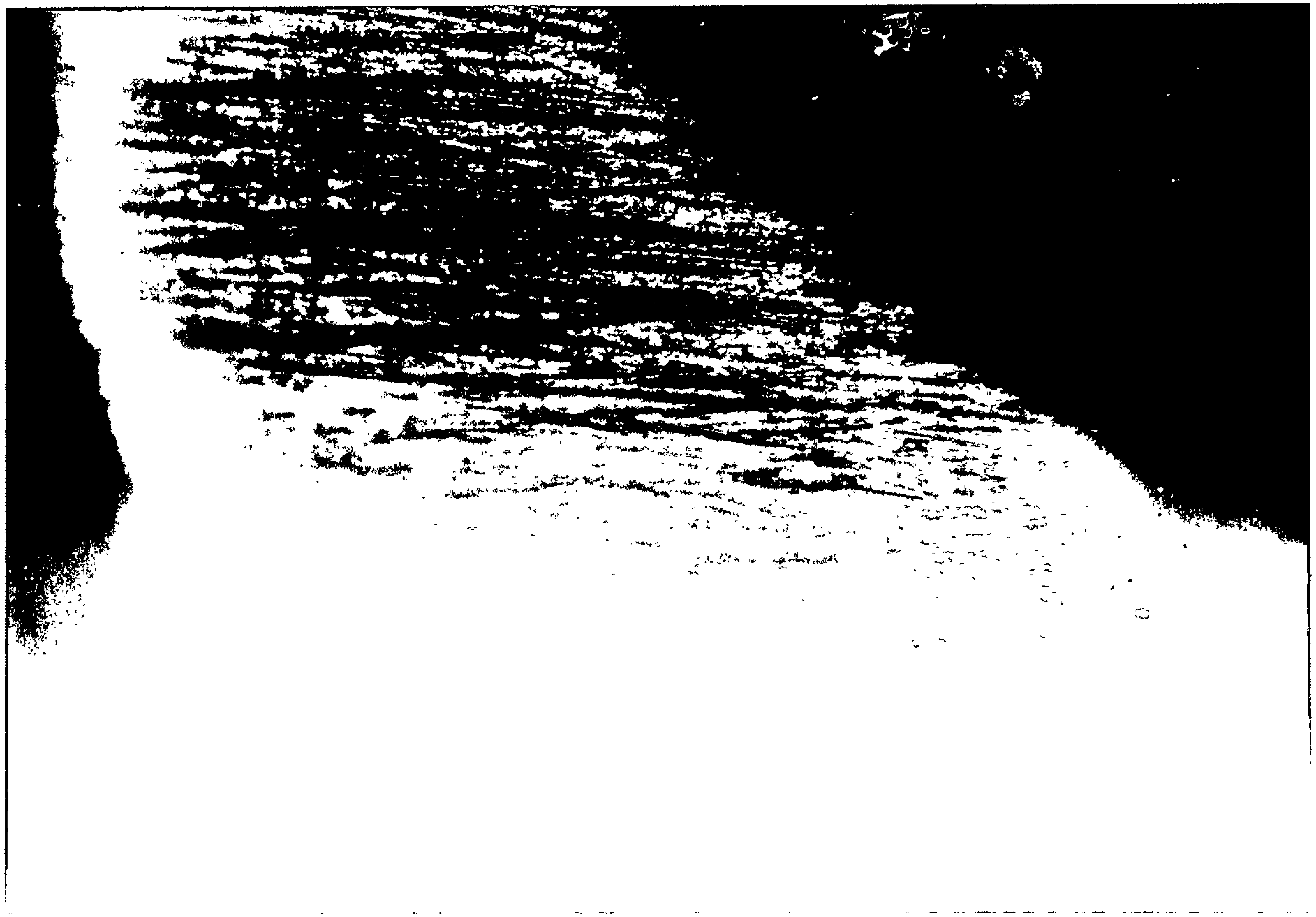


Fig. 27 A representative photomicrograph of a typical enamel surface which has been subjected to metal-backed polishing strip proximal stripping and has subsequently been polished with a medium and then fine polishing strip. (D/S M/S F/S).

Fig. 28 A representative photomicrograph of a typical enamel surface which has been subjected to diamond disc proximal stripping. (D/D).

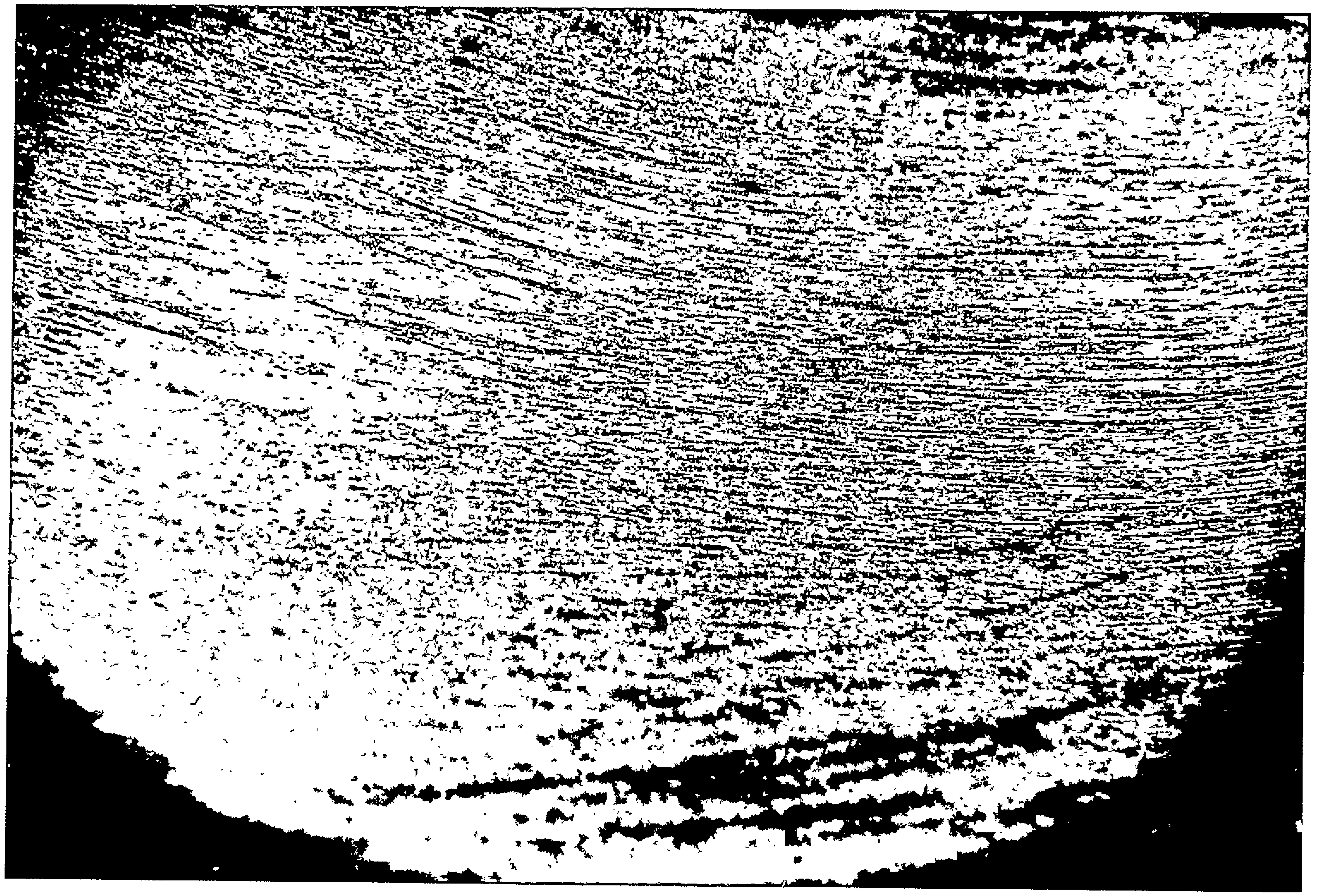


Fig. 29 A representative photomicrograph of a typical enamel surface which has been subjected to diamond disc proximal stripping and has subsequently been polished with a medium polishing disc. (D/D M/D).

Fig. 30 A representative photomicrograph of a typical enamel surface which has been subjected to diamond disc proximal stripping and has subsequently been polished with a medium and then fine polishing disc. (D/D M/D F/D).

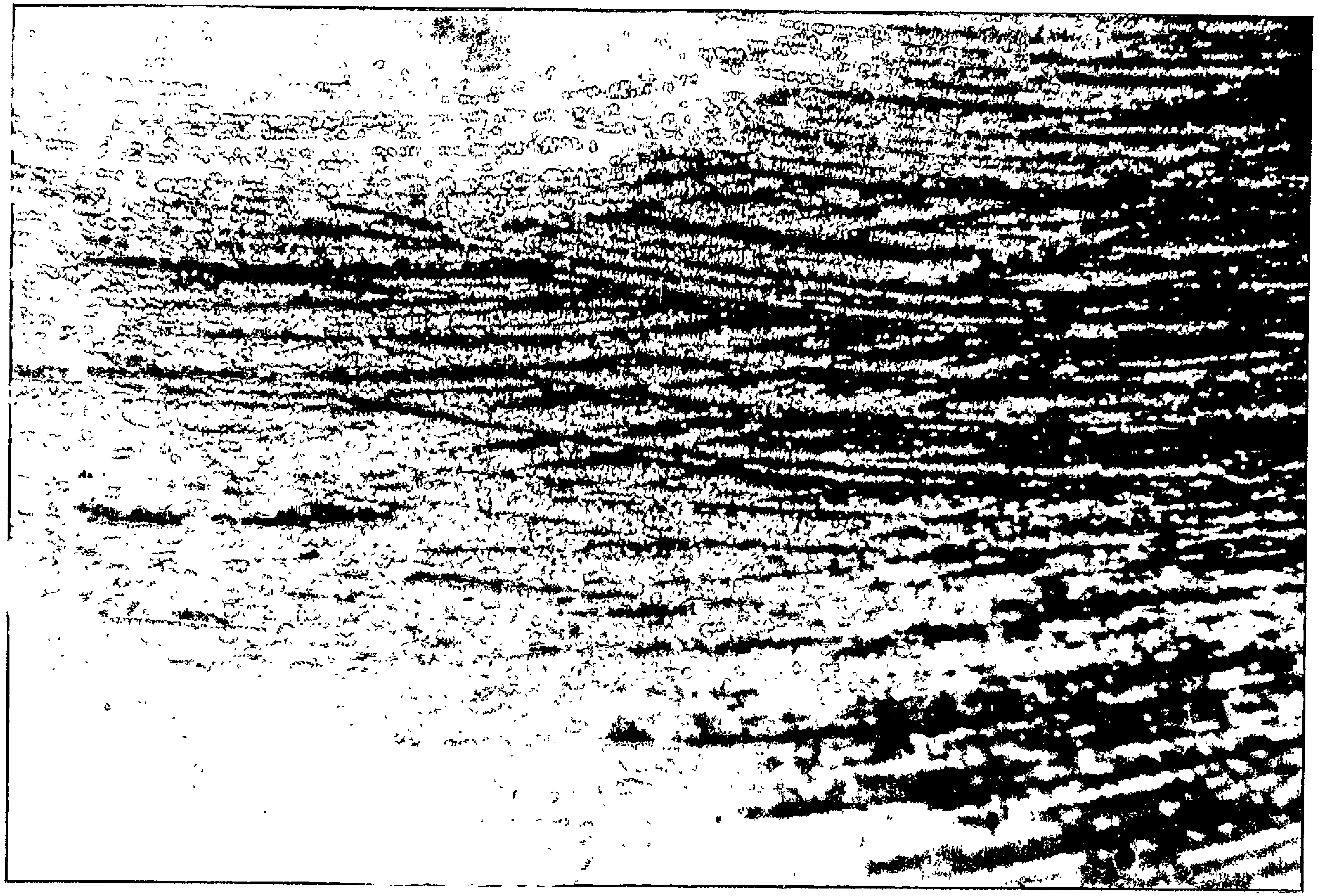


Fig. 31 A representative photomicrograph of a typical enamel surface which has been subjected to diamond disc proximal stripping and has subsequently been polished with a medium polishing strip. (D/D M/S).

Fig. 32 A representative photomicrograph of a typical enamel surface which has been subjected to diamond disc proximal stripping and has subsequently been polished with a medium and then fine polishing strip. (D/D M/S F/S).

CHAPTER 9

DISCUSSION

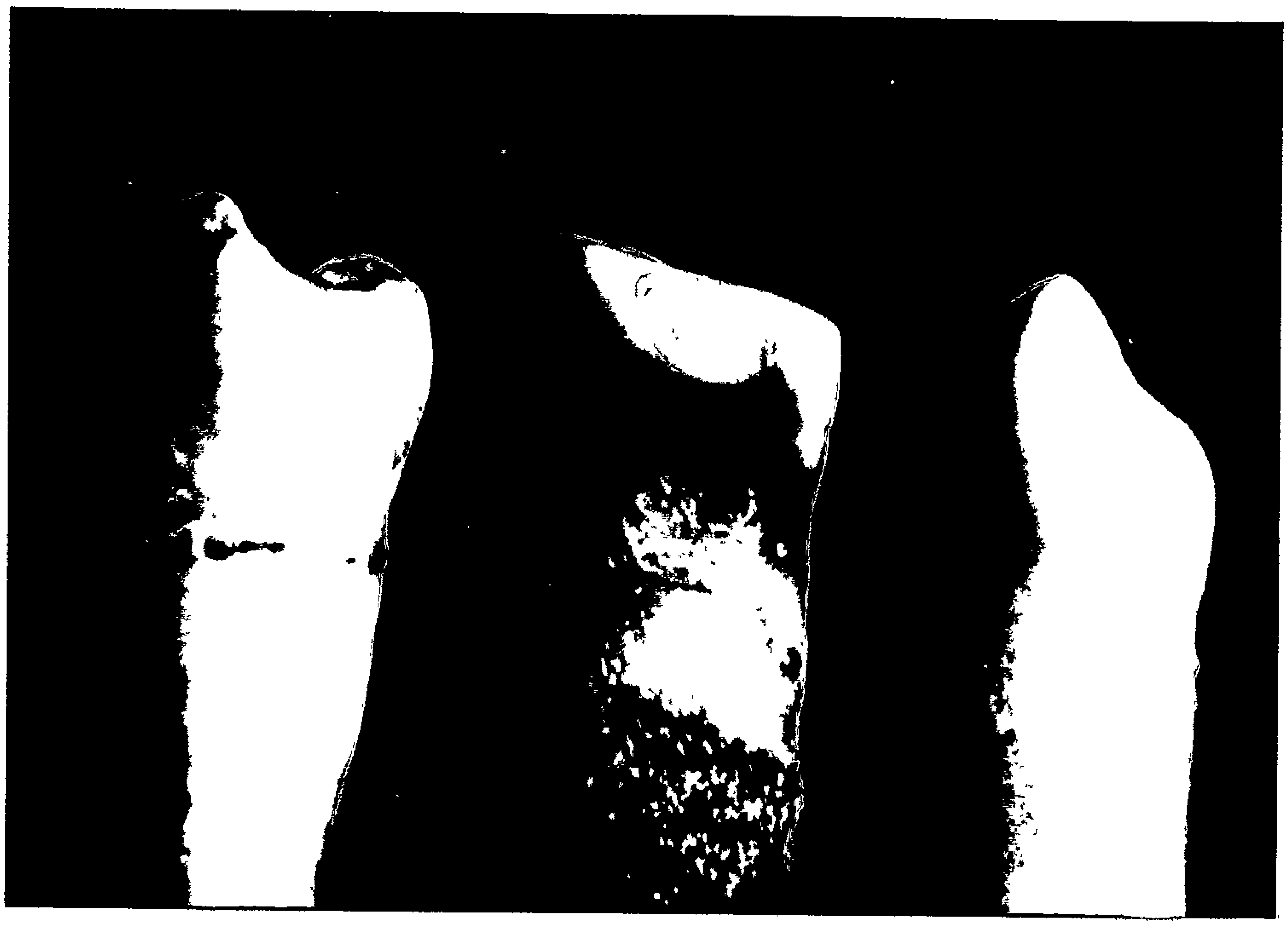
The combination of using the stereomicroscope and scoring the photomicrographs according to the E.R.I. system provided a useful tool for assessing the enamel surface roughness differences produced by the various proximal stripping and polishing procedures. The E.R.I. system was a valuable aid in determining the effect of particular proximal stripping and polishing procedures on the enamel surface, as well as in comparing these surfaces with more commonly found enamel surfaces.

The rank-ordering assessment made it possible, as Osborne et al (1976) had found, to observe minute differences in the enamel surface, as seen in the photomicrographs, and allowed the enamel surfaces as rated and grouped by the E.R.I. system to be further and more closely compared.

Nearly all the enamel surfaces, of the same category of preparation, were remarkably similar in appearance to each other, both macroscopically and microscopically.

The untreated enamel surfaces, both macroscopically and microscopically, have a shiny appearance, with generally a rough uneven surface appearance which is due to the presence of the perikymata. It is this rough appearance of the perikymata that influenced all the evaluators to consistently score the untreated enamel surface as "rough" (E.R.I. no. 3). Figures 15 and 33A.

The surface polished with the prophylaxis paste only, appears



A B C

Fig. 33 Photograph of proximal surfaces representative of the following preparation groups. A, untreated, B, attritional surface, C, polished with prophylaxis paste only.

very similar, both macroscopically and microscopically, to the untreated enamel (Figs. 16 and 33C); except that the surface appears to have a slightly higher sheen and that microscopically the perikymata are less distinct and some very fine scratches are apparent.

However, examining and comparing the photomicrographs of the untreated surfaces and those polished with the prophylaxis paste only, shows a marked difference between the surface appearances. This difference in the photomicrograph appearance was mirrored in the Enamel Roughness Index scores received by the two groups, with the prophylaxis paste consistently scoring 1, as opposed to the 3 score of the untreated group. This difference in appearance is not entirely due to the possible removal of the perikymata by the polishing, but probably due also to the method of photography employed. According to Pus and Way (1980) the polishing should have removed about 10 microns of enamel, which should have been more than enough to remove the 5 microns high perikymata ridges (Shey and Brandt, 1982); however, microscopically the perikymata were still present, though reduced, and should still have been apparent on the photomicrographs. Pus and Way (1980) have also found evidence of perikymata after reducing enamel by more than 5 microns; in their cases some evidence of perikymata were still visible after as much as an estimated 29 microns of enamel had been reduced.

The method of photography used in this study made considerable use of the light reflected from the specimen surface to highlight the surface texture, and as a result those surfaces that were flatter gave a broader image area. As a result the surfaces subjected to the proximal stripping and polishing procedures and the natural attrition surfaces, which had relatively flat surfaces, uniformly gave a good broad image of almost the entire area treated. The untreated surface images were selected, to give a similar broad image, from the proximal surface below the contact point where, on premolars, the surface is quite flat. However as the polishing with the prophylaxis paste was performed at the level of the rounded contact point of the proximal surface, this rounded surface had to be selected for the photomicrograph, and consequently gave a very restricted area for examination; the photomicrograph, as a consequence, focused mainly on the fine scratches at the small area of the rounded contact point and could not display a broad image field which would have exhibited the presence of the perikymata, and so would have probably produced a rougher image in appearance. This photographic anomaly only occurred with this one group of surfaces, and it is in this situation that the use of a

Scanning Electron Microscope, with its increased depth of field, would have been an advantage.

The proximal surfaces exhibiting natural attrition macroscopically appear flattened and have relatively shiny surfaces which do not appear to be as shiny or as smooth as the surrounding proximal enamel (Fig. 33B). Microscopically the majority of the surfaces (seven out of ten) have a lightly acid-etched appearance, differing from the surrounding enamel which is very shiny and smooth in appearance, exhibiting a small number of fine scratches (Fig. 17). Three of the ten surfaces were slightly different in appearance from these others, being smoother with only fine scratches and not lightly acid-etched in appearance. Of these three surfaces, one was randomly selected for the test, and it was scored by three of the evaluators as "very smooth" (E.R.I. no. 1) and by the other evaluator as "smooth" (E.R.I. no. 2) in the first run of the test, and "very smooth" (E.R.I. no. 1) by all four evaluators in the second run. Histories were not collected from the donors of these teeth. However, it is likely that these two types of attritional surfaces were produced by different procedures, the smoother surfaces were possibly as a result of more abrasion from foodstuffs, while the rougher surfaces were possibly produced by the continual small movements of the adjacent teeth rubbing against each other.

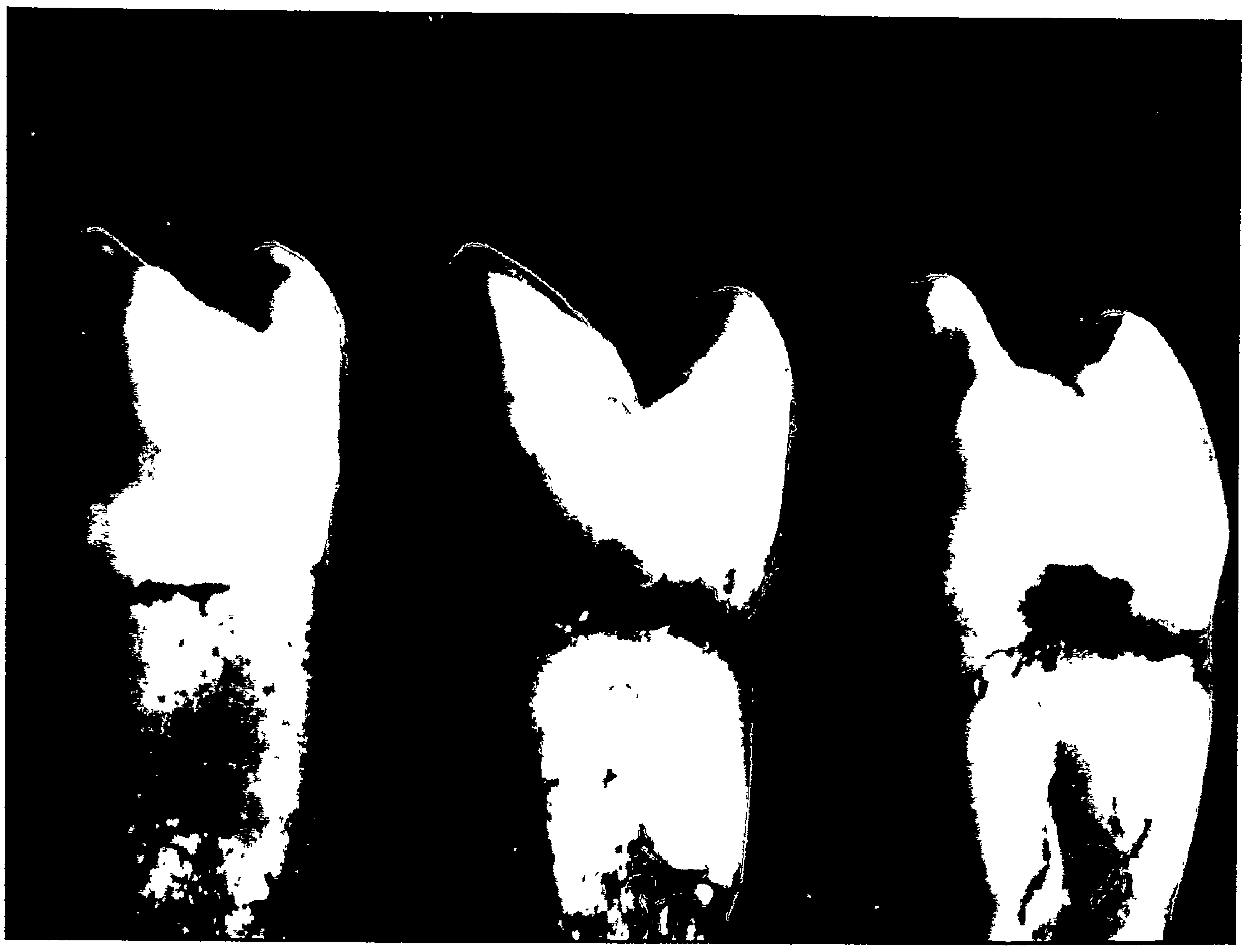
The macroscopic appearance of surfaces which had undergone proximal stripping with the ultrasonic unit, was of a very dull and fairly uniform surface, appearing rough, not unlike acid-etched enamel. The microscopic appearance confirmed the impression gained macroscopically, and not unexpectedly these surfaces were scored as "rough" (E.R.I. no.3) by the evaluators (Figs. 18, 34A, 35A, 36A). This method of stripping

A B C

Fig. 34 Photograph of proximal surfaces representative of the following preparation groups. A, ultrasonic stripping. B, metal-backed polishing strip stripping. C, diamond disc stripping.

A B C

Fig. 35 Photograph of proximal surfaces representative of the following preparation groups. A, ultrasonic stripping. B, ultrasonic stripping and polishing with a medium polishing disc. C, ultrasonic stripping and polishing with medium and fine polishing discs.

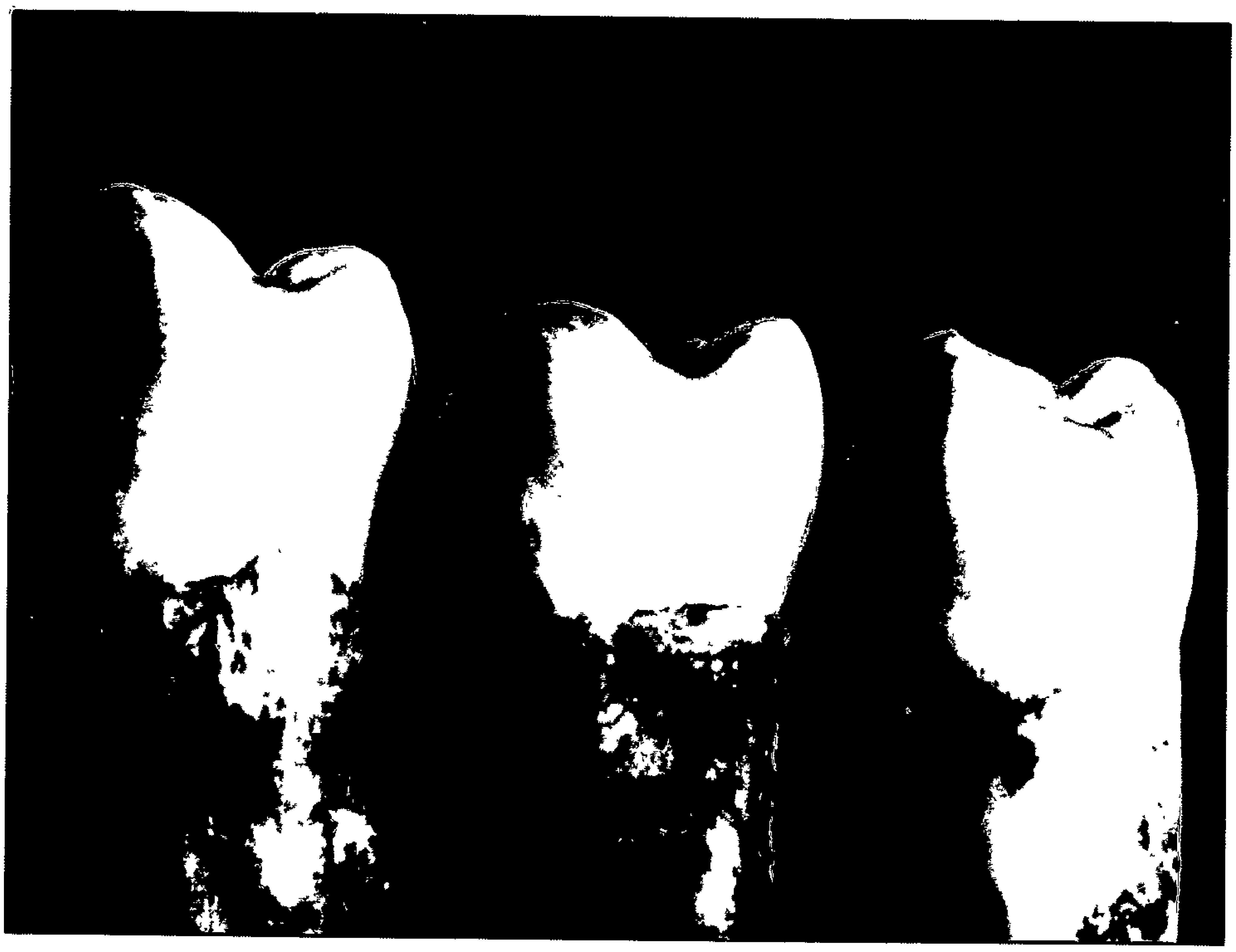


A B C

Fig. 36 Photograph of proximal surfaces representative of the following preparation groups. A, ultrasonic stripping. B, ultrasonic stripping and polishing with a medium polishing strip. C, ultrasonic stripping and polishing with medium and fine polishing strips.

occasionally left what were apparently stainless steel smears on the enamel surface, coming from the special tip of the instrument (Fig. 18). Whether this is generally a feature of the ultrasonic stripping technique, or simply a feature of the technique used by this author is not clear. However, it appears that it is due to a reduction in the quantity of the abrasive paste in the interproximal area during the stripping procedure from time to time, allowing the stainless steel tip to rub directly against the enamel for extended periods without the interface of the abrasive paste. This problem of keeping the abrasive paste at the site of application has been expressed by a number of clinicians. (Mackie 1982, Taylor 1982). These smears were not apparent on the surfaces subsequently polished by the polishing discs and strips, so it may be assumed that the smears are easily removed.

Both the diamond disc and metal-backed polishing strip techniques of proximal stripping produced characteristically both macroscopically and microscopically a dull surface which exhibited distinct deep, regular parallel grooves on the enamel surface. These grooves run approximately buccolingually, corresponding to the direction of the movement of the stripping instrument. Both these methods of proximal stripping produced surfaces of similar appearance which were consistently scored as "rough" (E.R.I. no.3). Figures 23, 28, 34B and C, 37A, 38A, 39A, 40A.



A B C

Fig. 37 Photograph of proximal surfaces representative of the following preparation groups. A, diamond disc stripping. B, diamond disc stripping and polishing with a medium polishing disc. C, diamond disc stripping and polishing with medium and fine polishing discs.

A B C

Fig. 38 Photograph of proximal surfaces representative of the following preparation groups. A, diamond disc stripping. B, diamond disc stripping and polishing with a medium polishing strip. C, diamond disc stripping and polishing with medium and fine polishing strips.

A B C

Fig. 39 Photograph of proximal surfaces representative of the following preparation groups. A, metal-backed polishing strip stripping. B, metal-backed polishing strip stripping and polishing with a medium polishing disc. C, metal-backed polishing strip stripping and polishing with medium and fine polishing discs.

A B C

Fig. 40 Photograph of proximal surfaces representative of the following preparation groups. A, metal-backed polishing strip stripping. B, metal-backed polishing strip stripping and polishing with a medium polishing strip. C, metal-backed polishing strip stripping with medium and fine polishing strip.

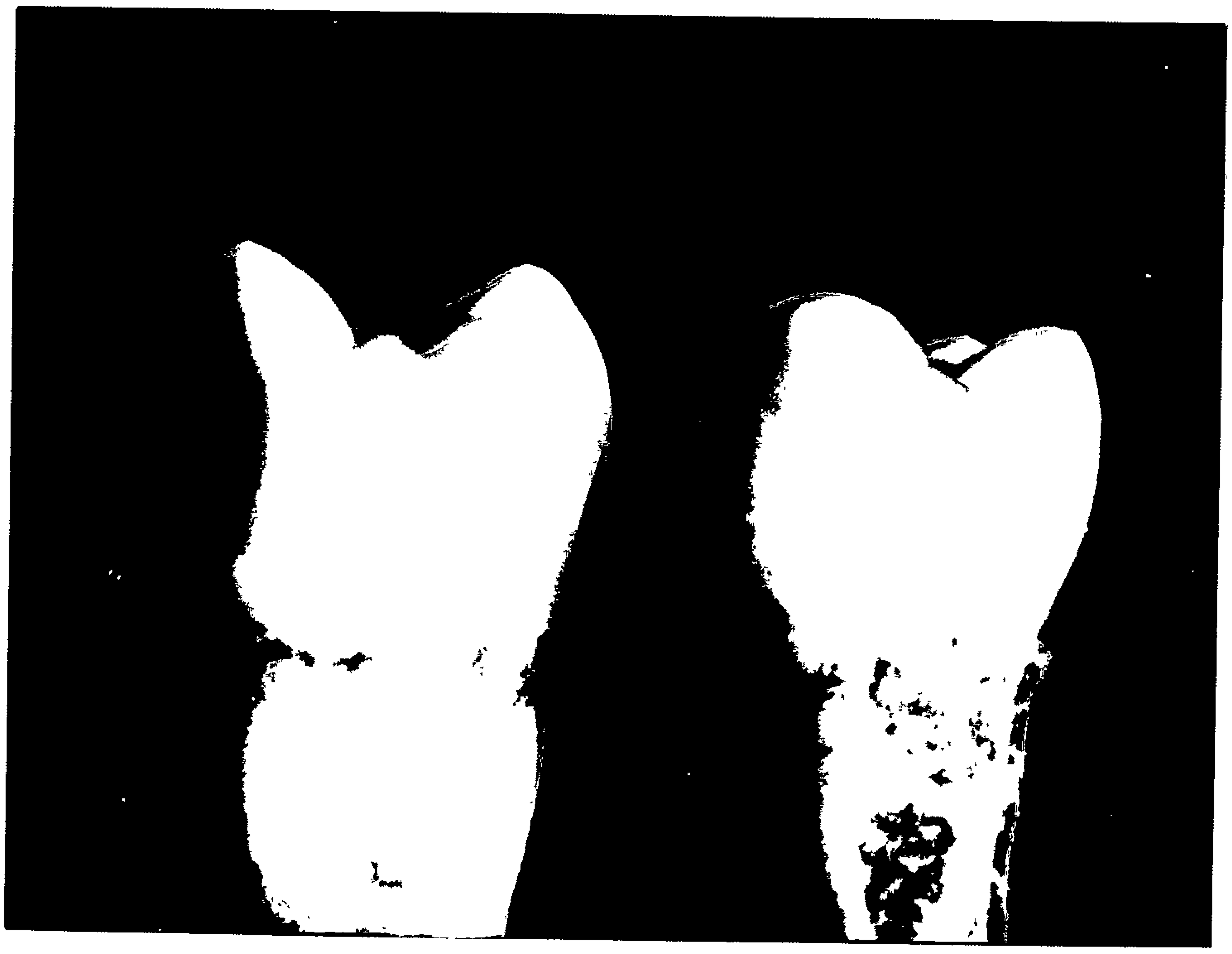
Unlike the ultrasonic stripping, which tended to leave the proximal surface with an indistinct very slightly rounded contour, both the diamond disc and the metal-backed polishing strip stripping procedures, left the proximal surface with a distinctly flattened surface where it had been stripped. In some cases in fact, the diamond disc and metal-backed polishing strip left two flattened planes, where the angle of the stripping instruments were inadvertently slightly changed during the stripping procedure.

In general the use of the medium and the medium and fine polishing strips appeared to reduce the rough appearance of all the variously stripped surfaces a little, with the medium and fine combination reducing the roughness perhaps a little more than just the medium strip alone. However, though the surfaces were left a little shinier and smoother, they still predominately exhibited the underlying appearance of the original stripping procedure (Figs. 21, 22, 26, 27, 31, 32, 36, 38, 40). Some bucco-lingually orientated fine scratches produced by the polishing were apparent. This impression is confirmed by all the evaluators who consistently scored the surfaces polished with the polishing strips as "rough" (E.R.I. no.3).

The appearance of the enamel after ultrasonic and metal-backed polishing strip proximal stripping in this study is consistent with the findings of the study by Gorelick and Tascher (1966). However Gorelick and Tascher found that subsequent polishing of these stripped surfaces with fine cuttlefish strips, for one minute each, markedly changed the surface appearance of the enamel, producing a shiny surface not unlike that of natural enamel, and microscopically a surface showing "many very fine furrows" with almost no trace of the deeper patterns produced by the previous proximal stripping. The results of this study do not agree with this finding of Gorelick and Tascher, as the surfaces polished by the polishing strips in this study consistently still portray the deeper patterns of the proximal stripping, with only a few of the fine scratches, produced by the polishing strips, being distinctly visible.

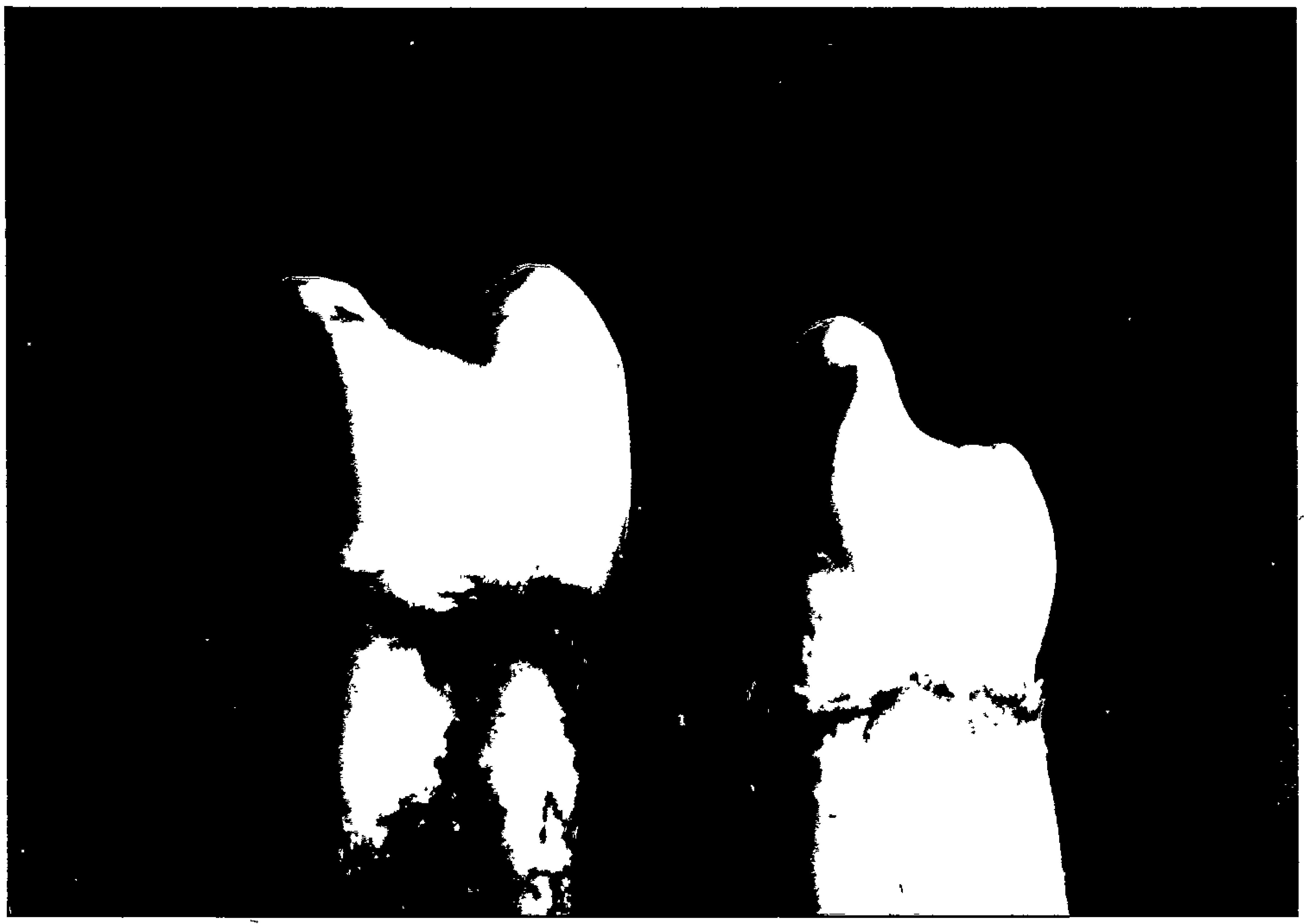
Similarly the results of this study do not agree with the observations of Hudson (1956), Peck and Peck (1975B), Reidel (1975) and Zachrisson (1978) who feel that polishing strips do reduce the roughness of the enamel surface after proximal stripping. The results of this study indicate that polishing for one and two minutes with the polishing strips, to reduce enamel surface roughness, has little apparent value, and does not reduce significantly the enamel roughness.

In contrast, the medium and the medium and fine polishing disc procedures appeared, both macroscopically and microscopically, to remove the rougher pattern left by all the original stripping procedures, leaving the surfaces with a very distinctly shiny and smooth mirror-like finish, which only microscopically showed a great number of very fine regular scratches (Figs. 41 and 42). These scratches were generally orientated bucco-lingually. However this pattern varied a little with the placement and orientation of the polishing disc as it was used. Little obvious difference was seen, by this author, between the surfaces



A B

Fig. 41 Photograph of proximal surfaces representative of the preparation groups, A, diamond disc stripping and polishing with a medium polishing strip, and B, diamond disc stripping and polishing with a medium polishing disc. The dull and rough appearance typically left after polishing with the polishing strip is contrasted by the typical smooth and shiny surface left after polishing with the polishing disc.



A B

Fig. 42 Photograph of proximal surfaces representative of the preparation groups, A, metal-backed polishing strip stripping and polishing with medium and fine polishing strips, and B, metal-backed polishing strip stripping and polishing with medium and fine polishing discs. The dull and rough appearance typically left after polishing with the polishing strips is contrasted by the typical smooth and shiny surface left after polishing with the polishing discs.

polished by the medium and the medium and fine polishing disc procedures, though perhaps the latter did seem to produce microscopically a very slightly more even surface. All the groups finished with the polishing discs tended to be scored as "very smooth" (E.R.I. no.1) by the evaluators. Figs. 12, 20, 24, 25, 29, 30, 35, 37, 39.

In general, according to the rank-ordering assessment in this study, it appears that the diamond disc stripping procedure followed by polishing with the polishing discs, leaves a rougher surface than both the ultrasonic stripping and metal-backed polishing strips followed by the polishing discs;

though this difference appears statistically significant, this difference may not in fact be clinically significant (Clayton and Green 1970, Rosenberg and Ash 1974) with the difference in roughness, both macroscopically and microscopically appearing to be only slight.

There also appears to be very little difference, in terms of enamel roughness, whether the proximal stripping was followed by the medium polishing disc or the medium and fine polishing disc combination polishing procedures; this has been shown by the statistical analysis of the rank-ordering assessment.

This is contrary to the observations of Rentief and Denys (1979) and Zachrisson and Arthun (1979), who in studying debonding procedures, found that fine polishing discs did in fact significantly improve the enamel surface appearance, after the use of medium polishing discs. This disagreement of this study with the studies of these above authors, may be in part due to the different techniques of polishing and assessment, the different polishing discs used, and the different purposes for which the polishing procedures were used.

On the whole it appears that polishing with the polishing discs, either medium or medium and fine, irrespective of the proximal stripping procedure previously used, will produce a uniformly consistent and smoother surface.

The appearance, in this study, of the enamel surface after proximal stripping with the diamond disc, and subsequently the appearance of the enamel after polishing with the polishing discs, is consistent with the observations and conclusions of Thornton Taylor (1982).

Polishing strips tended to scratch the enamel surrounding the stripped area, as they were drawn around the tooth, leaving very fine scratches. The strips, however, did not appreciably polish or round off the contact area as had been suggested by Hudson (1956), Peck and Peck (1975B), Reidel (1975) and Zahrisson (1978). Use of the polishing discs similarly left the adjacent enamel marked. However, the discs also tended to remove enamel and continue the stripping procedure, flattening the contact area further, and/or, rounding the edges of the stripped area, depending on the orientation of the polishing disc as it was used.

The polishing discs did not always reach the whole area that had been stripped, due in part to the interference of the shaft of the mandrel of the polishing disc with the tooth, which restricted the distance to which the disc could be inserted between the teeth. This was especially apparent when the polishing with the polishing disc followed the ultrasonic stripping, as the tip of the ultrasonic stripper tended to reach further gingivally than either the diamond disc or metal-backed polishing strip; thus a stripped area, commonly in the gingival col region, was left unpolished, and presumably this roughened area would tend to collect more dental plaque (Chapter 4), predisposing this very susceptible region of the proximal area to possible gingival and dental disease.

There was some difficulty in comparing the scratches produced by the various proximal stripping and polishing procedures with the perikymata of the enamel surface and the enamel surface of naturally abraded teeth. It is difficult to compare the depths and breadths of the scratches, imperfections and ridges and the use of a profilometer (with datum attachment) would be useful in gauging quantitatively these depths, breadths, contours and the frequency of these imperfections. Similarly it would be worthwhile comparing the quantity or amount of plaque that accumulates and is retained by the variously prepared and naturally produced proximal enamel surfaces, and also from which of these enamel surfaces the plaque is most easily and effectively removed by normal oral hygiene procedures, such as by the use of dental floss. With these further investigations the different enamel surface patterns may be further and more closely compared, and the practical significance of these different patterns may be more clearly defined.

The use of the ash separator appeared to have an added advantage, besides providing space for the ultrasonic and diamond disc stripping, it protected the gingiva (in this case the soft liner material) from laceration; laceration was apparent on many occasions with all the other proximal stripping and polishing procedures, where the separator was not used.

An effort was made, during the proximal stripping and polishing procedure, to simulate as much as possible, the situation that would occur clinically. By using a simulated clinical situation, an attempt was made in this study to obtain the advantages of an in vitro system, and still retain the clinical relevance of the results.

The main factors which are variables and affect the abrasion of surfaces by various abrasive and polishing agents in general, are, according to Rosenblum (1978) and Craig, O'Brien and Powers (1979).

1. Hardness of the abrasive.
2. Particle size of the abrasive.
3. Particle shape of the abrasive.
4. Lubrication.
5. Speed at which the abrasive travels across the surface being abraded or polished.
6. Pressure of the abrasive against the surface being abraded or polished.

The first three factors are controlled in this study and by the clinician in his daily practice, by the choice of the product to be used. The harder, larger and more irregular shaped the abrasive particle, the coarser and deeper will be the scratches, though the quicker the surface will be reduced. (For example in this study the diamond disc reduced the proximal enamel the quickest, and left the roughest surface after polishing with the polishing discs.)

Lubrication may modify the effectiveness of abrasive and polishing agents (and so the scratch pattern), as the lubricant may prevent clogging or build-up of debris on the abrasive instrument. The use of the water spray in this study, and saliva and water spray in the clinical situation should help to prevent this clogging from reducing the effectiveness of the abrasive agent.

The speed at which the abrasive agent was used was also controlled in this study, except in the use of the final polishing strips. However, the speed at which various operators would use these strips would not vary greatly. In general, with slower speeds, the scratching tends to be slightly deeper and coarser.

The exact pressure with which the abrasives are used is difficult to control. However, even though some clinicians may use very heavy pressures and others very light pressures, most would tend to use similar techniques in carrying out these procedures. In addition, though pressures used apparently do make a difference to the scratch patterns (Larsden-Backe, 1967; and Craig, O'Brien and Powers, 1979) the variation of pressures used clinically in the mouth do not vary so greatly that they would greatly alter the scratch pattern results obtained between clinicians, and between clinicians and this study. In general, the heavier the pressure, the deeper and coarser will be the scratches.

Various discs, strips, pastes and products which have similar hardness, shape and size (grit) of the abrasive particles, should perform in a similar manner to those chosen for this study (given similar handling technique); and bearing in mind that some variation in speed and pressures of the abrasives may exist, the results of this study should be applicable clinically to most operators. It is difficult to postulate whether hand-held metal-backed polishing strips will produce similar scratch patterns on enamel as did the motorised metal-backed polishing strips. However, despite the difference in the speed of the abrasive as it moves across the enamel, this author feels that the pattern would be generally similar. These conclusions have been drawn because it is the type and configuration of abrasive used (factors 1, 2 and 3) that is most important, rather than the other physical properties, in controlling the amount, degree and pattern of abrasion and polishing that occurs (Jackson 1974).

To what degree a rough enamel surface, produced by proximal stripping will collect plaque and as a consequence suffer carious attack is difficult to say. It appears that the rougher surfaces will collect more plaque, but whether they will become carious as a result depends on a number of factors such as:-

1. The caries resistance of the enamel. This varies amongst patients, but will often be related to the amount of fluoride taken up by the teeth during their development.

2. The diet of the individual. Those patients who have a highly cariogenic diet may be more susceptible to caries.

3. The standard of oral hygiene of the patient. Those patients who have a poor standard of oral hygiene are at greater risk from the

decay process.

4. Those patients who receive regular dental treatment and fluoride application (through the water supply, via their dentrifice or topically applied) should have a higher resistance to decay.

5. Various teeth in the mouth have different rates of caries susceptibility. For example the lower incisors which are continually being washed by the saliva from the submandibular gland are less susceptible to decalcification, and so, carrying out proximal stripping on these teeth is less likely to lead to decalcification than carrying out proximal stripping on for example the posterior teeth.

It would seem that a child who had poor oral hygiene, poor diet, whose teeth developed in a low fluoride area (without supplementary fluoride), received little or no topical fluoride in any form and in general had a high rate of caries incidence, would, if required to have posterior teeth to be proximally stripped, require, among other things, meticulous polishing of the proximally stripped surfaces to reduce the risk of predisposing the teeth to decalcification. No doubt a child in the reverse situation, who had a very low caries rate and required proximal stripping of the lower anteriors, would be less likely to develop decalcification on these roughened surfaces; however, it would seem like a wise precaution that all teeth, no matter how low their chance of developing decalcification may be, should be carefully polished (and be optimally contoured and have fluoride applied to them) after proximal stripping, to reduce the possibility of predisposing the teeth to decalcification (and possible staining).

CHAPTER 10

SUMMARY AND CONCLUSIONS

10.1 In the literature review the following aspects of proximal stripping were covered:

- Indications for proximal stripping
- When proximal stripping is carried out
- Which teeth and how much enamel can or should be stripped
- Techniques and procedures of proximal stripping
- The need to restore an acceptable interproximal contact area and embrasure
- The limitations that individual enamel, its thickness and properties, may place on proximal stripping.

10.2 Furthermore, the relationship between enamel surface roughness, plaque accumulation and enamel decalcification was discussed.

10.3 Similarly the relationship between enamel surface roughness, tooth appearance, possible staining and remineralisation were related.

10.4 The observations of previous studies which examined the effect of proximal stripping and polishing instruments on the enamel surface were briefly summarised.

10.5 This investigation was undertaken to compare and study the enamel surface roughness produced by various proximal stripping and polishing procedures.

10.6 A stereomicroscope was used to examine a number of extracted tooth surfaces, many of which had undergone, in vitro, various proximal stripping and polishing procedures. Photomicrographs were used in conjunction with an Enamel Roughness Index (E.R.I.) system and rank-ordering assessment to assess the roughness of the enamel surfaces.

10.7 The stereomicroscope, E.R.I. system and rank-ordering assessment were found to be useful tools for assessing enamel roughness.

10.8 It was difficult to make definite conclusions about the untreated, attritional tooth and prophylaxis paste polished enamel surfaces because of possible but uncertain problems with specimen selection and photography. However it appears that these various enamel surfaces do not appear to be greatly different, in terms of surface roughness, from surfaces produced by various proximal stripping and polishing procedures. The untreated and attritional tooth surfaces consistently appeared rough (E.R.I. 3), while the prophylaxis paste polished surface consistently appeared very smooth (E.R.I. 1).

10.9 The three methods of gross proximal stripping used in this study, ultrasonic, motorised metal-backed polishing strips and diamond discs, all left the enamel appearing rough (E.R.I. 3).

10.10 The use of the medium and medium and fine polishing strips after the proximal stripping, did not appreciably change the appearance of the enamel surface, and these surfaces still retained their rough appearance (E.R.I. 3). It is concluded that these polishing strips appear not to be very useful in polishing the enamel surface after proximal stripping procedures used in this study.

10.11 In contrast, the polishing discs, medium, and medium and fine in combination, did consistently markedly reduce the roughness of the enamel surface after proximal stripping. The enamel surface after polishing with the polishing discs consistently appeared to be very smooth (E.R.I. 1); therefore it is concluded that these polishing discs do appear to be very useful in polishing the enamel surfaces after the proximal stripping used in this study.

10.12 There appeared to be no appreciable difference between the enamel surfaces polished with the medium or the medium and fine polishing disc procedures, and there would seem to be no major benefit in polishing the enamel surface with a fine polishing disc after the use of a medium polishing disc. In addition the use of several polishing steps is cumbersome and too time consuming for routine practice. Therefore, it is recommended that only the medium polishing disc (as used and carried out in this study) be used to polish the enamel surface after proximal stripping to attain a smooth surface.

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APPENDIX 1

Table 6 Compilation of the record sheets used for the first run of the first assessment procedure, showing the surface preparation of each of the photomicrographs, in the order they were presented for assessment to the evaluators. The E.R.I. scores recorded for each of these photomicrographs by each of the four evaluators are also shown.

Code number and surface preparation		Evaluators			
		1	2	3	4
1	5.4 D/D M/D	1	1	1	1
2	3.7 D/S M/S	3	3	3	3
3	4.21 D/D M/D	2	1	1	2
4	4.31 D/D M/D	1	1	1	1
5	5.17 P	1	1	1	1
6	3.24 D/S M/D F/D	1	1	1	1
7	4.18 D/D M/S	3	3	3	3
8	3.25 D/S M/S F/S	3	3	3	3
9	3.15 D/S M/S F/S	3	3	3	3
10	3.22 D/S M/D F/D	1	1	1	2
11	5.34 AT	3	3	3	3
12	6.2 AT	3	3	3	3
13	1.3 U/S M/S F/S	3	3	3	3
14	3.20 D/S M/D F/D	1	1	1	1
15	4.20 D/D M/D F/D	1	1	1	1
16	2.35 D/S M/S	3	3	3	3
17	1.16 U/S	3	3	3	3
18	1.6 U/S M/S	3	3	3	3
19	3.33 D/D M/S F/S	3	3	3	2
20	1.23 U/S M/S	3	3	3	3
21	4.10 D/D M/S	3	3	3	3
22	1.4 U/S M/S	3	3	3	3
23	2.22 D/S M/D	1	1	1	1
24	2.33 D/S M/S	3	3	3	3
25	2.25 D/S	3	3	3	3
26	1.31 U/S M/D F/D	1	1	1	1
27	1.36 U/S M/D	1	1	1	1

Table 6 continued

Code number and surface preparation		Evaluators 1	2	3	4
28	2.2 U/S M/D	2	1	1	1
29	1.10 U/S M/S F/S	3	3	3	3
30	2.8 U/S M/D F/D	1	1	1	1
31	1.14 U/S M/S F/S	3	3	3	3
32	1.20 U/S	3	3	3	3
33	4.30 D/D M/D F/D	2	1	3	2
34	1.2 U/S M/S	3	3	3	3
35	5.10 P	2	1	1	1
36	2.6 U/S	3	3	3	3
37	4.24 D/D M/D F/D	2	1	3	1
38	1.15 D/S M/S	3	3	3	3
39	5.26 UT	3	3	3	3
40	5.32 AT	2	1	1	1
41	4.33 D/D M/D F/D	2	1	1	1
42	5.16 P	2	1	1	1
43	4.15 D/D M/S	3	3	3	3
44	4.19 D/D M/D	2	1	3	1
45	4.27 D/D M/D	1	1	1	1
46	3.13 D/S M/S F/S	3	3	3	3
47	3.2 D/S M/S F/S	3	3	3	3
48	3.27 D/S M/S F/S	3	3	3	3
49	3.35 D/D M/S F/S	3	3	3	3
50	4.14 D/D	3	3	3	3
51	4.2 D/D M/S	3	3	3	3
52	4.25 D/D	3	3	3	1
53	1.12 U/S M/S F/S	3	3	3	3
54	2.18 D/S M/D F/D	1	1	1	1
55	2.30 D/S	3	3	3	3
56	3.28 D/S M/D F/D	1	1	1	1
57	2.3 U/S M/D	2	1	1	1
58	5.14 P	1	1	1	1
59	4.29 D/D	3	3	3	3
60	2.34 D/S	3	3	3	3
61	5.22 UT	3	3	3	3
62	4.34 D/D	3	3	3	3

Table 6 continued

Code number and surface preparation		Evaluators			
		1	2	3	4
63	2.7 U/S M/D	2	1	1	1
64	2.13 U/S M/D	2	1	1	1
65	1.29 U/S	3	3	3	3
66	5.28 UT	3	3	3	3
67	2.28 D/S M/S	3	3	3	2
68	5.35 AT	3	3	3	3
69	3.8 D/S M/D	1	1	1	1
70	4.17 D/D	3	3	3	3
71	2.23 D/S	3	3	3	3
72	3.30 D/D M/S	3	3	3	3
73	1.34 U/S M/D F/D	1	1	1	2
74	1.32 U/S M/D F/D	1	1	1	1
75	2.9 U/S	3	3	3	3
76	2.9 U/S M/D F/D	2	1	1	1
77	3.10 D/S	3	3	3	3
78	5.12 P	2	1	1	1
79	5.23 UT	3	3	3	3
80	2.32 D/S M/S	3	3	3	3
81	1.22 U/S M/S F/S	3	3	3	3
82	5.21 UT	3	3	3	3
83	2.31 D/S M/D	1	1	1	1
84	2.26 D/S M/D	1	1	1	1
85	4.1 D/D M/S F/S	3	3	3	3
86	5.30 AT	3	3	3	3
87	4.16 D/D M/S F/S	3	3	3	3
88	3.12 D/S M/D	2	1	1	1
89	5.1 D/D M/D F/D	2	1	1	1
90	4.11 D/D M/S F/S	3	3	3	3

Table 7 The total number of E.R.I. scores from the first run of the first assessment procedure.

Preparation Groups	E.R.I. Scores 0	1	2	3	4
1. UT				20	
2. P		17	3		
3. AT		3	1	16	
4. U/S				20	
5. U/S M/D		16	4		
6. U/S M/D F/D		18	2		
7. U/S M/S				20	
8. U/S M/S F/S				20	
9. D/S				20	
10. D/S M/D		19	1		
11. D/S M/D F/D		19	1		
12. D/S M/S			1	19	
13. D/S M/S F/S				20	
14. D/D		1		19	
15. D/D M/D		16	3	1	
16. D/D M/D F/D		13	5	2	
17. D/D M/S				20	
18. D/D M/S F/S			1	19	

Table 8 Compilation of the record sheets used for the second run of the first assessment procedure, showing the surface preparation of each of the photomicrographs, in the order they were presented for assessment to the evaluators. The E.R.I. scores recorded for each of these photomicrographs by each of the four evaluators are also shown.

Code number and surface preparation		Evaluators 1	2	3	4
1	1.22 U/S M/S F/S	3	3	3	3
2	4.29 D/D	3	3	3	3
3	2.25 D/S	3	3	3	3
4	1.23 U/S M/S	3	3	3	3
5	2.3 U/S M/D	1	1	1	1
6	2.23 D/S	3	3	3	3
7	1.29 U/S	3	3	3	3
8	3.25 D/S M/S F/S	3	3	3	3
9	5.35 AT	3	3	3	3
10	4.20 D/D M/D F/D	3	1	3	1
11	3.28 D/S M/D F/D	1	1	1	2
12	4.14 D/D	3	3	3	3
13	3.33 D/D M/S F/S	3	3	3	3
14	5.10 P	1	1	1	1
15	3.20 D/S M/D F/D	1	1	1	1
16	2.28 D/S M/S	3	3	3	3
17	5.26 UT	3	3	3	3
18	3.27 D/S M/S F/S	3	3	3	3
19	5.23 UT	3	3	3	3
20	4.17 D/D	3	3	3	3
21	5.12 P	1	1	1	1
22	2.33 D/S M/S	3	3	3	3
23	5.16 P	3	1	1	2
24	2.35 D/S M/S	3	3	3	3
25	2.18 D/S M/D F/D	1	1	1	1
26	3.24 D/S M/D F/D	1	1	1	1
27	3.8 D/S M/D	1	1	1	1
28	5.17 P	1	1	1	1
29	3.12 D/S M/D	1	1	1	1

Table 8 continued

	Code number and surface preparation	Evaluators 1	2	3	4
30	3.10 D/S	3	3	3	3
31	5.32 AT	1	1	1	1
32	4.18 D/D M/S	3	3	3	3
33	2.30 D/S	3	3	3	3
34	4.34 D/D	3	3	3	3
35	2.8 U/S M/D F/D	1	1	1	1
36	4.15 D/D M/S	3	3	3	3
37	4.24 D/D M/D F/D	2	1	1	1
38	4.31 D/D M/D	2	1	1	1
39	5.4 D/D M/D	1	1	1	1
40	1.4 U/S M/S	3	3	3	3
41	3.35 D/D M/S F/S	3	3	3	3
42	1.16 U/S	3	3	3	3
43	4.21 D/D M/D	2	1	1	1
44	4.1 D/D M/S F/S	3	3	3	3
45	2.34 D/S	3	3	3	3
46	1.31 U/S M/D F/D	1	1	1	1
47	1.10 U/S M/S F/S	3	3	3	3
48	1.14 U/S M/S F/S	3	3	3	3
49	4.16 D/D M/S F/S	3	3	3	3
50	2.31 D/S M/D	1	1	1	1
51	4.25 D/D	3	1	3	3
52	4.11 D/D M/S F/S	3	3	3	3
53	3.15 D/S M/S F/S	3	3	3	3
54	2.6 U/S	3	3	3	3
55	1.34 U/S M/D F/D	1	1	1	1
56	5.30 AT	3	3	3	3
57	2.9 U/S	3	3	3	3
58	2.26 D/S M/D	1	1	1	1
59	3.22 D/S M/D F/D	1	1	1	1
60	3.13 D/S M/S F/S	3	3	3	3
61	1.12 U/S M/S F/S	3	3	3	3
62	2.22 D/S M/D	1	1	1	2
63	1.20 U/S	3	3	3	3

Table 8 continued

Code number and surface preparation		Evaluators 1	2	3	4
64	2.13 U/S M/D	2	1	3	1
65	1.3 U/S M/S F/S	3	3	3	3
66	4.27 D/D M/D	2	1	1	1
67	5.28 UT	3	3	3	3
68	1.2 U/S M/S	3	3	3	3
69	4.19 D/D M/D	2	1	3	2
70	4.2 D/D M/S	3	3	3	3
71	1.36 U/S M/D	1	1	1	1
72	3.2 D/S M/S F/S	3	3	3	3
73	3.30 D/D M/S	3	1	3	2
74	5.22 UT	3	3	3	3
75	2.32 D/S M/S	3	3	3	3
76	1.26 U/S M/D F/D	1	1	1	1
77	5.34 AT	3	3	3	3
78	4.33 D/D M/D F/D	2	1	1	1
79	2.2 U/S M/D	1	1	1	1
80	5.1 D/D M/D F/D	2	1	1	1
81	6.2 AT	3	3	3	3
82	1.15 U/S M/S	3	3	3	3
83	5.21 UT	3	3	3	3
84	5.14 P	1	1	1	1
85	3.7 D/S M/S	3	3	3	3
86	4.10 D/D M/S	3	3	3	3
87	1.32 U/S M/D F/D	1	1	1	1
88	1.6 U/S M/S	3	3	3	3
89	2.7 U/S M/D	1	1	1	1
90	4.30 D/D M/D F/D	2	1	1	2

Table 9 The total number of E.R.I. scores from the second run of the first assessment procedure.

Preparation Groups	E.R.I. Scores 0	1	2	3	4
1. UT				20	
2. P		18	1	1	
3. AT		4		16	
4. U/S				20	
5. U/S M/D		18	1	1	
6. U/S M/D F/D		20			
7. U/S M/S				20	
8. U/S M/S F/S				20	
9. D/S				20	
10. D/S M/D		19	1		
11. D/S M/D F/D		19	1		
12. D/S M/S				20	
13. D/S M/S F/S				20	
14. D/D			1	19	
15. D/D M/D		14	5	1	
16. D/D M/D F/D		13	5	2	
17. D/D M/S		1	1	18	
18. D/D M/S F/S				20	

Table 10 Compilation of the record sheets used for the second assessment procedure showing the code number and surface preparation in the order of ranking of the photomicrographs from smoothest (number 1) to roughest (number 30) by the four evaluators.

Ranking Order	Evaluators 1	2	3	4
1	3.28 D/S M/D F/D	1.34 U/S M/D F/D	3.28 D/S M/D F/D	1.34 U/S M/D F/D
2	2.26 D/S M/D	3.28 D/S M/D F/D	1.31 U/S M/D F/D	1.31 U/S M/D F/D
3	2.31 D/S M/D	2.8 U/S M/D F/D	2.8 U/S M/D F/D	3.28 D/S M/D F/D
4	1.31 U/S M/D F/D	2.31 D/S M/D	2.31 D/S M/D	2.26 D/S M/D
5	1.34 U/S M/D F/D	3.12 D/S M/D	1.36 U/S M/D	2.31 D/S M/D
6	1.32 U/S M/D F/D	2.26 D/S M/D	3.22 D/S M/D F/D	3.8 D/S M/D
7	2.22 D/S M/D	3.8 D/S M/D	2.26 D/S M/D	3.12 D/S M/D
8	3.22 D/S M/D F/D	3.20 D/S M/D F/D	1.34 U/S M/D F/D	5.1 D/D M/D F/D
9	3.12 D/S M/D	3.24 D/S M/D F/D	2.22 D/S M/D	2.8 U/S M/D F/D
10	3.20 D/S M/D F/D	3.22 D/S M/D F/D	3.20 D/S M/D F/D	1.32 U/S M/D F/D
11	3.24 D/S M/D F/D	1.36 U/S M/D	3.8 D/S M/D	2.22 D/S M/D
12	3.8 D/S M/D	1.31 U/S M/D F/D	3.24 D/S M/D F/D	3.24 D/S M/D F/D
13	2.8 U/S M/D F/D	2.22 D/S M/D	2.18 D/S M/D F/D	1.36 U/S M/D
14	2.7 U/S M/D	2.3 U/S M/D	2.3 U/S M/D	2.18 D/S M/D F/D
15	2.2 U/S M/D	1.32 U/S M/D F/D	2.7 U/S M/D	2.7 U/S M/D
16	1.36 U/S M/D	2.7 U/S M/D	3.12 D/S M/D	3.20 D/S M/D F/D
17	2.18 D/S M/D F/D	2.18 D/S M/D F/D	1.32 U/S M/D F/D	4.20 D/D M/D F/D
18	2.3 U/S M/D	1.26 U/S M/D F/D	4.21 D/D M/D	3.22 D/S M/D F/D

Table 10 continued

Ranking Order	Evaluators 1	Evaluators 2	Evaluators 3	Evaluators 4
19	1.26 D/S M/D F/D	2.2 U/S M/D	2.2 U/S M/D	2.3 U/S M/D
20	5.1 D/D M/D F/D	2.13 U/S M/D	4.33 D/D M/D F/D	1.26 U/S M/D F/D
21	2.13 U/S M/D	5.1 D/D M/D F/D	1.26 U/S M/D F/D	2.2 U/S M/D
22	5.4 D/D M/D	4.20 D/D M/D F/D	4.20 D/D M/D F/D	4.33 D/D M/D F/D
23	4.20 D/D M/D F/D	4.24 D/D M/D F/D	4.27 D/D M/D	4.30 D/D M/D F/D
24	4.31 D/D M/D	4.21 D/D M/D	2.13 U/S M/D	2.13 U/S M/D
25	4.24 D/D M/D F/D	4.33 D/D M/D F/D	5.1 D/D M/D F/D	4.27 D/D M/D
26	4.33 D/D M/D F/D	4.19 D/D M/D	4.30 D/D M/D F/D	4.31 D/D M/D
27	4.21 D/D M/D	4.31 D/D M/D	5.4 D/D M/D	4.19 D/D M/D
28	4.30 D/D M/D F/D	4.27 D/D M/D	4.31 D/D M/D	4.24 D/D M/D F/D
29	4.27 D/D M/D	4.30 D/D M/D F/D	4.24 D/D M/D F/D	4.21 D/D M/D
30	4.19 D/D M/D	5.4 D/D M/D	4.19 D/D M/D	5.4 D/D M/D

Table 11 The Rank ordering performed by the four evaluators

Evaluator	Preparation Group	Ranks assigned	Sum of Ranks
1	U/S M/D	14,15,16,18,21	84
	U/S M/D	4,5,6,13,19	47
	D/S M/D	2,3,7,9,12	33
	D/S M/D F/D	1,8,10,11,17	47
	D/D M/D	22,24,27,29,30	132
	D/D M/D F/D	20,23,25,26,28	122
2	U/S M/D	11,14,16,19,20	80
	U/S M/D F/D	1,3,12,15,18	49
	D/S M/D	4,5,6,7,13	35
	D/S M/D F/D	2,8,9,10,17	46
	D/D M/D	24,26,27,28,30	135
	D/D M/D F/D	21,22,23,25,29	120
3	U/S M/D	5,14,15,19,24	77
	U/S M/D F/D	2,3,8,17,21	51
	D/S M/D	4,7,9,11,16	47
	D/S M/D F/D	1,6,10,12,13	42
	D/D M/D	18,23,27,28,30	126
	D/D M/D F/D	20,22,25,26,29	122
4	U/S M/D	13,15,19,21,24	92
	U/S M/D F/D	1,2,9,10,20	42
	D/S M/D	4,5,6,7,11	33
	D/S M/D F/D	3,12,14,16,18	63
	D/D M/D	25,26,27,29,30	137
	D/D M/D F/D	8,17,22,23,28	98

APPENDIX 2

Assessment 1

1. Chi-square tests (Chilton 1967)

1.1 Comparison of the two evaluations performed five days apart.

	E.R.I. Score observed (0) 1	2	3	TOTAL
First evaluation	122	22	216	360
Second evaluation	126	16	218	360
TOTAL	248	38	434	720
Expected (E)	124	19	217	

	0	E	0-E	$(0-E)^2$	$\frac{(0-E)^2}{E}$
First evaluation E.R.I. 1.	122	124	-2	4	0.03
First evaluation E.R.I. 2.	22	19	+3	9	0.47
First evaluation E.R.I. 3.	216	217	-1	1	0.00
Second evaluation E.R.I. 1.	126	124	+2	4	0.03
Second evaluation E.R.I. 2.	16	19	-3	9	0.47
Second evaluation E.R.I. 3.	218	217	+1	1	0.00

$$x^2 = \frac{(0-E)^2}{E}$$

$x^2 = 1.00$
P $= 0.70$

This indicates that there was very little variation between the two evaluations.

1.2 Comparison of the groups that were consistently rated as 'very smooth' (E.R.I. 1.) and those consistently rated as 'rough' (E.R.I. 3)

	E.R.I. score observed (0)			
	1	2	3	TOTAL
very smooth	239	33	8	280
rough	9	5	426	440
TOTAL	248	38	434	720
Expected (E)	124	19	217	

$$x^2 = \sum \frac{(O-E)^2}{E}$$

$x^2 = 636.52$

$P < 0.001$

This indicates that there was a statistically significant difference between the groups that were consistently scored as 'very smooth' and those that were consistently scored as 'rough'.

Assessment 2

1. Spearman's rank-order correlation coefficient (p) (Mendenhall, Ott and Larson 1974)

Code number and preparation	Rankings by evaluators				Differences between rankings between evaluators											
					1-2		1-3		1-4		2-3		2-4		3-4	
	1	2	3	4	d	d^2	d	d^2	d	d^2	d	d^2	d	d^2	d	d^2
3.28 D/S M/D F/D	1	2	1	3	-1	1	0	0	-2	4	1	1	-1	1	-2	4
2.26 D/S M/D	2	6	7	4	-4	16	-5	25	-2	4	-1	1	2	4	3	9
2.31 D/S M/D	3	4	4	5	-1	1	-1	1	-2	4	0	0	-1	1	-1	1
1.31 U/S M/D F/D	4	12	2	2	-8	64	2	4	2	4	10	100	10	100	0	0
1.34 U/S M/D F/D	5	1	8	1	4	16	-3	9	4	16	-7	49	0	0	7	49
1.32 U/S M/D F/D	6	15	17	10	-9	81	-11	121	-4	16	-2	4	5	25	7	49
2.22 D/S M/D	7	13	9	11	-6	36	-2	4	-4	16	4	16	2	4	-2	4
3.22 D/S M/D F/D	8	10	6	18	-2	4	2	4	-10	100	4	16	-8	64	-12	144
3.12 D/S M/D	9	5	16	7	4	16	-7	49	2	4	-11	121	-2	4	9	81
3.20 D/S M/D F/D	10	8	10	16	2	4	0	0	-6	36	-2	4	-8	64	-6	36
3.24 D/S M/D F/d	11	9	12	12	2	4	-1	1	-1	1	-3	9	-3	9	0	0
3.8 D/S M/D	12	7	11	6	5	25	1	1	6	36	-4	16	1	1	5	25
2.8 U/S M/D F/D	13	3	3	9	10	100	10	100	4	16	0	0	-6	36	-6	36
2.7 U/S M/D	14	16	15	15	-2	4	-1	1	-1	1	1	1	1	1	0	0
2.2 U/S M/D	15	19	19	21	-4	16	-4	16	-6	36	0	0	-2	4	-2	4
1.36 U/S M/D	16	11	5	13	5	25	11	121	3	9	6	36	-2	4	-8	64
2.18 D/S M/D F/D	17	17	13	14	0	0	4	16	3	9	4	16	3	9	-1	1
2.3 U/S M/D	18	14	14	19	4	16	4	16	-1	1	0	0	-5	25	-5	25
1.26 U/S M/D F/D	19	18	21	20	1	1	-2	4	-1	1	-3	9	-2	4	1	1

Code number and preparation	Rankings by evaluators				Differences between rankings between evaluators											
					1-2		1-3		1-4		2-3		2-4		3-4	
	1	2	3	4	d	d^2	d	d^2	d	d^2	d	d^2	d	d^2	d	d^2
5.1 D/D M/D F/D	20	21	25	8	-1	1	-5	25	12	144	-4	16	13	169	17	289
2.13 U/S M/D	21	20	24	24	1	1	-3	9	-3	9	-4	16	-4	16	0	0
5.4 D/D M/D	22	30	27	30	-8	64	-5	25	-8	64	3	9	0	0	-3	9
4.20 D/D M/D F/d	23	22	22	17	1	1	1	1	6	36	0	0	5	25	5	25
4.31 D/D M/D	24	27	28	26	-3	9	-4	16	-2	4	1	1	1	1	2	4
4.24 D/D M/D F/D	25	23	29	28	2	4	-4	16	-3	9	-6	36	-5	25	1	1
4.33 D/D M/D F/D	26	25	20	22	1	1	6	36	4	8	5	25	3	9	-2	4
4.21 D/D M/D	27	24	18	29	3	9	9	81	-2	4	6	36	-5	25	-11	121
4.30 D/D M/D F/D	28	29	26	23	-1	1	2	4	5	25	3	9	6	36	3	9
4.27 D/D M/D	29	28	23	25	1	1	6	36	4	16	5	25	3	9	-2	4
4.19 D/D M/D	30	26	30	27	4	16	0	0	3	9	-4	16	-1	1	3	9
total d^2						538		742		642		588		676		1008

1.1 Correlation between evaluators 1 and 2

$$p = 1 - \frac{6 \sum d^2}{n\,(n^2-1)} = 1 - \frac{6\,(538)}{30(30^2-1)} = 0.88$$

$$t = p\sqrt{\frac{n-2}{1-p^2}} = (.88)\sqrt{\frac{30-2}{1-(.88)^2}} = 9.71 \quad (P < 0.0005)$$

1.2 Correlation between evaluators 1 and 3

$p = 0.83$, $t = 7.89$ $(P < 0.0005)$

1.3 Correlation between evaluators 1 and 4

$p = 0.86$, $t = 8.92$ $(P < 0.0005)$

1.4 Correlation between evaluators 2 and 3.

$p = 0.87$, $t = 9.40$ $(P < 0.0005)$

1.5 Correlation between evaluators 2 and 4

$p = 0.85$, $t = 8.50$ $(P < 0.0005)$

1.6 Correlation between evaluators 3 and 4

$p = 0.78$, $t = 6.61$ $(P < 0.0005)$

Spearman's rank-order correlations between the four evaluators (multiple correlations) ranged from a low of + 0.78 to a high of + 0.88, giving very consistent relationships ($P < 0.0005$) with a high level of correlation, indicating that there was no significant difference in the way the evaluators rated the photomicrographs.

2 Friedman two-way analysis of variance by ranks (Siegel 1956)

2.1 To test for differences between the preparation groups.

	Preparation group					
Evaluator	1.U/S M/D	2.U/S M/D F/D	3.D/S M/D	4.D/S M/D F/D	5.D/D M/D	6.D/D M/D F/D
1 rank	84 4	47 2.5	33 1	47 2.5	132 6	122 5
2 rank	80 4	49 3	35 1	46 2	135 6	120 5
3 rank	77 4	51 3	47 2	42 1	126 6	122 5
4 rank	92 4	42 2	33 1	63 3	137 6	98 5
Total of ranks	16	10.5	5	8.5	24	20

$$X_r^2 = \frac{12}{Nk\ (k+1} \sum (R_j)^2 - 3N\ (k+1)$$

$$= \frac{12}{(4)(6)(6+1)} \left[(16)^2+(10.5)^2+(5)^2+(8.5)^2+(24)^2+(20)^2 \right] - (3)(4)(6+1)$$

$$= 18.82 \qquad P < 0.01$$

Indicating that there were significant differences between the preparation groups.

2.2 To test the differences among the evaluators

Preparation groups	Evaluators 1	2	3	4
1. U/S M/D	84	80	77	92
rank	3	2	1	4
2. U/S M/D F/D	47	49	51	42
rank	2	3	4	1
3. D/S M/D	33	35	47	33
rank	1.5	3	4	1.5
4. D/S M/D F/D	47	46	42	63
rank	3	2	1	4
5. D/D M/D	132	135	126	137
rank	2	3	1	4
6. D/D M/D F/D	122	120	122	98
rank	3.5	2	3.5	1
Total of ranks	15	15	14.5	15.5

$$x_r^2 = \frac{12}{Nk(k+1)} \sum (R_j)^2 - 3N(k+1)$$

$$= 0.05 \qquad P > 0.95$$

This indicates that there was no significant difference in the way the evaluators ranked the photomicrographs.

3. Student's t-test (Hill 1977)

This type of data can either be treated by nonparametric statistics or by traditional analysis of variance, the later has been used in this instance.

Preparation group	Sum of ranks	Mean	S.D.	S.E.
1. U/S M/D	333	16.65	4.51	1.01
2. D/S M/D F/D	189	9.45	6.95	1.55
3. D/S M/D	148	7.40	3.68	0.82
4. D/S M/D F/D	198	9.90	5.29	1.18
5. D/D M/D	530	26.50	3.14	0.70
6. D/D M/D F/D	462	23.10	4.80	1.07
1+3+5 All M/D	1011	16.85	8.71	1.12
2+4+6 All M/D F/D	849	14.15	8.53	1.10

3.1 Comparison between preparation groups 1. U/S M/D and 2. U/S M/D F.D.

$$\text{Significance Ratio} = \frac{\text{difference of means}}{\text{S.E. of difference}} = \frac{\text{difference of means}}{\sqrt{(S.E_1)^2 + (S.E_2)^2}}$$

$$= \frac{16.65-9.45}{\sqrt{(1.01)^2+(1.55)^2}} = 3.89 \quad (P < 0.003)$$

3.2 Comparison between preparation groups 1. U/S M/D and 3. D/S M/D

Significance Ratio = 7.12 $(P < 0.003)$

3.3 Comparison between preparation groups 1. U/S M/D and 4. D/S M/D F/D

Significance Ratio = 4.35 $(P < 0.003)$

3.4 Comparison between preparation groups 1. U/S M/D and 5. D/D M/D

Significance Ratio = 8.01 $(P < 0.003)$

3.5 Comparison between preparation groups 1. U/S M/D and 6. D/D M/D M/D

Significance Ratio = 4.39 $(P < 0.003)$

3.6 Comparison between preparation groups 2. U/S M/D F/D and 3. D/S M/D

Significance Ratio = 1.17 $(P \approx 0.03)$

3.7 Comparison between preparation groups 2. U/S M/D F/D and 4. D/S M/D F/D

Significance Ratio = 0.23 $(P > 0.3)$

3.8 Comparison between preparation groups 2. U/S M/D F/D and 5. D/D M/D

Significance Ratio = 10.03 $(P < 0.003)$

3.9 Comparison between preparation groups 2. U/S M/D F/D and 6. D/D M/D F/D

Significance Ratio = 7.26 $(P < 0.003)$

3.10 Comparison between preparation groups 3. D/S M/D and 4. D/S M/D F/D

Significance Ratio = 1.74 $(P \approx 0.09)$

3.11 Comparison between preparation groups 3. D/S M/D and 5. D/D M/D

Significance Ratio = 17.69 $(P < 0.003)$

3.12 Comparison between preparation groups 3. D/S M/D and 6. D/D M/D F/D

Significance Ratio = 11.63 $(P < 0.003)$

3.13 Comparison between preparation groups 4. D/S M/D F/D and 5. D/D M/D

Significance Ratio = 12.12 $(P < 0.003)$

3.14 Comparison between preparation groups 4. D/S M/D F/D and 6. D/D M/D F/D

Significance Ratio = 8.30 $(P < 0.003)$

3.15 Comparison between preparation groups 5. D/D M/D and 6. D/D M/D F/D

Significance Ratio = 2.66 $(P \approx 0.01)$

3.16 Comparison between preparation groups 1. U/S M/D, 3.D/S M/D, 5.D/D M/D and 2. U/S M/D F/D, 4. D/S M/D F/D. 6. D/D M/D F/D

Significance Ratio = 1.72 $(P \approx 0.09)$

Applying the t-test between the six preparation groups (multiple correlations) at $P < 0.003$ level of significance, indicates that there is a significant difference between groups shown in calculations 1, 2, 3, 4, 5, 8, 9, 11, 12, 13 and 14, but not between groups shown in calculations 6, 7, 10, 15 and 16.