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## Changes in Perikymata and Their Significance to a Postmortem Dental Identification

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**ABSTRACT:** Perikymata are wavelike features that are normally found in the surface enamel of teeth. These structures are known to undergo regressive changes due to gradual attrition, mechanical abrasion, or chemical erosion. Forensic science has suggested that significance be placed on some forms of their loss as indicators of age, oral habits, and alignment of individual teeth. The dental identification of victims of a Vietnam War military aircraft crash is presented. The unusual pattern of perikymata change on two of the teeth suggests the antemortem existence of a removable partial denture. These findings support the exclusionary conclusions.

**KEYWORDS:** odontology, perikymata, human identification

Perikymata are the external result of the incremental deposition of enamel during tooth crown development. These wavelike structures appear to correlate directly with the striae of Retzius [1–4]. The normal orientation of perikymata is transverse and circumferential with a density approximating 30 per millimetre near the cemento-enamel junction and decreasing to 10 per millimetre in the occlusal or incisal segment of the crown [1,4]. With a spacing of 30 to 100  $\mu\text{m}$ , perikymata can be viewed grossly but are best examined under low to medium magnification with a stereomicroscope [4,5]. The gradual loss of the perikymata has been shown to relate to age, specific tooth surface, and location of the tooth in the mouth [1,4]. Although the natural attrition of perikymata is slower on the protected interproximal surfaces, the loss of these features still occurs through contact with an adjacent tooth, resulting in a proximal wear facet [6]. Naturally occurring changes in the tooth surface may also be attributed to hypoplastic disturbances in enamel matrix production. The consequence may be exaggerated or irregular perikymata formation [5].

Although attrition, abrasion, and erosion are recognized as major causes of regressive alteration in tooth structure, the recent literature provides few case reports illustrating the forensic value of such wear [7]. However, in his *Variation in the Morphology of the Teeth*, Taylor does allude to the potential significance of wear left by a removable partial denture [8]. The term "wear" is interpreted by this author to include the localized loss of perikymata. The following case report demonstrates the significance of perikymata loss in a pattern that suggested the antemortem presence of a removable partial denture. This finding became critical in the determination of a postmortem identification.

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## Background

The Vietnamese Office for Seeking Missing Personnel (VNOSMP) is the point of contact for the ongoing American Missing In Action (MIA) recovery effort in the Socialist Republic of Vietnam (SRV). On Friday, 8 July 1988, the staff of the U.S. Army Central Identification Laboratory, Hawaii (CILHI) received a message stating that the VNOSMP were prepared to return 24 sets of remains believed to be those of U.S. service members lost in Vietnam.

Alleged MIA cases are returned to CILHI for complete evaluation with the ultimate hope that the biological evidence will be sufficient to establish the identification of a missing U.S. service member. Unfortunately, returned remains are frequently those of a non-American caught in the intensive recovery process of the VNOSMP. Occasionally, names, dates, and locations are provided by the Vietnamese with the cases they return. Such information is sometimes quite valid and may furnish an early lead in the identification process. But since the accuracy of these data has been found to fluctuate greatly, this information is considered cautiously until it can be verified by U.S. sources.

Among the 24 boxes of remains that arrived at the Laboratory in mid-July were four cases that the VNOSMP stated were from the same incident. The discoloration and degree of erosion were consistent throughout all four sets of dentition and supported the possibility that these individuals had a similar provenience. The dental evidence was severely fragmented, with substantial portions of the alveolar bone missing in each case. Figure 1 shows the teeth that were recovered with each of the cases.

## Documentation of the Postmortem Evidence

The dental evidence in each of the four cases was radiographed in duplicate using Size 2 and Size 3 dental film at 10 MA, 80 kVP, and 18/60 s. The results were placed in standard full-mouth series mounts, labeled and dated. Afterwards, the dental remains were cleaned with warm tap water and a soft-bristle toothbrush. Each case was allowed to air-dry and then photographed, using Panatomic-X print film (32 ASA) and Kodachrome (64 ASA) slide film. Alveolar fragments that could be articulated along fracture lines, or teeth that could be matched to their respective sockets were reassociated and stabilized with medical tape or small quantities of butyl acetate cement. Radiographs were retaken if the orientation of the dental remains had been changed by the articulation of loose portions. The teeth were charted on a DA Form 891, with specific emphasis placed on the location, shape, and composition of any restorations (Fig. 2). Caries, tori, rotation of teeth, and radiographic features were also noted on the reverse of this form.

CASE #1	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17
CASE #2	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17
CASE #3	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17
CASE #4	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17

25 TOOTH NOT RECOVERED  
25 TOOTH RECOVERED

FIG. 1—Teeth recovered: the numbers on the black background indicate those teeth recovered with each case (Universal System).

RECORD OF IDENTIFICATION PROCESSING																
CASE #				DENTAL CHART				22 August 1988								
LAST NAME - FIRST NAME - MIDDLE INITIAL (or unknown number)										GRADE		SERVICE NO./SOCIAL SECURITY ACCT NO.				
NAME OF CEMETERY, EVACUATION NUMBER, OR SEARCH AND RECOVERY NUMBER										PLOT		ROW		GRAVE		
MARKING ABBREVIATIONS: P-Paste    Q-Quartz    D-Dental    A'-Amalgam    -Fill-Filling    Perc-Porcelain    Back-Backing L-Lingual    M-Metal    I-Inlay    CB-Crown    Plus-Plastic    Sil-Silicate    Pac-Pacing																
CARIES																CARIES
RESTORATIONS																RESTORATIONS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
UPPER RIGHT															UPPER LEFT	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
LOWER RIGHT															LOWER LEFT	
RESTORATIONS																RESTORATIONS
CARIES																CARIES
THE FOLLOWING CONDITIONS WILL BE INDICATED IF PRESENT (Describe in detail in Remarks section)																
NOTCHED ENAMEL		ROTATION		FRACTURED ENAMEL		IRREGULARITY OF ALIGNMENT										
ENAMEL HYPOPLASIA		ERUPTED TEETH		FRACTURES OF TEETH		UNUSUAL RESTORATIONS										
EROSION		MALOCCLUSION		RETAINED DECIDUOUS TEETH		UNUSUAL APPLIANCES										
ABRASION		SUPERNUMERARY TEETH		ABNORMAL INTERDENTAL SPACES		MALPOSED TEETH										
PREPARED BY: (Typed Name and Signature) <i>William C. Smith</i> WILLIAM C. SMITH, MAJ., DE. USA										VERIFIED BY: (Typed Name and Signature) N/A						

FIG. 2—The DD Form 891, the postmortem dental chart used by the U.S. Army Casualty and Memorial Affairs Office.

### **Name Associations**

Although the Vietnamese presented no name associations for these four cases, they did provide the date (2 June 1968) and province (Thanh Hoa) in which the aircraft crash allegedly occurred. The local populace had related the following grim account<sup>2</sup>:

The aircraft was shot down by air defense forces at 0800 hours on 2 June 1968 in Quang Vinh Village, Quang Xuong District, Thanh Hoa Province. One pilot parachuted from the aircraft but the parachute did not open, and the pilot fell into the sea. Almost one week later, the body of the pilot surfaced and drifted into the beach in Hai Linh village, Tinh Gia district. The three other cases were not able to parachute out and were burned to death in the aircraft.

The CILHI Casualty Data Analysis Section provides accumulated intelligence from all available sources to the scientific staff and isolates the most likely candidates for identification through the interpretation of the circumstantial evidence. In this case, one incident was found to match the same date, location, and number of personnel as the crash described by Vietnamese sources. The forensic anthropologist and odontologist assigned to the four cases were given the following information [9]<sup>3</sup>:

On 2 June 1968, Lt. (JG) Kelly, pilot, Lt. (JG) Fredricks, copilot, AT3 Buchanan and AT3 Wright, crewmen, were flying an EA-1F aircraft on a Search and Rescue Mission over North Vietnam. While circling the location where the downed pilot had ejected, the aircraft made a low pass over the area and was hit by enemy fire. The aircraft went out of control and was seen to crash and burn on impact.

As an independent and objective method of obtaining possible candidates for identification, the dental characteristics of all four cases were screened against the Southeast Asia database using the computer-assisted postmortem identification (CAPMI) system [10,11]. The CILHI Southeast Asia database contains over 2400 dental records of those U.S. service members listed as killed in action/body not recovered (KIA/BNR), as well as those individuals whose partial dental remains have been identified over the past four years. The CAPMI program produced a list of dental records of individuals whose antemortem dental status was known to have been similar to Cases No. 1 through 4. AT3 Buchanan's dental record appeared high on the list for Case 1, whereas Lt. (JG) Fredrick's name was closely associated with Cases 2 and 3. Lt. (JG) Kelly was cited as a remote possibility for Case 4, but AT3 Wright appeared on none of the lists.

After considering the CAPMI screening and the information provided by the Vietnamese, it was decided that the records of these four personnel should be examined first.

### **Interpretation of the Antemortem Data**

The Casualty Data Analysis Section put out a general request for any additional medical or dental data on the four navy aviators not already on file at CILHI. Subsequently, the Department of Naval Records confirmed that we possessed all available antemortem information. A review of the four dental records revealed that Buchanan, Fredricks, and Wright had quality antemortem radiographs, whereas Kelly's antemortem dental file contained only a single-sided carbon copy of a Standard Form 603 dated 42 months prior to his loss (Fig. 3).

The number and quality of their antemortem radiographs would certainly facilitate the

<sup>2</sup>Vietnamese Office for Seeking Missing Personnel, repatriation ceremony, Noi Bai Airport, Socialist Republic of Vietnam, July 1988.

<sup>3</sup>The names of the service members involved have been changed to maintain the privacy of their families.

Standard Form 603  
Rev. November 1958  
Bureau of the Surgeon  
General 16-58 (Rev. 1-22-54)

603-102-01

<b>HEALTH RECORD</b>			<b>DENTAL</b>								
<b>SECTION I. DENTAL EXAMINATION</b>											
PURPOSE OF EXAMINATION: <b>NAVCAD APPL</b>			1 TYPE OF EXAM			2 DENTAL CLASSIFICATION					
<input checked="" type="checkbox"/> 1 INITIAL	<input type="checkbox"/> 2 SEPARATION	<input type="checkbox"/> 3 OTHER (Specify)	1	2	3	4	1	2	3	4	5
<b>MISSING TEETH AND EXISTING RESTORATIONS</b>											
											REMARKS Cast Lingual Bar Mand Partial
<b>DISEASES ABNORMALITIES AND X RAYS</b>											
											A CALCULUS <input type="checkbox"/> SLIGHT <input type="checkbox"/> MODERATE <input type="checkbox"/> HEAVY B PERIODONTITIS <input type="checkbox"/> LOCAL <input type="checkbox"/> GENERAL <input type="checkbox"/> INCIPENT <input type="checkbox"/> MODERATE <input type="checkbox"/> SEVERE C STOMATITIS (Specify)
<b>INDICATE X-RAYS USED IN THIS EXAMINATION</b>											
<input type="checkbox"/> FULL MOUTH PERIAPICAL			<input type="checkbox"/> POSTERIOR BITE-WINGS			<input type="checkbox"/> OTHER (Specify)					
DATE			PLACE OF EXAMINATION			SIGNATURE OF DENTIST COMPLETING THIS SECTION					
<b>SECTION II. PATIENT DATA</b>											
10. NAME (Last, First, Middle Initial) <b>KELLY, Calvin C.</b>		11. GRADE, RATING, OR POSITION <b>1st Class</b>		12. ORGANIZATION UNIT <b>NAS SEATTLE</b>		13. COMPONENT OR BRANCH <b>USNR-3</b>		14. SERVICE, DEPT., OR AGENCY			
15. DATE OF BIRTH (DAY-MONTH-YEAR) <b>6 April 1943</b>						16. IDENTIFICATION NO. <b>227-80-5593</b>					

**DENTAL**  
Standard Form 603

FIG. 3—Carbon duplicate of a Standard Form 603 which constituted Lt. (JG) Kelly's only available dental record. The reverse side of this form was blank. The charting in Section I, Part 4, appeared to be skewed to the right.

identification or exclusion of Buchanan, Fredricks, and Wright. However, the carbon copy record for Kelly was less promising. Section I of his SF 603 indicated several conventional restorations as well as the existence of a "cast lingual bar mand. partial." The reverse side of this form was completely blank. As an added complication, the overlying original and the carbon duplicate were not in alignment at the time of transcription. This circumstance resulted in a displacement of all restoration drawings to the

right, making the exact interpretation of their antemortem location quite subjective. In an effort to quantify the error and establish an accurate antemortem restorative pattern, it was determined that the average displacement was 1.20 mm to the right. This measurement was obtained with Vernier calipers scaled to 0.05 mm. Only those antemortem restoration drawings whose identities were not questionable were measured for distance of displacement. The drawings selected for measurement were No. 3 mesioocclusal (MO) (1.35 mm), No. 12 distoocclusal (DO) (1.25 mm), and Nos. 13-DO (1.2 mm), 18-MO (1.25 mm), and 29-MO (0.95 mm). All four quadrants were represented and indicated that displacement was fairly uniformly lateral to the right, with very little torsion or vertical variation. The average displacement calculation was used in establishing the status of the original antemortem charting for Lt. (JG) Kelly. The results were listed on the left side of a DA Form 5520-R for comparison with the postmortem evidence (Fig. 4).

**Comparison**

Because Kelly had no antemortem films, comparison with his record was conducted after other cases were identified or excluded through the radiographic evaluation. All available antemortem radiographs from the suspected incident were compared with the postmortem films of each piece of dental evidence. Since much of the alveolar bone and teeth were fragmented and loose, the possibility of commingling among the boxes was considered to be high. The comparison was cautiously pursued, and the results are presented in Fig. 5. Note that all dental evidence in Case 1 was identified as that of AT3 Buchanan, whereas all dental material in both Cases 2 and 3 were confirmed as remains of Lt. (JG) Fredricks. Case 4 was found to contain the dental remains of two individuals.

**PHYSICAL AND DENTAL COMPARISON CHART**  
For use of this form see AR 600 8-1 the proponent agency is MILPERCEN

REMAINS OF		NAME
CASE #4		KELLY, Calvin C. LTJG, USNR
1		<input checked="" type="checkbox"/> MISSING
2		2 MODL-AM or MOL-AM
3		3 MO-AM, DO-AM
4		<input checked="" type="checkbox"/> MISSING
5		5
6	MAXILLAE AND	6 M-SIL, F-Restoration (See For, Odont. Rpt)
7	TEETH NOT	7 M-SIL, D-SIL
8	RECOVERED EXCEPT	8 MIL-SIL, D-SIL
9	TEETH #12 AND #15	9 M-SIL
10	RECOVERED	10
11	LOOSE	11
12	DO-AM	12 DO-AM
13		13 DO-AM
14		<input checked="" type="checkbox"/> MISSING
15	MO-AM, OL-AM	15 MO-AM, OL-AM
16		<input checked="" type="checkbox"/> MISSING
17		<input checked="" type="checkbox"/> MISSING
18		18 MO-AM
19		19 MOD-AM, F-AM
20		<input checked="" type="checkbox"/> MISSING
21	SEGMENT OF MANDIBLE AND	21 MOD-AM or DO-AM
22	TEETH NOT RECOVERED	22
23	EXCEPT TEETH #27	23
24	AND #29 RECOVERED	24
25	LOOSE	25
26		26
27	D-AM	27 Unrestored or D-Restoration (See For, Odont. Rpt)
28		28 MOD-AM or MO-AM
29	MO-AM	29 MO-AM
30		<input checked="" type="checkbox"/> MISSING
31	D-AM	31 (See For, Odont. Rpt)
		<input checked="" type="checkbox"/> MISSING

FIG. 4—DA Form 5520-R, providing a side-by-side comparison of postmortem and antemortem written records.

<b>CASE #1</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>BUCHANAN</b>	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
<b>CASE #2</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>FREDRICKS</b>	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
<b>CASE #3</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>?</b>	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
<b>WRIGHT</b>	<b>REMAINS NOT RECOVERED</b>															

25 TOOTH NOT RECOVERED  
25 TOOTH RECOVERED  
25 TOOTH RECOVERED BUT COMMINGLED

FIG. 5—Chart summarizing the results of the radiographic comparison.

The mandibular left first premolar from Case 4 was identified as that of Lt. (JG) Fredricks, but the balance of the teeth were radiographically excluded as representing any dental portions of Buchanan, Fredricks, or Wright.

The results of the radiographic comparison accounted for AT3 Buchanan and Lt. (JG) Fredricks and totally excluded AT3 Wright as being represented by any of the dental remains. The principal dental remains of Case 4, although unidentified, were still considered for association with the same incident due to the demonstrated commingling. The circumstances provided by the Vietnamese and the CAPMI printout also supported the possibility that Case 4 could have been the remains of Lt. (JG) Kelly. The next step was to compare the one SF 603 for Kelly (Fig. 3) with the five remaining teeth in Case 4 (Figs. 6a, 6b, and 6c). The results of that comparison are described here:



FIG. 6—Dental evidence from Case 4: (a) facial view, (b) occlusal view, (c) lingual view.



FIG. 6—Continued.

*Tooth No. 12:* This tooth has a DO-amalgam (AM) restoration which is consistent with the recorded dental features of Lt. (JG) Kelly. The antemortem charting for this tooth is fairly clear.

*Tooth No. 15:* This tooth has MO-AM, occlusolingual (OL)-AM restorations which are consistent with the recorded dental features for Lt. (JG) Kelly. The aforementioned displacement is obvious in this case. An OL-AM restoration normally follows the OL groove, but here it appears 1.20 mm to the right (or distal). The location and shape of such a restoration is clinically unlikely.



*Tooth No. 27:* This tooth was received with a distal (D)-AM restoration. It cannot be absolutely determined from the antemortem records if a D-restoration existed on Tooth 27 at the time of Lt. (JG) Kelly's examination. The drawing does not impinge upon the distal surface of Tooth 27, but it does extend 2 mm beyond the mesial surface of Tooth 28. It is not inconceivable that a conservative, interproximal restoration in this area might be overlooked entirely by an examiner, nor is it unreasonable to believe that in the 42 months between the examination and Lt. (JG) Kelly's last mission, a restoration was placed in this area.

*Tooth No. 29:* This tooth was received with a MO-AM restoration, which is consistent with the recorded dental features of Lt. (JG) Kelly. The antemortem charting for this tooth is fairly clear. In addition, the antemortem SF 603 indicates that Lt. (JG) Kelly had a cast removable partial denture (RPD) replacing Teeth 20 and 30 (Fig. 3). Conventional RPD design would dictate that Tooth 29 should serve as an abutment for the restoration of edentulous space No. 30. A Nikon Model SMZ-10 stereoscopic microscope was used to examine Tooth 29 at magnifications of  $\times 15$  to  $\times 35$ . Vertical interruptions in the perikymata on the lingual surface were attributed to partial denture placement and removal over the lingual height of contour (Figs. 7a and 7b).

*Tooth No. 31:* This tooth was received with an occlusal (O)-AM restoration, whereas there is no record of an O-AM on Tooth 31 for Lt. (JG) Kelly. Considering the high decayed, missing, filled surfaces (DMFS) history exhibited by his dental records, however, it is not improbable that such a restoration was placed during the 42-month period between his examination and last mission. Conventional RPD design would again suggest that Tooth 31 should be clasped and rested as the immediate and sole distal abutment available to edentulous space No. 30. Examination of Tooth 31 at  $\times 15$  to  $\times 35$  revealed distinct horizontal wear facets on the facial and lingual surfaces. These areas of perikymata loss were believed to be the result of the abrasive action of RPD retentive and bracing clasps (Figs. 8a, 8b, 9a, and 9b).

## Conclusions

The shape and location of the perikymata change on Teeth 29 and 30 are inconsistent with the routine causes of regressive alterations in tooth structure. The facial and lingual heights of contour are unlikely to be altered by occlusal attrition, and the areas are too confined to be the abrasive result of faulty oral hygiene habits. The shape, as well as the location, is not similar to the conventional ovoid convexity of interproximal faceting. Furthermore, the staining on the facial surface of Tooth 31 suggests the presence of a "plaque trap," such as a retentive clasp. This unusual pattern of perikymata change on two of the teeth suggests the antemortem existence of a removable partial denture. These findings support the exclusionary conclusions and Case 4 was identified as Lt. (JG) Kelly.

This case illustrates some of the complexities encountered in the odontologic analysis of incomplete and commingled skeletonized remains. The microscopic evaluation of individual portions of the dental evidence may reveal aberrations not observed on gross examination. One such alteration is the potential change in perikymata structure. Although such change may be attributable to conventional causes, they may also provide some otherwise unavailable antemortem clues.

## Acknowledgments

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FIG. 7—Lingual view of Tooth 29: (a) the arrow indicates vertical abrasions on the tooth surface; (b) higher magnification of Fig. 7a showing abrasive changes in perikymata.

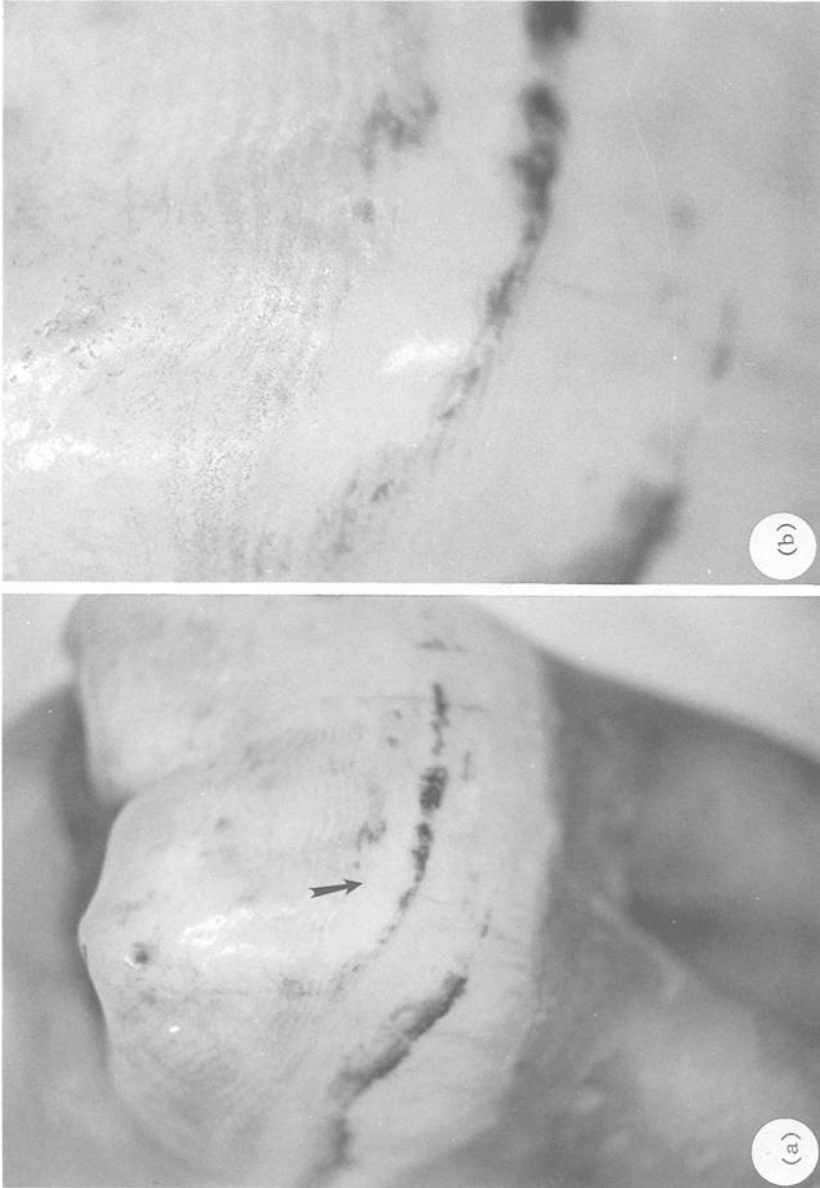


FIG. 8—Facial view of Tooth 31: (a) the arrow indicates an area of perikymata loss and calculus retention; (b) higher magnification showing perikymata loss.



FIG. 9—Lingual view of Tooth 3I: (a) the arrow indicates an area of perikymata loss; (b) higher magnification of this area.

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