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Fractures of clasp-retained partial dentures

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Summary

Fractures of cast clasps are practically irreparable and impaire both therapeutic and prophylactic value of partial dentures. On purpose to explain causes of this rather frequently occuring damage, examination of fracture surface with optical and electronic microscopes and assessment of stress in the retainers were carried out. Microscopic examinationes comprised fracture surfaces of 30 cast clasps divided into 2 groups: Group I (control group): cast clasps formed and cast under controlled laboratory conditions; Group II (test group): fractured cast clasps. It was found that surfaces of cast clasp fractures had a complex structure containing developed dendrites and separated carbide phases. In contrast to the control group, fracture surface from the test group showed signs of alloy fatigue, increased porosity and presence of new phases. On base of the analysis of partial denture movement it was assessed that stress in cast clasps approached both proportionality and fatigue level. In the conclusion it is pointed to two main factors causing cast clasp fractures: plastic deformation and material porosity.

Key words: cast clasp, microstructure, assessment of stress.

INTRODUCTION

Fracture of different framework parts is, unfortunately, a frequently occuring damage. According to clinical experiences, cast clasps are most often subject to fracture. After them come minor connectors, while fractures of lingual and palatal bars take place rather seldom and those of broad palatal major connectors only in exceptional cases. (Bates[1], Earnshaw[2], Harcourt[3])

On purpose to find an explanation of a large number of retainer fractures particularly in comparasion with fractures of other framework parts, following research objectives were set:

(1) To analyse microstructure of cast clasp made under controlled laboratory conditions.

(2) To analyse microstructure of fractured cast clasps.

(3) On base of micrograph comparision and assessment of stress in the cast clasp to suppose causes of fractures.

MATERIALS AND METHODS

A clinical examination of 400 partial dentures that had been in use for 2–5 years discovered 69 fracture surfaces on 62 frameworks. These fractures were mostly found on cast claps and impaired both prophylactic and therapeutic value of partial denture. Table 1.

Table 1

LOCATION OF PARTIAL DENTURE FRACTURE SURFACE

	Location			number	%
1	CAST CLASP	rest	11	61	88,4
		retentive clasp arm	31		
		stabilizing clasp arm . . .	12		
		clasp body	7		
2	MINOR CONNECTORS			4	5,8
3	MAJOR CONNECTORS	lingual bar	2	3	4,3
		palatal bar	1		
4	BROAD PALATAL MAJOR CONNECTOR			1	1,4
		total number of fracture surface found in 400 examined partial dentures		69	100,0

Frameworks were cast from cobalt-chromium alloy supplied by the Krupp Company, WG. Clasps to be examined were divided into two groups:

GROUP I (control group) — 6 clasps assemblies ofrmed and cast under controlled laboratory conditions.

GROUP II (test group) — 24 fractured cast clasps (10 clasp assemblies, 10 bar clasp arms, 2 back-action clasps and 2 ring clasps).

Microscopic examinations were performed on an optical metallographic microscope and a scanning electron microscope (SEM).

Three clasps from Group I and 12 from Group II were cut and ground with abrasive papers from 2/00 to 5/00. Then they were polished by means of machine with abrasive paper and Al_2O_3 suspension (alumina). Electrolitic etching was carried out in two 30-second periods with 10% $HClO_4$ solution in C_2H_5OH and a 5V electric circuit.

Fracture surfaces of 12, not specially prepared, cast clasps from the Group II were subjected to SEM examination. For the comparision served SEM micrographs of fracture surfaces on 3 clasps fractured (Group I) on purpose in a specially assembled apparatus.

RESULTS AND DISCUSSION

Cast clasps from Group I had a complex microstructure containing developed crystalographically favourable oriented dendrites and a separated carbide phase.

Carbides were located along grain boundaries and in interdendrits areas in form of continuous formations. In addition there were present eutectic phases and micropores in a smaller extent (Figures 1, 2 and 3., Table 2.).

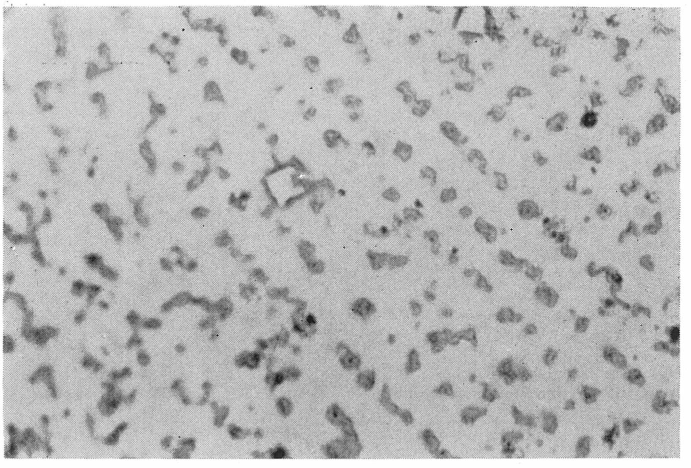

Fig. 1. Metallographic micrograph of a clasp assembly fracture surface. × 300.

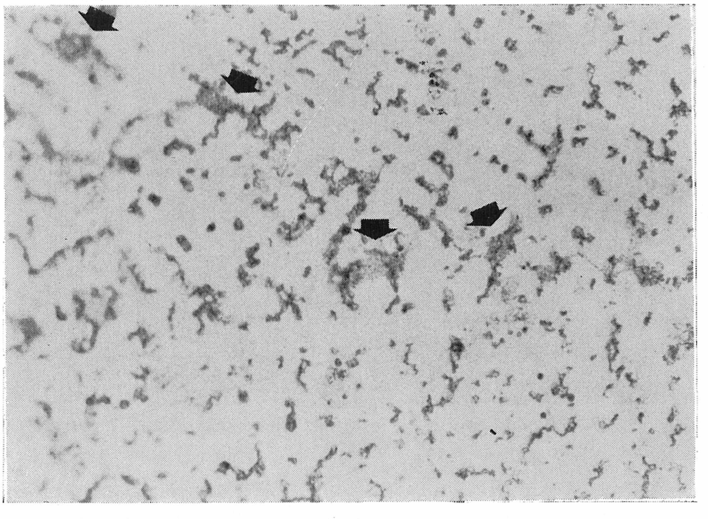

Fig. 1a. Metalographic micrograph of a bar clasp arm fracture surface. Arrow points to dark eutectoid arreas lamellar in nature. × 300.

Microstructure of cast clasps from Group II was also complex with more or less developed dendrites and material segregation. Carbide phase was in form of both continuous and discontinuous carbide formations separated along grain

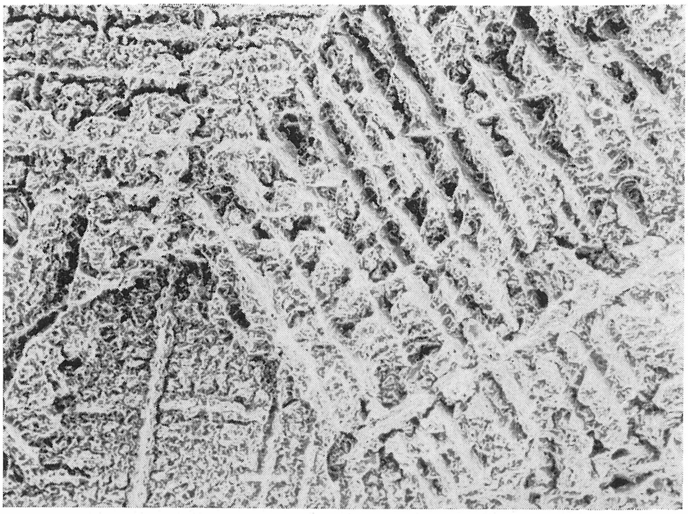

Fig. 2. SEM micrograph of a clasp assembly fracture surface. × 120.

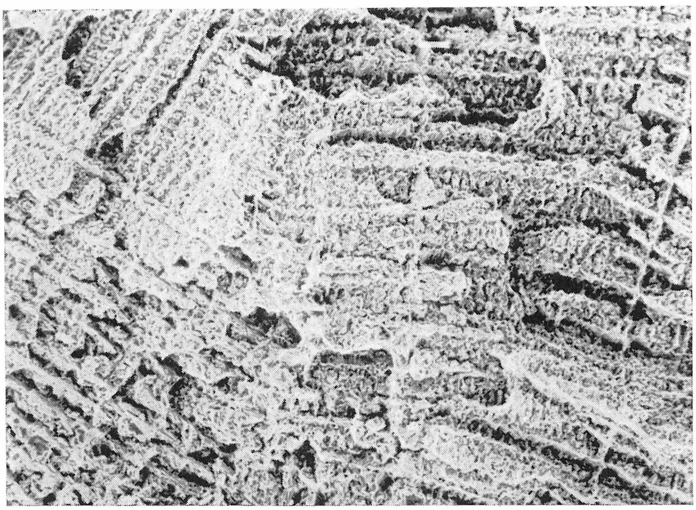

Fig. 2a. SEM micrograph of a clasp assembly fracture surface. × 120.

boundaries and in interdendrite areas. It was also characterised by the presence of dark eutectoid areas lamellar in nature (Figures 1a, 2a, 3a, 4, 5, 6, and 7. Table 3).

In many cases microscopic examinations revealed material porosity with heterogeneuosly distributed micropores and microcavities (Figures 8. and 8a). Micropores were situated within a relatively small area and represented points at which initial fractures took place when small quantities of energy were introduced. (Lewis').

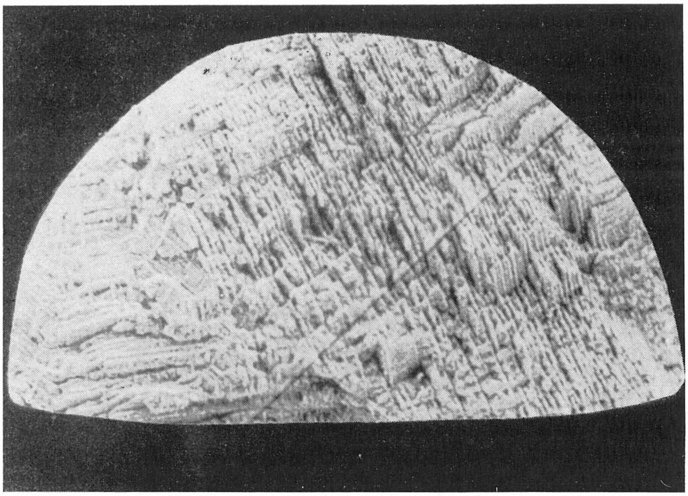

Fig. 3. SEM micrograph of a retentive clasp assembly arm fracture surface. Fracture provocated by a 29 N load on a specially asembled apparatus. × 50.

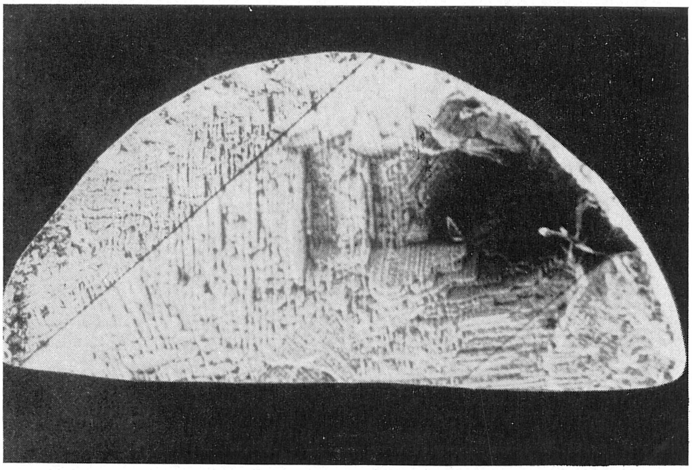

Fig. 3a. SEM micrograph of a clasp assembly fracture surface. Fracture occured due to the presence of a macrocavity and many micropores in the moment the partial denture was handed to the patient. × 50.

Assessment of stress in major connectors and cast clasps of partial denture

Stress in lingual and palatal bars are half as high as proportionality limit and pretty below the limit fatigue. (Bates[1], Stamenković[5]) Therefore fractures of major connectors occur very seldom in the mouth. In course of a 10-years period of use under load in swallownig and chewing processess major connectors are subjected

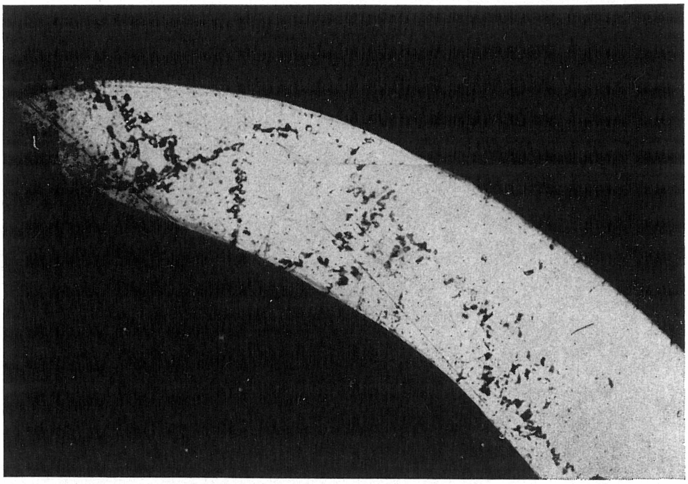

Fig. 4. Metallographic micrograph of a retentive claps arm fractured after 1,5 year of use. In the microstructure prevail large grains with carbide phase along grain boundary. × 20.

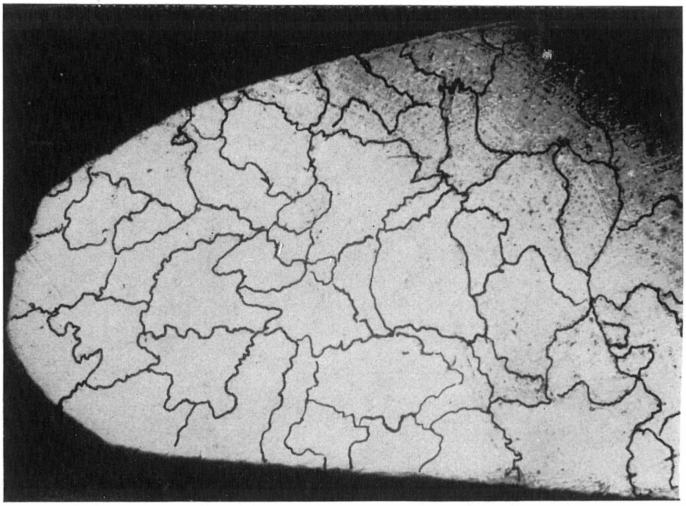

Fig. 5. Metallographic micrograph of the longitudinal section of a rest fractured after 9 years of denture use. Boundaries of extremly fine grains may be seen on the micrograph. There is no developed microstructure. × 20.

to a great number of stress that according to Brewer and Hundson amount to $5 \cdot 10^6$ microinsults. (Bates[1]). Stress in retentive clasp arms approches both proportionality and fatigue limit. (Bates[1], Stamenković[5]) However, stress in incorrectly shaped cast clasps may reach the limit fatigue and provoke fracture. In course of

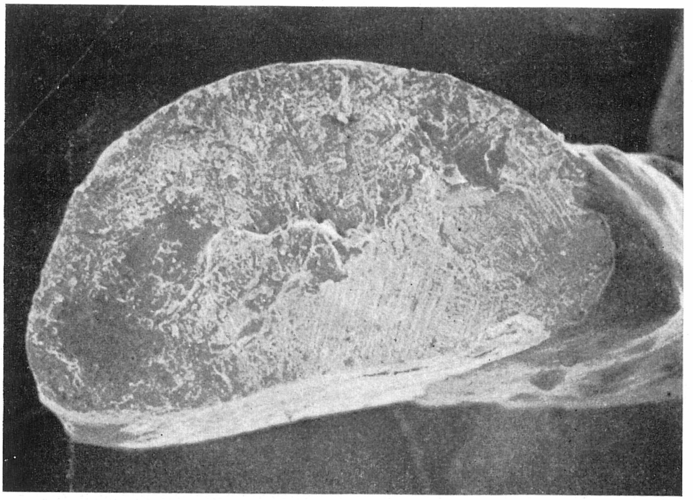

Fig. 6. SEM micrograph of a retentive clasp assembly arm fracture surface.

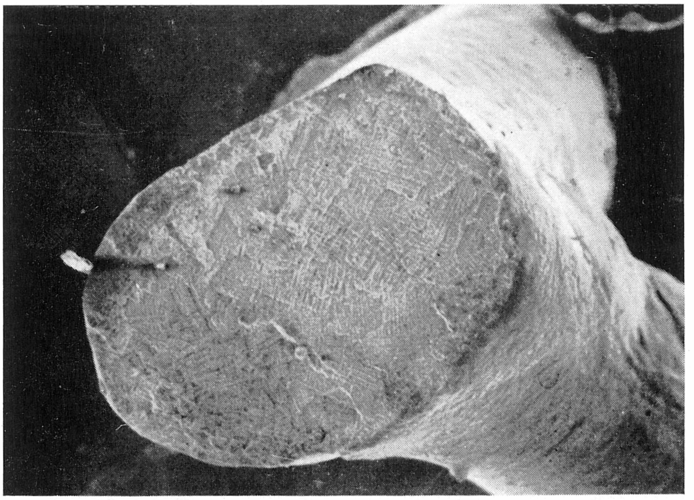

Fig. 7. SEM micrograph of a retentive bar clasp arm fracture surface.

a 10-year period of use, a partial denture is alternatively put in and taken out of the mouth, so that retentive clasp arms suffer a relatively small number of macroinsults: about 10.000 (Babić[6]) or 30.000 (Bates[7]). Consequently, major connectors are subjected to low, but numerous stresses of no essential influence on alloy fatigue, while retentive clasp arms support high, but fewer stress that under given circustances may lead to plastic deformation. These facts confirm clinical

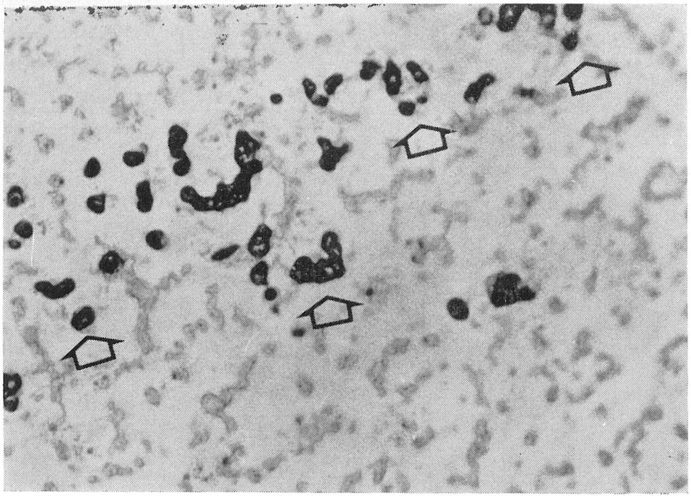

Fig. 8. Metallographic micrograph of a bar clasp arm fracture surface. Arrow points to micropores. × 400.

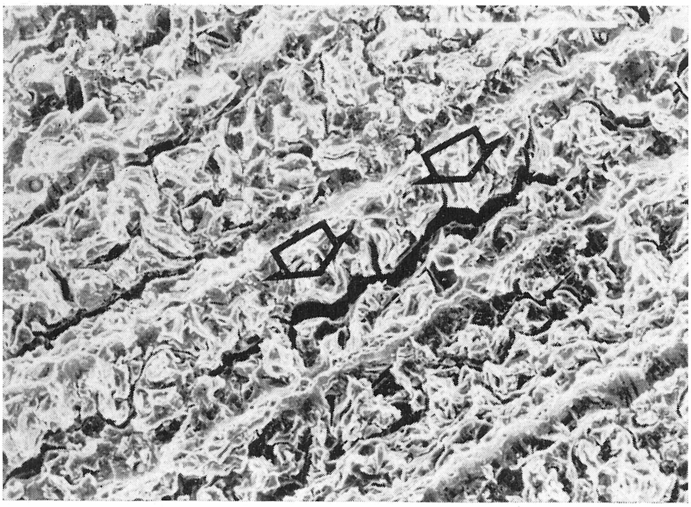

Fig. 8a. SEM micrograph of a back-action clasp fracture surface. Arrow points to micropores. 1000 ×.

expereinces according to which fractures and plastic deformation of retentive clasp arms take place very often and those of bars relatively seldom. Experimental measurements have shown that a 15–20 N force provokes plastic deformation of retentive clasp arms, while a force above 20–30 N causes cast fracture in most cases, (Stamenković[5]).

Table 2

CHARACTERISTICS OF GROUP I
CAST CLAPS MICROSTRUCTURE

GRAIN	— Larger with developed and favourably crystallographycally oriented dendrites.
PHASES	— Continuous carbide formations separated along grain boundaries and in interdendrite area. — Eutectic areas.
POROSITY	— Smaller number of micropores.

Table 3

CHARACTERISTICS OF GROUP II
CAST CLASP MICROSTRUCTURE

GRAIN	— Larger with developed dendrites and/or — smaller with less developed dendrites and material segregation.
PHASES	— Continuous carbide formations. — Discontinuous carbide formations. — Eutectic areas. — Dark eutectic areas lamellar in nature.
POROSITY	— Larger number of micropores. — Smaller number of micro and macrocavities.

CONCLUSION

I tis fully justified to make researches related to fractures of partial denture cast clasps, since elimination of main factors causing these fractions creates new possibilities for increasing prophylactic value of partial dentures, and thereby also new perspectives for the reparatory therapy in the field of dentistry.

Cast clasp fractures result mostly from a joint action of several factors. As it may be concluded from all abovesaid, main factors inducing these fractures are:

(1) material porosity due to incorrecly performed laboratory procedures for alloy melting and casting and

(2) plastic deformation resulting from putting partial denture in and taking it out of the mouth by force and at a wrong angle, as well as from »adjusting« cast clasps with forceps.

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Sažetak

ANALIZA PRELOMA SKELETIRANIH PROTEZA SA LIVENIM KUKICAMA

Praktično nemogući za reparaturu, prelomi livenih kukica skeletiranih proteza umanjuju terapijsku i profilaktičnu vrednost proteze. Sa ciljem da se objasne uzroci, ovoj relativno čestoj pojavi, obavljena su optička i elektronsko mikroskopska ispitivanja prelomnih površina i procenjeni su pritisci u retencionim elementima. Mikroskopska ispitivanja su obavljena na ukupno 30 prelomnih površina livenih kukica, svrstanih u dve grupe: 1. grupa (kontrolna) — livene kukice modelovane i livene pod kontrolisanim laboratorijskim uslovima. 2. grupa (ispitivana) — prelomljene livene kukice. Prelomne površine livenih kukica imaju složenu mikrostrukturu sa razvijenim dendritnim granama i izdvojenom karbidnom fazom. Za razliku od kontrolne grupe, ispitivana grupa prelomnih površina pokazuje znakove zamora materijala, prisustvo novih faza i povećanu poroznost materijala. Nakon analize kinematike skeletirane proteze procenjeno je da je pritisak u livenim kukicama u blizini tačke proporcionalnosti i blizu granice zamaranja. U zaključku su izdvojena dva najvažnija uzroka preloma livenih kukica: plastična deformacija i poroznost materijala.

Ključne reči: livene kukice, mikrostrkutura, procena pritiska