Marginal integrity of amalgam restorations

TORGER INGAR LEIDAL & JON E. DAHL

Department of Operative Dentistry and Institute of Community Dentistry, University of Oslo, Blindern, Oslo 3, Norway

Leidal, T. I. & Dahl, J. E. Marginal integrity of amalgam restorations. *Acta Odontol. Scand.* 1980, 38, 81 – 88

Amalgam fillings using alloy with lathe – cut or spherical particles were placed in 38 Class II cavities of dental students. One part of each cavity was left unfinished in order to maximize differences in preparation quality, whereas the rest of the cavity was well finished. The cavities were replicated prior to restoration, after carving, polishing, and then after one year and four years. Quality evaluation was performed clinically using a scoring system for marginal integrity and by scanning electron microscopy of replicas. After four years the restorations filled with lathe-cut amalgam showed better quality than those made with spherical amalgam. No difference could be detected due to variations in the finishing technique of the margins.

Key-words: Dental materials; cavity preparation; replica; SEM; clinical assessments

Torger Ingar Leidal, Department of Operative Dentistry, Dental Faculty, Geitmyrsvn. 71, Oslo 4, Norway

The most important reasons for replacement of dental amalgam restorations are failures in the marginal area including poor adaptability, fracture or development of secondary caries (7, 12, 15, 19, 21). These failures may be due to operative shortcommings and/or to the choice of restorative material.

Alloys with spherical shaped particles have been available since 1962 (8). They are claimed to significantly improve the marginal adaptation of the amalgam restoration (18). Because of the small particle size and easy handling, these alloys are reported to be superior to lathe-cut products (1, 2).

Finishing of cavity margins is an important step in cavity preparation (3, 5), and faulty cavity margins are thought to influence the quality and durability of the dental restorations. The quality of the cavity margins after finishing with different techniques has been reported previously (4, 16, 23, 24).

The purpose of the present *in vivo* study was to assess the quality of amalgam restorations after several years of service. Two alloys, one lathe-cut and one with spherical shaped particles were compared. The influence of different finishing techniques on the marginal integrity of these restorations was also evaluated.

Received for publication, November 22, 1979

MATERIAL AND METHODS

The experimental material consisted of 38 Class II restorations placed in molars and premolars in 14 freshmen dental students. The restorations included both replacements of old restorations and treatment of primary caries. The restorative work was carried out by one operator (T. I. L.).

All cavities were prepared with a tungsten carbide bur (no 1557, SS White, Philadelphia, Pa, U.S.A.) in an air turbine (Midwest American, Melrose Park, Ill. U.S.A.) at ultra speed. Soft dentin was removed by means of round burs in a conventional contra angle handpiece. Retention grooves were placed at the gingivo-axial, bucco- and linguo-axial line angles using small round burs and/ or gingival margin trimmers. Prior to the finishing procedures, the dentin was covered with Copalite® (Cooley & Cooley, Ltd. Houston, Texas, U.S.A.).

When preparing a proximal box in Class II cavities at ultra speed, a neat margin is produced at the entry side (i.e. the side where the bur rotates into the cavity) whereas irregularities are frequently found at the exit side (i.e. the side where the bur rotates out of the cavity) (16). In the present study, an attempt was made to maximize the difference in quality between the two embrasure margins of the proximal boxes. Thus the entry sides were finished with an embrasure margin trimmer while the exit sides were left unfinished (24). All gingival margins were finished with a gingival margin trimmer (Black 77–78, 15–25–8–12 or 79–80, 15–80–8–12, Ash, London, England).

After finishing, the cavities were replicated by a two-stage technique. Impressions were made using a heavy-bodied and a light-bodied silicone product (Optosil® Hard & Xantroprene® Blue, Bayer, Leverkusen, Germany). Positive replications were made in epoxy casting resin (Stycast 1266® Oeval, Brussels, Belgium).

The alloys chosen for the investigation were a lathe-cut type, (DAB Standard Alloy, Batch no 710114, A. B. Svenske Dental Instrument, Stockholm, Sweden) and a spherical type (Hi-Atomic, Batch no. BX 22, G. C. Chemical MFG, Tokyo, Japan). The two amalgams were randomly distributed in the cavities. Through a stereo microscope, the particle size of the spherical alloy was measured to range from 8–50 μm. The lathe-cut alloy contained spike-shaped particles ranging from 20 to 900 μm. The creep values were 1.2 (DAB Standard Alloy), and 0.7 (Hi-Atomic) (26).

Micro thin matrix bands (Starlite, Star, dental Mfg. Co. Inc. Conshohocken, PA. 19428 U.S.A.) were used in combination with a Dentatus retainer (Dentatus, Hägersten, Sweden), according to Nyström (20). The amalgam was placed in the cavity by means of an S.S. White no 10 A amalgam carrier (SS. White Limitied, 51, St. Ann's Road, Harrow, Middx. HAI ILR, England) and condensed with a Nyström approximal condenser no 1 (20) and a Black condenser 10-7-12 or 20-7-12 (Ash, Amalgamated Dental, Ltd. London W1, England). The condensation technique was identical to that routinely used by the operator. Generally lower pressure was applied in condensing the spherical than the lathe-cut amalgam. Moisture control was performed by means of cotton wool rools and saliva ejector.

The restorations were replicated three times during the observation period, after polishing and after one and four years of service. In order to remove plaque and organic debris, the actual areas were washed with a 3 % solution of sodium hypochlorite prior to the replicating procedure. The epoxy resin replications were given an electrical conducting coat of gold, and the quality of the marginal areas was examined in a scanning elec-

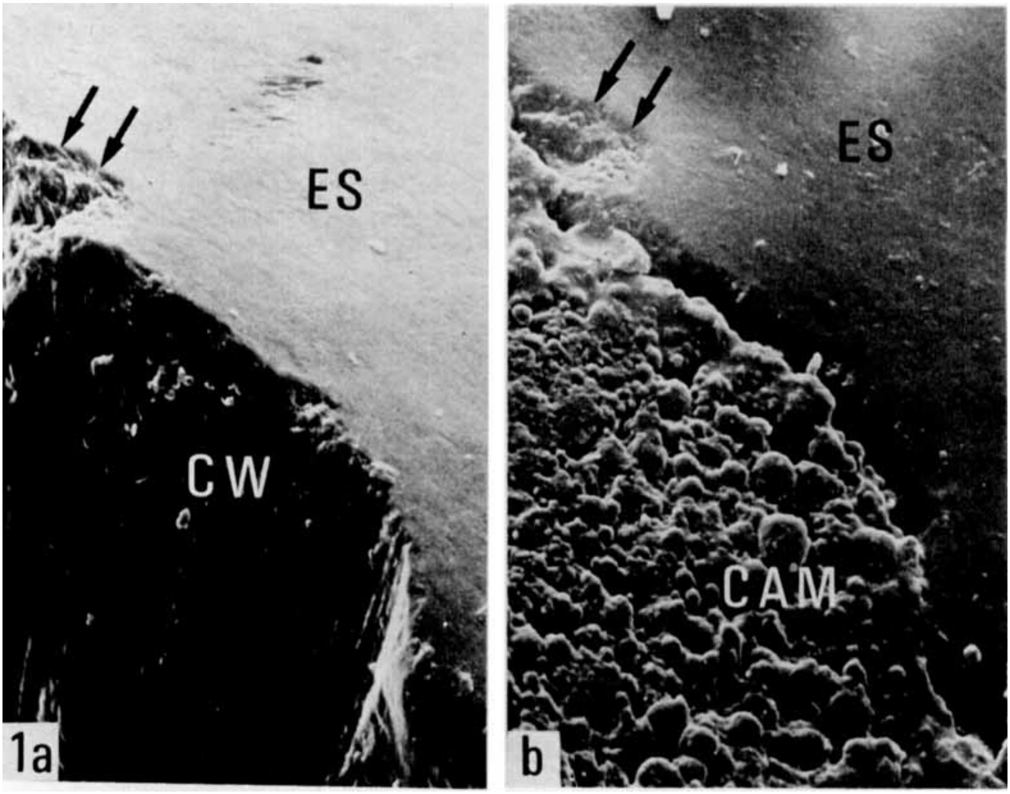

Fig. 1. Part of unfinished prepared cavity. Arrows show defect at the enamel margin after cavity preparation (1a) which was not covered by the amalgam (1b). CW, cavity wall; ES, enamel surface; CAM, carved, unpolished amalgam. X 150

tron microscope (J.M.S. 50 A, Joel, Tokyo, Japan) usually operated at 25 kV. Due to the difficult access, some embrasure margins could not be reproduced in cavities with narrow bucco-lingual extention. Therefore scoring based on the replicas alone was not performed. A total of 157 micrographs were taken in the SEM.

After four years of service the restorations were also evaluated clinically. The restorations were examined in good clinical light by means of a mouth mirror and a new explorer after being dried with air. The quality of the margins was recorded by gently moving the explorer perpendicularly over the tooth-restoration interface. The criteria used were as follow: Score 0: No catch of the explorer. Score 1A: Catch towards restoration. Score 1B: Catch towards tooth substance. Score 2: Catch towards both restoration and tooth substance.

From each restoration the bucco-occlusal, the linguo-occlusal, the bucco-approximal and the linguo-approximal enamel-restoration interfaces were evaluated. The evaluator (J.E.D.) was unaware of the preparation technique used and the type of amalgam inserted. The reproducability of the examiner was tested on the basis of independent double examinations in vitro carried out on 82 amalgam/tooth interfaces on consecutive days. The chi-square test was used for statistical evalutaion of the results.

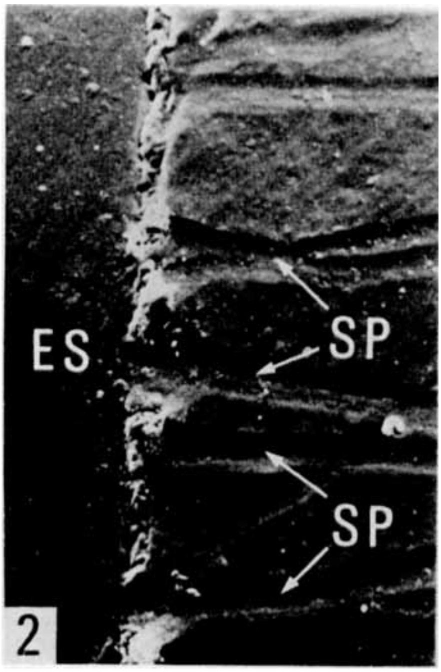

Fig. 2. Scrathes (SP) on amalgam surface caused by probing during clinical examination. ES, enamel surface. X 150

Table 1. *Margins according to score, surface and type of alloy. Clinical evaluation after four years*

No.of margings	Occl. 64	Approx 64	Lathe-cut 60	Spherical 68
Score 0	6	4	7	3
Score 1 A	24	32	33	23
Score 1 B	0	6	1	5
Score 2	34	22	19	37

Table 2. *Margins according to score for entry and exit sides. Clinical evaluation after four years*

No. of margins	Entry side 32	Exit side 32
Score 0	2	2
Score 1 A	16	16
Score 1 B	3	3
Score 2	11	11

RESULTS

The double examination showed that 89 % of all amalgam/tooth interfaces were assigned the same score on both occations. In the SEM, the structure of the entry and exit margins was similar to that reported previously (16, 23, 24). Irregularities at the exit side of the cavity were not always covered by the restorative material after carving (Fig. 1 a and b). Thus failures undetected in the clinical situation could be demontrated by SEM in some cases. Traces on the restoration from the explorer having moved over the amalgam/cavity margin interface could also be observed (Fig. 2).

After four years, the quality of the restorations made with the lathe-cut type alloy was better than of those made with spherical type alloy (Table 1). In the spherical alloy group, 37 out of 68 margins were given score 2, whereas 19 out of 60 were classified as score 2 in the lathe-cut alloy group. The difference was significant ($p < 0.02$).

No quality difference could be demonstrated between entry and exit parts of the restorations (Table 2).

The present investigation demonstrated a good correspondence between clinical and SEM findings. Smooth interfaces given score 0 clinically (no catch in any direction), also showed the best marginal integrity in the SEM (Fig. 3). Small fractures of excessive amalgam on the occlusal surface resulting in score 1 A (catch toward restoration) could easily be demonstrated (Fig. 4). This irregularity was the one most frequently recorded at the margins of the lathe-cut amalgam restorations (Table 1). «Ditching» was found mainly on the occlusal surfaces, resulting in score 2 (Fig. 5). This score was the one most frequently found at the margins of the spherical amalgam restorations. On occlusal as well as on proximal interfaces, score 1A and 2 occurred with equal frequency (Table 1). Only few margins resulted in score 1B (catch to-

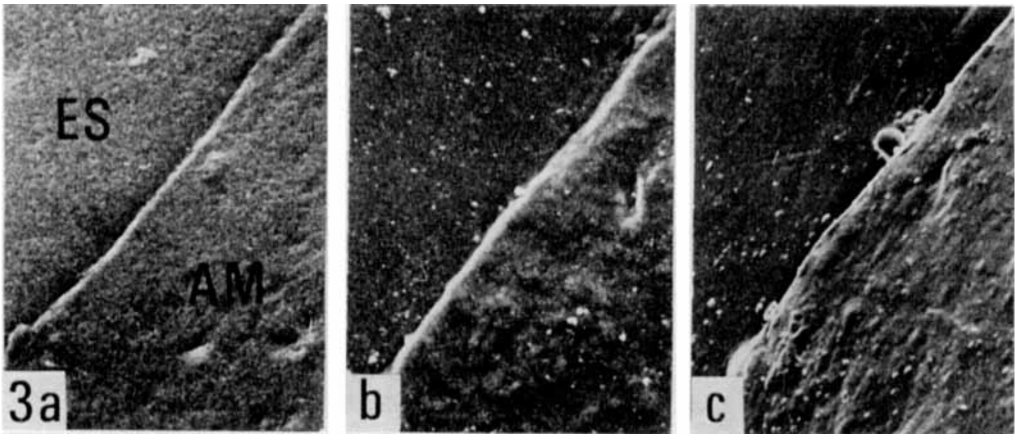

Fig. 3. Enamel (ES)/amalgam (AM) interface corresponding to score 0. After polishing (3a); after one year (3b), and after four years of service (3c). X 150

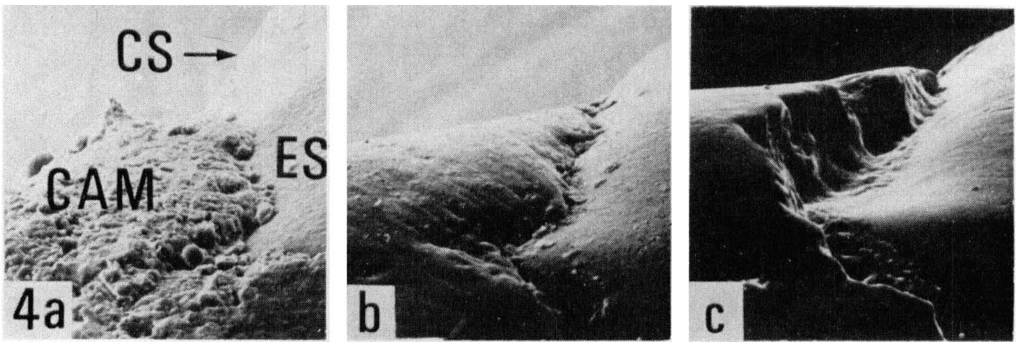

Fig. 4. The same enamel (ES)/amalgam interface of carved, unpolished amalgam (CAM) (4a), after polishing (4b) and after four years (4c). Note fracture of excessive amalgam (4c). CS, cuspal slope. X 150

ward tooth substance) (Fig. 6). The number of observations was inadequate to study differences, if any, in the quality of occlusal and approximal surfaces according to type of alloy. Secondary caries was not found adjacent to any restoration after four years.

DISCUSSION

The better quality of the restorations made of conventional alloy was uexpected, because of the difference in particle size and shape between the two alloys. Apparently the smaller spherical alloy particles did not result in a better marginal adaptation of the amalgam than if larger particles were present in the alloy powder. It is therefore conceivable that proper handling of the amalgam is more important for the final result than the choice of alloy as such. This has also been emphasized by Lavelle (15), and by Healy & Phillips (12), claiming that 96% of amalgam failures are due to improper cavity preparation or faulty manipulation of the material.

The literature is controversial concerning the adaptability of the two types of alloy. Cunningham (6) found significant differences between the lathe-cut and spherical alloys in favor of the first group. Eden & Waterstraat (9) and Mathewson, Bruner & Noonan (18) on the

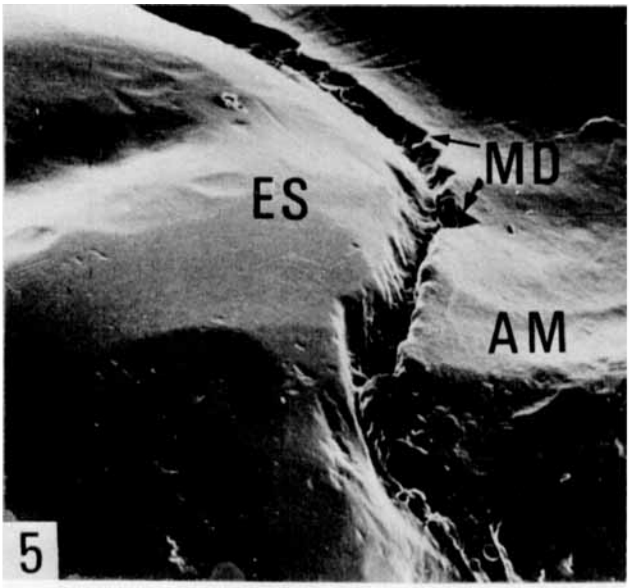

Fig. 5. Interface of restoration showing typical «ditching» occlusally. ES, enamel surface; MD, marginal defect («ditch»). AM, amalgam. X 150

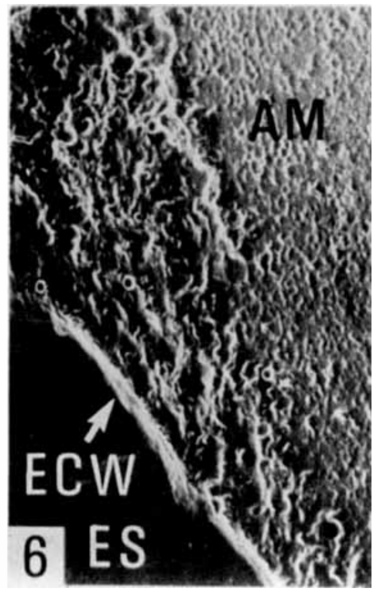

Fig. 6. Sulcus at the filling/tooth interface due to deficit of the amalgam. ES, enamel surface; ECW, enamel cavity wall; AM, amalgam. X 80

other hand claimed spherical alloy to be superior to lathe-cut when adaptability was considered. Wing (25) found spherical alloy to have an adaptibility as good as lathe-cut. The easy manipulation properties of amalgam with spherical shaped alloy particles is held to be important (2). Undoubtedly, the force necessary to produce well condensed lathe-cut amalgam restorations may easily lead to fatigue in the operator's hand during a long days work. The easy manipulation property of spherical amalgam may therefore be advantageous from a clinical point of view, but this advantage may mask or annul any other differences between the amalgams.

The ditching phenomenon, related to the creep property of the amalgam (17), was frequently observed on the occlusal aspect of the restorations, resulting in score 2. In this area, the slopes of the cusps make it difficult to achieve acceptable cavosurface angles. When the restorative material is exposed to masticatory forces, marginal breakdown occurs (13). This may be the explanation why score 2 was found more frequently in occlusal than in approximal areas. Espevik & Mjör (11) have claimed corrosion to be responsible for marginal breakdown, which seems likely. However, the question of what occurs initially, craks or corrosion, remains unsolved. When the cavosurface angle of the restoration is unfavorable it seems reasonable to expect marginal breakdown or ditching to be more frequent. Therefore the cavosurface angle should probably be considered when investigating this phenomenon.

Score 2 was also found more frequently on restorations made of amalgam with spherical shaped alloy particles than on those with lathe-cut particles. This observation indicated that the large particle size of the lathe-cut alloy is probably responsible for the higher resistance to masticatory force in the marginal area (10), as the creep values did not differ significantly.

However, the clinical significance of ditching in the occlusal area should not be overemphasized since most failures responsible for replacement of amalgam restorations, (7, 15, 19, 21), are obviously found in the embrasure part of the restorations (22).

Recurrent caries is the main reason for replacing amalgam restorations (7, 15, 19, 21), and it may be anticipated that the caries attack takes place more frequently at unfinished and irregular margins than at well finished ones. This could not be confirmed in the present study. The quality of entry side margins was similar to that of the exit side margins. The use of dental students may possibly explain this result, because of their high standard of oral hygiene. This indicates, among other factors, the importance of oral hygiene for the integrity of dental restorations. Lang, Cumming & Löe (14) have shown that freshmen dental students had poor oral hygiene with improvement in the sophomore year and with further improvement in the 3rd and 4th year. The present results would indicate a difference in the retention factor for plaque accumulation; which is expected to be higher at margins where the probe catches, than at smooth interfaces.

The difference in quality between the two types of amalgam, although significant in favor of the lathe-cut type, was not obvious in the clinical situation. The clinical recorder being unaware of the initial treatment, reported that he was unable to distinguish between them. Thus the quality differences reported were detected only through the scoring system.

REFERENCES

1. Baker, D.L. Amalgam filling technique. Some recent advances. Br. Dent. J. 1977, 142, 181 – 184
2. Baker, D.L. & Greasley, A. Clinical handling characteristics of spherical amalgam. Br. Dent. J. 1978, 144, 377 – 383
3. Barton, R.E. Fundamentals in cavity preparation. In: Sturdevant, C.M., Barton, R.E., Brauer, J.C. & Harrison, M.L. (eds.) The art and science of operative dentistry, New York: McGraw-Hill, 1968, p. 97
4. Boyde, A. Finishing techniques for the exit margin of the approximal box of Class II cavities, Br. Dent. J. 1973, 134, 319 – 382
5. Black, G.V. A work on operative dentistry, Vol. 2, Medico-Dental Publishing Co., 1908, p. 115
6. Cunningham, J. Finishing amalgam restorations. A comparison of techniques. Br. Dent. J. 1977, 142, 9 – 16
7. Dahl, J.E. & Eriksen, H.M. Reasons for replacement of amalgam dental restorations, Scand. J. Dent. Res. 1978, 86, 404 – 407
8. Demaree, N.C. & Taylor, D.F.. Properties of dental amalgam made from spherical alloy particles. J. Dent. Res. 1962, 41, 890-906
9. Eden, G.T. & Waterstraat, R.M. Effects of packing pressures on the properties of spherical alloy amalgams. J. Am. Dent. Assoc. 1977, 74, 1024 – 1029
10. Espevik, S. & Sorensen. S.E. Creep of dental amalgam. Scand. J. Dent. Res. 1975, 83. 245 – 253
11. Espevik, S. & Mjør, I.A. Degradation of amalgam restoration in vivo. STP 684, ASTM 1979, in press
12. Healey, H.J. & Phillips. R.W. A clinical study of amalgam failures. J. Dent. Res. 1949, 28, 439 – 446
13. Jörgensen, K.D. The mechanism of marginal fracture of amalgam fillings. Acta Odontol. Scand. 1965, 23, 347 – 389
14. Lang, N.P., Cumming, B.R. & Löe, H.A. Oral hygiene and gingival health in Danish dental students and faculty. Community Dent. Oral Epidemiol. 1977, 5, 237 – 242
15. Lavelle, C.L.B. A cross – sectional longitudinal survey into the durability of amalgam restorations. J. Dent. 1976, 4, 139 – 143
16. Leidal, T.I. & Tronstad, L. Scanning electron microscopy of cavity margins finished with ultra-speed instruments. J. Dent. Res. 1975, 54, 152 – 159
17. Mahler, D.B., Terkla, L.G., Eysden, J.V. & Reisbick, M.H. Marginal fracture vs mechanical properties of amalgam. J. Dent. Res. 1970, 49, 1452 – 1457
18. Mathewson, R.J., Bruner, F.W. & Noonan, R.G. The clinical comparison of a spherical amalgam alloy and a conventional amalgam alloy: A pilot study. J. Dent. Child. 1967, 34, 176 – 182
19. Mjör, I.A. Orsaker till revision av fyllningar. Tandläkartidn. 1979, 71, 552-556

20. Nyström, P. Amalgamteknikk, Halmstad, Sweden, Meijdels Bokindustri, 1963, p. 37, p. 47
21. Richardson, A.S. & Boyd, M.A. Replacement of silver amalgam restorations by 50 dentists during 246 working days. J. Can. Dent. Assoc. 1973, 39, 556 – 559
22. Sellman, S. Studier över sekundärkariesfrekvensen på Tandläkarinstitutets klientel. Odont. T. 1944, 52, 241 – 273
23. Tronstad, L. & Leidal, T.I. Scanning electron microscopy of cavity margins finished with chisels or rotating instruments at low speed. J. Dent. Res. 1974, 53, 1167 – 1174
24. Tronstad, L. & Leidal, T.I. New instrument for finishing of embrasure margins of class II cavities. J. Am. Dent. Assoc. 1976, 93, 94 – 97
25. Wing, G. Spherical particle amalgams. Aust. Dent. J. 1966, 11, 265 – 273
26 Personal communication, NIOM, Scandinavian Institute of Dental Materials, Oslo, Norway