

# The teaching of all-ceramic restorations in Scandinavian dental schools: A survey

Asbjørn Jokstad, Ivar A. Mjör and Kevin B. Frazier

Department of Prosthetic Dentistry and Stomatognathic Physiology, Dental Faculty, University of Oslo, Oslo, Norway, and Department of Operative Dentistry, College of Dentistry, University of Florida, Gainesville, Florida, and School of Dentistry, Medical College of Georgia, Augusta, Georgia, USA

Jokstad A, Mjör IA, Frazier KB. The teaching of all-ceramic restorations in Scandinavian dental schools: a survey. *Acta Odontol Scand* 1996;54:200–204. Oslo. ISSN 0001–6357.

The study was designed to survey the curricular requirements, types of clinical experience, and materials/techniques used in teaching programs for all-ceramic restorations in Scandinavian dental schools. All 13 dental schools responded. Ten offered some clinical experience to pre-doctoral students, but only one required one all-ceramic restoration. The departments of fixed prosthodontics had the main teaching responsibility. All-ceramic crowns were taught at 9, veneers at 7, and inlays/onlays at 10 dental schools. A wide range of different teaching concepts, materials, and views on indications and contraindications was reported. It appears as if all-ceramic restorations are regarded as experimental by the teaching institutions, although the dental industry and some practitioners strongly recommend these types of restorations.

□ *Ceramics; crowns; dental education; inlays/onlays; veneers*

*Asbjørn Jokstad, Department of Prosthetic Dentistry and Stomatognathic Physiology, P.O. Box 1109 Blindern, N-0317 Oslo, Norway*

Dental amalgam has been the most commonly used restorative material, and it still is in most parts of the world. However, in Scandinavia many patients today wish to avoid metallic restorations in their teeth for various reasons. One of the reasons is the fear of mercury release from dental amalgam (1); others include esthetic concerns, supplied by strong marketing efforts, and the fact that few and smaller restorations are needed, especially in the younger population. Although direct restorations made with composite resin are a satisfactory alternative to amalgam in several situations, often their placement is contraindicated (2). Metal-ceramic and all-ceramic crowns usually satisfy the patients' demands for esthetics, but this treatment often results in significant removal of sound tooth tissue.

Tooth-colored, all-ceramic restorations include veneers, inlays, onlays, and crowns, and they have increased in popularity (3). Unpublished surveys of the selection of restorative materials in Sweden (1993–95), where banning of dental amalgam is under consideration, show ceramic restorations to be a frequent alternative restorative material to amalgam for indirect applications (I. A. Mjör. Unpublished observations). Ceramic materials for inlays and onlays (4) and for small bridges (5) have been in use, but ceramic veneers are of a relatively new date. Although ceramic materials have been used in dentistry for many years (6–8), only recent innovations and improved fabrication procedures have made ceramic restorations a realistic alternative in many clinical situations.

The introduction of new ceramic materials has changed the restorative practice of many dentists. The

knowledge base for the change has often been information from the manufacturer of ceramic products and from dental technicians, since few clinical data related to ceramic restorations have been accumulated in academic centers. Therefore, the present survey was designed to examine how the dental schools in Scandinavia provide teaching to undergraduate or pre-doctoral students, the curricular requirements and indications for use, and which materials and techniques that currently are in use.

## Materials and methods

A survey questionnaire was sent to all 13 dental schools in Scandinavia in September 1994. Two schools are located in Denmark, four in Finland, one in Iceland, two in Norway, and four in Sweden. The survey was sent directly to the clinical departments believed to be responsible for teaching the application of all-ceramic materials. The survey questionnaire was identical to the questionnaire used to determine the extent of teaching all-ceramic restorations in North American (9) and British (10) dental schools.

The survey included topics like the types of clinical experience, teaching responsibility, indications and categories taught, requirements, indications and contraindications for specific ceramic restorations, limitations to teaching, and the relative importance of instruction in the application of these materials as a component of the curriculum. Furthermore, the materials and clinical techniques used were surveyed.

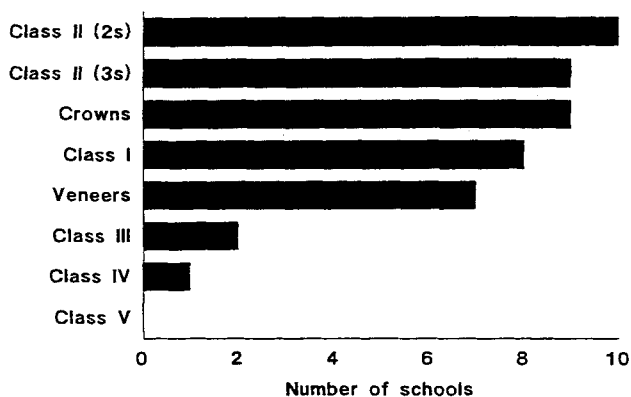


Fig. 1. Types of all-ceramic restoratives included in the curriculum at 10 Scandinavian dental schools (s = surfaces).

Two months after the initial questionnaire was mailed, a follow-up letter was sent and a telephone contact was made to the non-respondents. All 13 schools responded and returned the questionnaire by December 1994, after which time the responses were tabulated and evaluated.

## Results

### *School policy*

Three of the 13 dental schools did not offer clinical experience with all-ceramic restorations to pre-doctoral students. All three schools stated that there was insufficient longitudinal research available to support the utilization of these materials, and this lack of data was the main reason for excluding the topic from their clinical curriculum. Two additional arguments were that the technique was too difficult for the students, and that it was too time-consuming. Only one dental school reported that a specific number of restorations (one) was required. The other schools offered all-ceramic restorations as optional requirements or as elective credit. Four schools indicated that all-ceramic restorations could also be made under special circumstances such as in a clinical research setting.

All 13 schools replied in the questionnaire that the relative importance of all-ceramic restorations as a component of the dental school curriculum was increasing. The arguments for not increasing the teaching volume were similar to those cited by the three dental schools as reasons for not including the topics in their curriculum.

### *Teaching responsibility*

The department with the primary responsibility for teaching procedures using all-ceramic restorations was either the fixed prosthodontics department ( $n = 4$ ) or the

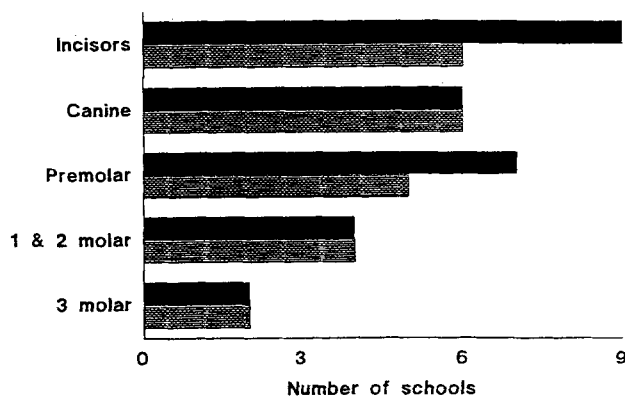


Fig. 2. The teeth considered suitable for all-ceramic crowns as reported by nine Scandinavian dental schools. Dark shade = maxillary teeth; light shade = mandibular teeth.

restorative dentistry department alone ( $n = 1$ ). Three schools reported primarily fixed prosthodontics and secondarily restorative dentistry. One school reported material science as the primary department and shared responsibility with prosthodontic and restorative departments. In one school the primary responsibility was shared between prosthodontic and restorative departments, and the material science department played a secondary role.

### *Restoration types*

The most common all-ceramic restorations taught were class-II inlays/onlays, followed by crowns, class-I inlays, and veneers (Fig. 1). Other classes of restorations were rarely included in the curricula of the surveyed dental schools.

Seven schools included onlays in their curriculum. The cavity size necessary to convert an MOD inlay to MOD onlay varied markedly. Two schools did not recommend making onlays at all. One school considered missing cusps as a definite indication for an onlay. Other schools suggested conversion at 3/4 of the intercuspal distance ( $n = 1$ ), 2/3 ( $n = 1$ ), 1/2 ( $n = 4$ ), and at 1/3 ( $n = 1$ ) intercuspal distance.

The fabrication of full crowns was taught by 9 of the 10 dental schools that included clinical experience by the students in their curriculum. Two schools suggested that all-ceramic crowns could be placed on any tooth, whereas most schools limited the placement to specified intraoral locations (Fig. 2). Except for incisors and premolars, no differences were noted between maxillary and mandibular teeth.

Veneers were taught at seven dental schools. The institutions considered that primary indications for veneer placement were non-carious enamel defects—that is, fluorosis, amelogenesis, tetracycline stain, restoration of incisal edge defects, diastema closures,

Table 1. Contraindications for placing all-ceramic restorations (10 schools)

Category	No. of schools
Poor oral hygiene	7
Bruxing/clenching	7
No enamel cervically	6
Removable partial abutment	5
Large pulp chamber	5
No valid esthetic requirement	3
Lack of moisture control	3
Short clinical crown	3
Abrasion potential (enamel)	2
Temporomandibular joint dysfunction	1
Endodontically treated tooth	1
Others (molars)	1

esthetic change (such as shade change), misalignment correction, and carious enamel. Extensive erosion was cited under the 'other' category by one school.

The contraindications for placing all-ceramic restorations varied markedly among the different dental schools and are presented in Table 1.

#### Materials and procedures

During the procedures for restoring a tooth with all-ceramic materials the dental schools used different bases and liners, impression materials, fabrication methods, and all-ceramic products. Three different regimens of cavity treatment with bases and liners were identified. Dentin adhesive materials were most commonly used, followed by glass ionomer and calcium hydroxide bases (Table 2). The most common impression material used was addition silicone ( $n = 10$ ). Polyether and hydrocolloid was used by five schools, whereas alginate and polysulfide were each used in one school.

The restoration was usually manufactured at a commercial laboratory, but the four schools in Finland had the restorations made by technicians at their own dental school laboratories. The CAD/CAM inlays—that is, Cerec and Celay—were made at the chairside. The all-ceramic restorations were made from different ceramic products, as shown in Table 3.

The commonest luting agent used was dual-cured resin cement ( $n = 10$ ). Three schools also used chemically cured resin cements, whereas three other schools used light-cured resin cements for veneers. Glass ionomer cement was limited to crowns ( $n = 4$ ) and

Table 2. Bases and liners currently used with all-ceramic restorations made by dental students in Scandinavia (10 schools)

	Crowns	Veneers	Inlays	Onlays
Dentin adhesives	8	10	10	8
Glass ionomer	4	—	7	5
Calcium hydroxide	2	2	3	3

Table 3. Materials currently used for fabrication of all-ceramic restorations by dental students in Scandinavia (10 schools)

Material	No. of schools			
	Crowns	Veneers	Inlays	Onlays
Empress	7	4	8	7
CAD/CAM	1	2	7	4
Inceram	5	1	4	2
Dicor	4	3	3	2
Vita porcelain	4	3	2	2
Mirage	2	3	2	1
Ceramco	—	2	2	—
Cerinate	—	2	—	—
Optec HSP	1	—	1	1
Procera	1	—	—	—

inlays ( $n = 1$ ). In addition, five schools used zinc-phosphate cement for crowns.

The use of rubber dam during cementation varied markedly. Three schools reported that rubber dam was never used, whereas other schools always used rubber dam for some procedures, such as inlays, but not during the cementation of crowns (Table 4). After cementation the commonest instrumentation for finishing and polishing was rubber points ( $n = 10$ ), diamonds ( $n = 9$ ), paper discs and strips ( $n = 9$ ), diamond paste ( $n = 9$ ), finishing burs ( $n = 3$ ), and stones ( $n = 3$ ).

#### Discussion

The variation in choice of department with the primary responsibility for teaching all-ceramic restoration therapy probably reflects differences in departmental organization and preferences or interests by the faculty involved. However, prosthodontics usually had the prime teaching responsibility, as was the case in North American dental schools (9).

The number of reported contraindications for placing all-ceramic restorations varied from eight reasons to two. The commonest reason for not placing all-ceramic restorations was poor oral hygiene and occlusal dysfunction. These contraindications are in accordance with most textbooks on the subject (11, 12). There are no references in the literature as to whether

Table 4. Frequency of use of rubber dam isolation, expressed in percentage ranges, during cementation of all-ceramic restorations made by dental students in Scandinavia (10 schools)

	No. of schools			
	Crowns	Veneers	Inlays	Onlays
0%	6	5	3	3
30–40%	1	1	2	2
50–60%	1	1	—	1
75%	—	—	2	—
100%	1	—	3	1

molars or endodontically treated teeth should be considered unfit to receive all-ceramic restorations. The fact that these teeth were suggested as contraindications should probably only be regarded as cautious measures rather than real contraindication. Among the contraindications listed in the questionnaire only 'previous history of periodontal disease' was not listed as a contraindication by any of the respondents. One contraindication that was not listed in the questionnaire, which some authors have suggested (13), is preparations with excessive undercuts.

The range of acceptable teeth for all-ceramic crowns as suggested by the dental schools varied markedly from only the upper incisors to all teeth. On the basis of the literature it is impossible to conclude which of these policies is most sound.

The suggestion as to when an inlay should be converted to an onlay varied markedly, as reflected in the literature. Christensen (13) suggests dimensions in excess of half the intercuspal distance should be converted to onlays, which agrees with most dental schools in the present study and with the average value reported for North American dental schools (9). However, other authors argue that there are no reports in the literature that shows better survival of onlays than inlays (14).

The commonest types of restorations taught were class-I and class-II inlays/onlays. However, other designs were also taught, which is surprising considering that there are no reports in the literature on studies of these inlay designs. Historically, the commonest inlay type has been class-V inlays (4), but none of the Scandinavian dental schools reported that this was included in their curricula. Today the bonded class-V composite resin or glass ionomer restoration is regarded as the only viable alternative in these situations (15). Class-V inlays are also rarely included in the teaching of all-ceramic restorations in North America (9).

The use of materials for all-ceramic restorations at Scandinavian dental schools differed in many respects, including bases and liners and ceramic material. Bases are primarily used to block out undercuts (16). Christensen (13) suggests that calcium hydroxide should be used if less than 0.5 mm dentin remains. Furthermore, he suggests that glass ionomer cement should be used as a base so that the depth dimension of the ceramic inlay preparations becomes between 1.5 and 2 mm. However, different layers of bases and liners have an effect on the microleakage (17), and the rationale for these procedures can be questioned.

All fabrication categories of ceramic restorations were represented: cast, milled, fired, and spark erosion. Although most schools used dual-cured resin luting cements, three schools also advocated the use of glass ionomer cement. However, glass ionomer cements are not recommended, according to some authors (18, 19). The effect of dentin adhesives remains uncertain, and the thickness should be kept at a minimum (20).

Finally, the survey shows that the use of rubber dam during cementation procedures for inlays/onlays varies from never in most schools to always, like in British and Irish dental schools (10). In general, the use of rubber dam in connection with cementation of all-ceramic restorations at Scandinavian dental schools is low, which has also been reported for general practitioners (21).

#### Concluding remarks

The wide range of different teaching concepts, materials, and opinions and views with regard to indications and contraindications for all-ceramic restorations in Scandinavian dental schools reflects the confusion and often contradictory data reported in the literature. That 10 of 13 dental schools in Scandinavia (77%) at present offer some sort of clinical experience to pre-doctoral student indicates that teaching the topic to students is regarded as important. Such teaching programs are especially relevant in countries where the banning of dental amalgam is being considered—for example, Sweden in 1997 and Denmark in 1999. It is, therefore, thought-provoking to note that although in theory, the students today may not be allowed to place amalgam restorations when they graduate, they receive minimal training in the fabrication of alternative restorations like all-ceramic materials. Only one school included mandatory fabrication of all-ceramic restorations and this was limited to one restoration on the upper incisors. An unpublished survey of the type of restorations placed by practitioners in Sweden (I. A. Mjör. Unpublished observation) has shown a marked change from that reported in 1978/79 (22), and all-ceramic restorations are clearly increasing among practitioners as an alternative to amalgam restorations. However, this survey indicates that all-ceramic restoration therapy still is regarded as experimental by teaching institutions.

#### References

1. Berglund A. Release of mercury vapor from dental amalgam [dissertation]. Umeå: Umeå University, 1992.
2. Vanherle G, Degrange M, Willems GC, editors. State of the art on direct posterior filling materials and dentine bonding. Proceedings of the International Symposium, March 1993. Leuven: van der Poorten, 1993.
3. Esthetic dentistry: ethics and excellence. *J Am Dent Assoc* 1988; 117(4) (Spec Iss).
4. Qualtrough JW, Wilson NH, Smith GA. The porcelain inlay: a historical view. *Oper Dent* 1990;15:61-70.
5. Pröbster L, Diehl L. Slip-casting alumina ceramics for crown and bridge restorations. *Quintessence Int* 1992;23:25-31.
6. McLean JW. The science and art of dental ceramics. Vol. II. Chicago: Quintessence Publishing Co., 1980.
7. Jones DW. Development of dental ceramics—an historical perspective. *Dent Clin N Am* 1985;29:621-43.
8. Preston JD, editor. Perspectives in dental ceramics. Proceedings

- of the 4th International Symposium on Ceramics. Chicago: Quintessence Publishing Co., 1988.
9. Frazier KB, Mjör IA. Teaching all-ceramic restorations in North American dental schools. Curricular requirements and indications. *J Esthet Dent* 1996. In press.
  10. Wilson NHF, Qualtrough AJE, Mjör IA. All-ceramic restorations: teaching in UK and Irish dental schools. *Eur J Prosthodont Restor Dent* 1996;4:21-8.
  11. Grossmann DG. Cast glass ceramics. *Dent Clin N Am* 1985;29:725-39.
  12. Garber DA, Goldstein RE. Porcelain & composite inlays and onlays. Esthetic posterior restorations. Chicago: Quintessence Publishing Co., 1994.
  13. Christensen GJ. A look at the state of the art. Tooth colored inlays and onlays. *J Am Dent Assoc* 1992;123:66-8.
  14. Pallesen U. Kliniske erfaringer med nyere systemer til fremstilling af keramiske indlæg. *Tandlaegebladet* 1994;98:308-9.
  15. Van Meerbeek B. Dentine adhesion: morphological physico-chemical and clinical aspects [thesis]. Leuven: Katholike Universiteit, 1993.
  16. Roulet JF, Herder S. Bonded ceramic inlays. Chicago: Quintessence Publishing Co., 1991.
  17. Staehle HJ, Emmerich M, Scharbeth C. Randdichtigkeit von Kompositinlays bei verschiedenen unterfüllungen. *Schweiz Monatsschr Zahnmed* 1992;102:1189-94.
  18. Höglund C, Van Dijken J, Olofsson AL. A clinical evaluation of adhesively luted ceramic inlays. *Swed Dent J* 1992;16:169-71.
  19. van Dijken J, Hörstedt P. Marginal breakdown of fired ceramic inlays cemented with glass polyalkenoate (ionomer) cement or resin composite. *J Dent* 1994;22:265-72.
  20. Burke FJ, Qualtrough AJ. Aesthetic inlays: composite or ceramic? *Br Dent J* 1994;176:53-60.
  21. Liebenberg WH. General field isolation and the cementation of indirect restorations. I. *J Dent Assoc South Afr* 1994;7:349-53.
  22. Mjör IA. Placement and replacement of restorations. *Oper Dent* 1981;6:49-54.

---

Received for publication 28 September 1995

Accepted 6 November 1995