# Fit of a New Pressure-Sintered Zirconium Dioxide Coping

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**Purpose:** The aim of this study was to determine in vitro the internal and marginal fit of zirconium dioxide ceramic copings manufactured using a recently introduced CAD/CAM-based technique (Denzir). **Materials and Methods:** Two master models were produced in metal, representing the maxillary right central incisor and first premolar. Two A-silicone impressions were used for each of the master models, and from each of the impressions five stone dies with the corresponding ceramic copings were produced, for a total of 20 copings. The A-silicone replica of the misfit of the ceramic coping to the corresponding stone die and master model was sectioned buccolingually and mesiodistally. The obtained sections were measured at occlusal, axial, and marginal locations under light microscopy. Twenty-four measurements for each replica were made. The Student's *t* test was used to detect significant differences between coping–stone die and coping–master model misfits. **Results:** For any combination, the marginal fit was superior to the axial and occlusal fit. In general, the misfit between the coping and the stone die did not differ significantly from the misfit detected between the coping and the master model. However, a better fit was recorded for the first premolar at the occlusal portion in the coping–stone die combination compared to the coping–master model combination. The mean marginal discrepancy between the copings and master models was clearly below 50 µm, with a range of 0 to 115 µm. **Conclusion:** The accuracy achieved by the Denzir manufacturing process for the production of zirconium dioxide copings is well within the range of clinical acceptability. *Int J Prosthodont 2004;17:59–64.*

Denzir (Dentronic) is a new dental restorative material made of pressure-sintered zirconium dioxide. At a 1996 international symposium in Munich, zirconium dioxide, which has long been used in the field of orthopedics for hip transplantation, was considered to fulfill all the criteria for an ideal restorative material in dentistry.[1] A clear advantage of the material was claimed to be its unique crystal structure, preventing fracture formation along the crystals. The only clear problem was that it was impossible to handle the material with precision machines. This problem has apparently been solved by Dentronic with a new computer-aided design/manufacturing (CAD/CAM)–based technique, and the prefabricated yttrium oxide–partially stabilized zirconia ceramic can now be handled for the production of tooth restorations.[2] Preliminary reports regarding the hardness of the Denzir coping have been presented.[1]

Another aspect to be investigated is the fit and/or congruence of the inner surface of a Denzir coping and the corresponding surface of the prepared tooth, defined as discrepancy or gap. An interface discrepancy can be internal and/or marginal. An internal discrepancy is misfit of the coping at the occlusal/incisal and axial surfaces. The marginal discrepancy can be defined as a vertical dimension from the finish line of the preparation to the cervical margin of the restoration. This gap is caused by too-short crowns or improper seating of the crowns. The marginal gap can also be defined as a horizontal discrepancy, perpendicular to the tooth axis, caused by a too-wide

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**Fig 1** Metal master model for maxillary right first premolar.

crown.[3] Thus, the marginal fit may be defined by a vertical and horizontal gap width.

In dentistry, the discussion has long concerned the range of an acceptable marginal discrepancy not resulting in deleterious effects on the tooth structure or surrounding tissue. A marginal gap ranging from 10 to 500 µm, with mean values from 50 to 100 µm, has been reported, and even higher values have been found for the incisal/occlusal discrepancies.[3–7] The clinical significance of a particular value is difficult to establish. Clinical experience and empiric data seem, however, to advocate a marginal discrepancy of less than 100 µm.[4] Furthermore, absence of a marginal gap and an excellent fit are perhaps not always clinically desirable, since there must always be a space for the luting cement.

The present study was undertaken to evaluate, by a replica technique in vitro, the internal and marginal fit of Denzir zirconium dioxide copings to a master model and to a stone die. The study hypothesis was that the CAD/CAM technique would allow the production of ceramic copings with a marginal discrepancy of less than 50 µm.

## Materials and Methods

Two acrylic resin teeth were used for the preparation of abutments for single crowns representing the maxillary right central incisor and first premolar. The teeth were prepared according to Dentronic's recommendations. Occlusally, 2 mm of the tooth substance was removed, and buccally, lingually, and approximally, 1.0 to 1.5 mm was removed. A chamfer preparation with a convergence angle of about 4 to 10 degrees was performed, and all sharp edges were removed. The two acrylic resin teeth were sent to the Dentronic Laboratory, Skellefteå, Sweden, and the preparations were analyzed for fulfillment of the preparation requirements, after which small adjustments were made. Thereafter, an impression of the incisor and premolar was taken with an A-silicone material (Impress Light Body and Impress Heavy Body, E&D Dental Products). According to the lost-wax technique, master models of the central incisor and first premolar were manufactured in metal (Phantom-Metal, Degussa Dental) (Fig 1). The two master models were used as original abutment preparations for the rest of the investigation.

Two impressions for each of the master models were taken with A-silicone material (Impress) and sent to the Dentronic Laboratory, where the technical procedure, from stone dies to ceramic coping, was performed. From each of the two impressions, five stone dies and five ceramic copings were made, for a total of 20 copings: 10 for the central incisor and 10 for the first premolar.

Replicas of the intermediate space between the inner surface of the copings and the stone die surface were later taken. This was achieved by applying a light-bodied A-silicone impression material (Impress) with the help of a pencil and by filling about half of the coping with the light-bodied material. The coping was then placed onto the stone die, and maximum finger pressure was applied. After setting of the impression material, the coping was removed, resulting in a thin film of light-body material representing the discrepancy, cement space, between coping and stone die. In most cases, the film dressed the outside of the stone die. For stabilization purposes, a heavy-bodied material (Impress) was applied around the stone die with the support of a small box. The heavy-body material joined the light body to form one piece, and by this procedure it was possible to remove and handle the intermediate replica of light-body material.

The same methods were applied for the production of the replica of the intermediate space between the inner surface of the coping and the master model. In most of the master model cases, the light-body film dressed the inside of the coping, and the heavy-body material was injected into the coping. The replica adhering to the heavy-body material was cut with a scalpel in two axial directions: buccolingually and mesiodistally. In this manner, the replica was divided into four pieces (Fig 2). Care was taken to equalize the portions as much as possible. The gap width was measured with an optical measuring microscope (UWM-DigS, Leitz) used at 30× magnification. All registrations were made to the nearest 0.0001 mm. The gap width was measured as the thickness of the Impress Light Body impression material at the measuring points.

**Fig 2** A-silicone light-body replica adhering to heavy-body material is cut with scalpel in two axial directions: buccolingually and mesiodistally. In this manner, replica is divided into four pieces.

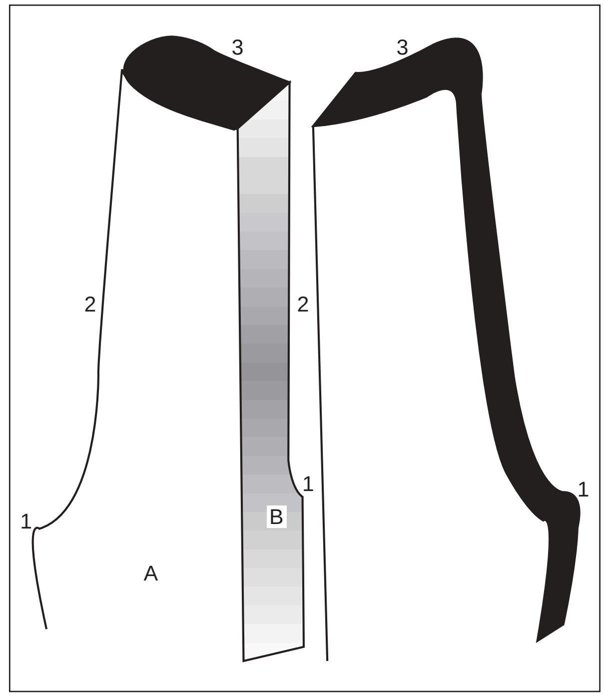


**Fig 3** *(right)* Points of measurement for each of the four pieces into which the replica was cut: *1* = marginal; *2* = axial; *3* = occlusal. Buccolingual *(A)* and approximal *(B)* aspects.

**Table 1** Discrepancy (Mean, Standard Deviation [SD], and Range in µm, and Coefficient of Variation [CV] in %) Between Stone Die/Master Model and Inner Surface of Coping for the Two Teeth

| | Stone die | | | | | Master model | | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurement | Mean | SD | Range | CV | *P* | Mean | SD | Range | CV |
| **Maxillary right first premolar** | | | | | | | | | |
| Occlusal | 164 | 45 | 73–292 | 27 | < .001 | 192 | 52 | 103–323 | 27 |
| Axial | 115 | 30 | 66–169 | 26 | .520 NS | 110 | 31 | 34–163 | 28 |
| Marginal | 42 | 36 | 0–97 | 85 | .840 NS | 41 | 36 | 0–115 | 87 |
| **Maxillary right central incisor** | | | | | | | | | |
| Occlusal | 165 | 56 | 80–281 | 37 | .660 NS | 163 | 47 | 90–251 | 29 |
| Axial | 122 | 41 | 42–213 | 33 | .850 NS | 123 | 42 | 37–202 | 34 |
| Marginal | 34 | 26 | 0–124 | 76 | .050 | 22 | 25 | 0–75 | 110 |

NS = no statistically significant difference.

Measurements of the film thickness were performed at three different locations: *(1)* at the margin, *(2)* at the axial wall, and *(3)* at the occlusal/incisal surface. This resulted in four measurements of each location and two measurements of each point, making a total of 24 measurements for each replica (Fig 3). At the margin, the film thickness was recorded as the shortest distance from the edge of the crown to the closest tooth structure. Measurements along the axial wall were performed approximately halfway between the margin and the occlusal border, perpendicular to the surface and in an area representative of the surface. A total of 960 measurements were made.

All measurements were performed by the same operator. However, to estimate the inherent individual measurement error, the operator and another observer individually measured the fit of the same five copings on the master, and the figures were compared. The Student's paired *t* test was applied to find statistically significant differences between film thickness recorded for the master model and the die stone.

## Results

The mean value of the differences between the measurements performed by the two observers was 8 µm (standard deviation [SD] 25). The recorded adaptation of the Denzir copings to the individual master and die stone is presented in Table 1. A large SD and coefficient of variation were found for all measuring points, irrespective of location. For any combination, the marginal fit was superior to the axial and occlusal fit.

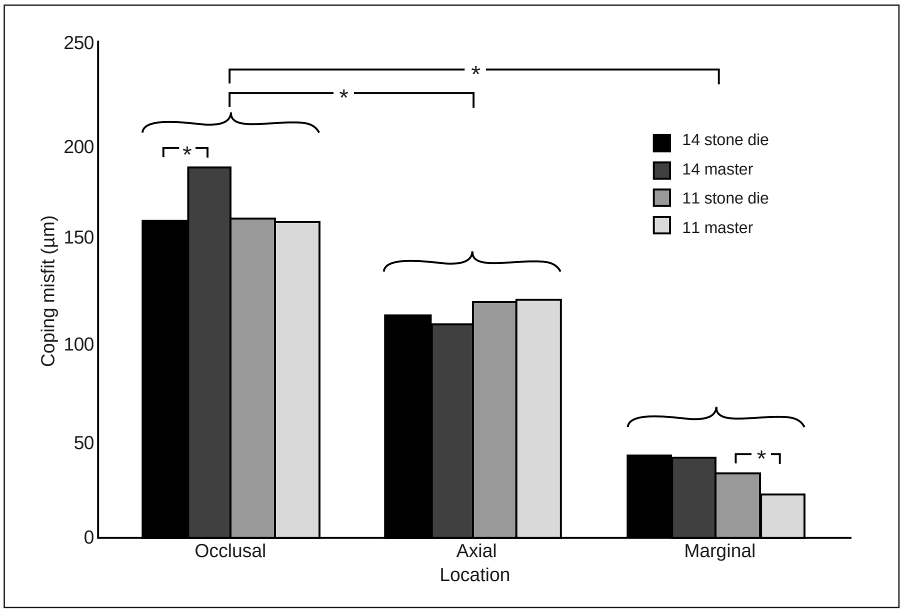


**Fig 4** Mean value of the misfit between Denzir copings and stone die–master model for maxillary right central incisor and first premolar at occlusal, axial, and marginal locations. * = statistically significant difference with 95% probability.

A thinner impression material film was recorded for the first premolar at the occlusal portion in the coping–stone die combination compared to the coping–master model combination (Table 1 and Fig 4). No significant differences in discrepancy between coping–stone die and coping–master model could otherwise be detected in the axial or marginal portions. In the case of the central incisor, the misfit registered between the coping and the stone die did not differ significantly from the misfit detected between the coping and the master model, except for the marginal location ($P = .05$).

The copings produced from the first impression showed a marginal and axial misfit to the master model similar to that shown by the copings produced from the second impression, whereas a significant difference was detected between the two impression groups for the misfit at the occlusal portion. The last copings produced from one impression did not show any significant difference compared to the first copings produced from the same impression.

## Discussion

An in vitro evaluation of crown/die–master model discrepancy certainly has its inherent errors, one of which may be the seating force. Another source of error could be inaccurate placement of the coping to the master or stone die. A coping is produced for a unique preparation and, consequently, there is only one position giving an optimal fit. When the coping is placed and/or cemented, this position may not be found. A minimal rotation of the coping on the stone die/master model may result in an increased discrepancy at one site and a smaller one at another site.[8] In the present investigation, the only guide to the correct positioning of the coping was the fingers' "feeling." Likewise, the problems related to the replica material used and methodologic errors have been discussed earlier.[3] One such problem has been related to the search for a replica material with a flow close to that of the cementing medium. Different silicone impression materials have been found to fulfill these criteria.[4] Measurement errors may also have occurred because of instrument and/or observer errors. The inherent error of the microscope used was estimated to be 0.1 μm. The inherent individual measurement error was evaluated by having two observers measure the fit of the same five copings on the master individually. The mean value of the differences between the measurements performed by these two observers was 8 μm (SD 25). The explanation could be that the two operators did not choose exactly the same measuring points, as well as differences in interpretation of the starting and ending points of the discrepancies.[8] The same amount of measurement error between different operators has been reported earlier,[9] and it is small in comparison to the registered mean values.

Although care was taken to section the replicas perpendicular to the surface to be measured, it cannot be excluded that in some cases the cut was oblique, and therefore that the measurement overestimated the discrepancy between coping and stone die/master model. Another factor to be considered is that some of the sections may not have been representative of the replica as a whole. Several replicas showed thickness variations over short distances. Thus, the placement of the cut was decisive for the discrepancy measured. This observation is supported by a scanning electron microscopic study in which the discrepancy between crown and tooth was found to be in the range of 50 to 180 μm over a distance of 300 μm.[10] Taken together, these factors can explain the high SDs found in the present study. The problem could partly be compensated for by a high number of copings measured at several points.

When making a survey of the current literature, controversies regarding the clinical relevance of the size of the marginal gap and/or crown discrepancies are common. Theoretically, a well-fitting crown reduces the chance of recurrent caries and periodontal disease, whereas the space between a poorly fitting artificial crown and tooth preparation enables accumulation of bacterial plaque.[11] Löe[12] reported that plaque accumulated in this area induces inflammation of the periodontium. American Dental Association Specification No. 8 states that the luting cement film thickness for a crown should be no more than 25 μm when using a type I luting agent, or 40 μm with a type II luting agent.[13] A marginal gap of less than 50 μm has been recommended as clinically acceptable.[14–17] Most authors agree, however, that marginal gaps or inaccuracies on the order of 100 μm seem to be in the range of clinical acceptability.[3–5,18]

It seems more likely that factors other than the marginal gap (eg, viscosity and grain size of the luting agent, with resulting film thickness, and mode of preparation) are of greater importance to the final result.[19,20] Clinically, the dentist has to accept the inevitability of a cement film between the tooth and the crown. It should, however, be kept to a minimum, as poor marginal fit will increase the dissolution of the cementing medium and possibly predispose subsequent failures.[21] A clinical study of 1,000 restorations over a 5-year period concluded that 120 μm is the maximum clinically acceptable marginal misfit.[4] It indicated that a 50-μm opening might be difficult to achieve clinically. The marginal gap recorded in the present study is in accordance with, or smaller than, that reported previously.[6,11,22,23] The detection of occlusal/incisal discrepancies significantly greater than the axial and marginal ones is also in line with previous studies and other techniques.[3,5,6]

The geometric relationship between angle of convergence and marginal/axial adaptation will influence the occlusal discrepancy and is probably one reason for the large values and ranges recorded. Hence, the geometric form of the premolar abutment could partly explain the recorded occlusal difference between stone die and master for the maxillary right first premolar. Another contributing factor could be inaccurate placement of the coping to the master or to the stone die, as discussed above. To overcome most of the methodologic errors discussed in the present investigation, a new study applying instruments used in engineering for profile comparison is in progress.

## Conclusion

In general, the misfit between the coping and the stone die did not differ significantly from the misfit detected between the coping and the master model. The recorded values for the marginal fit were lower compared to those for the axial wall and incisal/occlusal surface. The coefficient of variation was great, especially for the marginal discrepancy. The mean value of the marginal discrepancy between the copings and the master models was clearly below 50 μm, with a range of 0 to 115 μm, and therefore the null hypothesis was accepted. Within the limitations of this in vitro study, it can be concluded that the accuracy achieved by the Denzir manufacturing process is well within the range of clinical acceptability.

## Acknowledgment

This study was supported by Dentronic, Skellefteå, Sweden.

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*Literature Abstract*

**A survey of treatment outcomes with removable partial dentures.**

This study assessed patient satisfaction with RPDs to include factors such as retention, speech, esthetics, chewing, and comfort as a function of the influence of socioeconomic factors, Kennedy classification, construction, material, denture base shape, denture support, and number of missing teeth. Surveyed were 205 patients ranging from 38 to 89 years old; using a specially designed questionnaire, dentures were evaluated on a scale of 1 to 5, with 1 being dissatisfied and 5 being excellent. This scale was reversed for the level of comfort, with 5 being the maximum level of discomfort and 1 being the lowest level of discomfort. Zero was used to denote no discomfort at all. Prosthodontists evaluated the dentures based on quality of fit, extension and occlusion, number of clasps, occlusal rests, partial denture connectors, and quality of framework design on a scale of 1 to 5, with 1 being poor construction and 5 being excellent. A one-way Kolmogorov-Smirnov test was used to analyze the statistics, and a Kruskal-Wallis test determined significant differences between the variables. The majority of patients were satisfied with their dentures, and patients did tend to rate their RPDs on the higher end of the scale. Results revealed no significant differences in general patient satisfaction relative to the influence of age, gender, marital status, smoking habits, chronic diseases, education, socioeconomic status, denture hygiene grades, tooth loss, or previous experience with RPDs. A significant correlation was noted in patients who had a higher socioeconomic status: They were less pleased with the esthetics of their RPDs. A significant correlation was also seen among mandibular RPD wearers: the greater the number of missing teeth, the less comfort.

**Knezovic Zlataric D, Celebic A, Valentic-Peruzovic M, Jerolimov V, Panduric J.** *J Oral Rehabil* 2003;30:847–854. **References:** 34. **Reprints:** Dr Dubravka Knezovic Zlataric, Department of Prosthodontics, School of Dental Medicine, University of Zagreb, Gunduliceva 5, 10000 Zagreb, Croatia. e-mail: dkzemail.hinet.hr—*Josephine Esquivel-Upshaw, San Antonio, Texas*