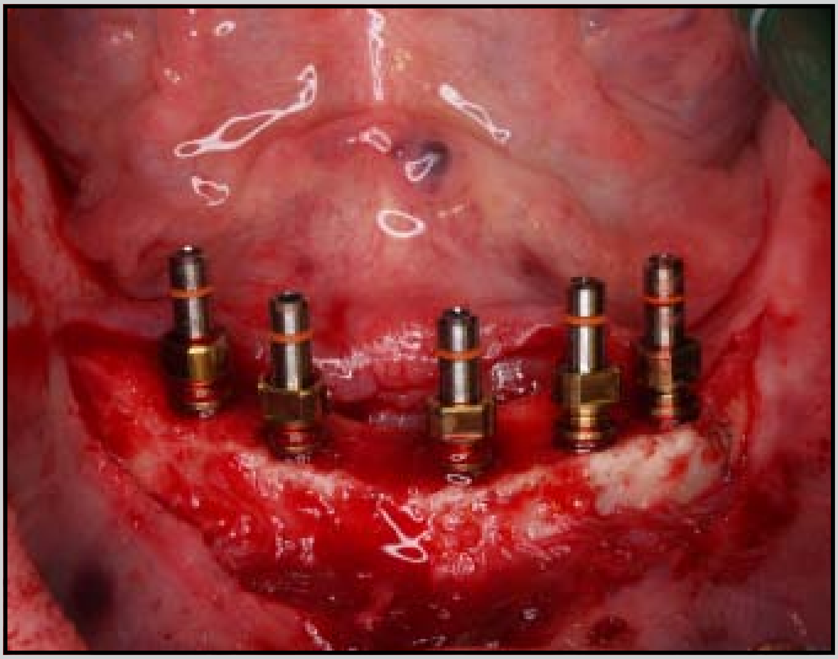

Long-Term Follow-up of Conical Crown–Retained Dentures Fabricated Using Different Technologies

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This study presents the results of a long-term clinical evaluation of conical crown–retained dentures fabricated using different technologies. Four different material connections between the outer and inner crowns were used: cast gold/cast gold, cast gold/electroforming, nonprecious alloy/electroforming, and titanium abutment/electroforming. Technical failures and retention values were assessed. The best clinical outcome was found with dentures in which both crowns were cast from gold alloy. The most frequent technical failures were observed in restorations with electroformed outer crowns. Better clinical outcomes were noted when the electroformed outer crowns were used in dentures retained by implants as compared to dentures on natural dentition. (Int J Periodontics Restorative Dent 2012;32:467–475.)

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Dentures supported by double crowns are used in chosen cases to restore both natural dentition and implants. The double crown consists of precisely fitting cylinders with parallel walls (telescopic crowns) or cones (conical crowns).[1,2] Indications for the application of conical crowns are vast. They can be used as an element supporting overdentures, teeth, or tooth and tissue–supported partial dentures.[3–6]

There are a number of laboratory methods used to fabricate these types of prostheses. In traditional technology, the primary and secondary crowns are fabricated using a casting technique. The secondary crowns are luted or soldered to the denture framework or may be cast as a homogenous unit together with the framework. Outer crowns can also be fabricated from pure electroplated gold, and this technique can be used in a variety of ways.[7,8] The inner crown can be cast using a traditional lost-wax technique or fabricated from zirconia using computer-aided design/computer-assisted manufacturing.[9–15] The precision with which conical crowns are fabricated using the classic lost-wax technique affects the retentive value of the denture. Both low and too high retentive forces are not desirable. The former hinder normal function, whereas with the latter, complications may occur, including periodontal injury, primary crown decementation, and abutment fracture.[10,16–18]

Conical crown–retained dentures fabricated by use of the electroforming technique should be devoid of the problems mentioned previously since the outer crown has an ideal fit to its inner component. However, the construction becomes more complicated since the electroplated copings have to be luted to the separately fabricated framework.[8–11]

This variety of technical solutions used to fabricate dentures on conical crowns allows us to assume that the optimal solution has not yet been achieved.

The literature on clinical outcomes of the use of conical crown–retained dentures reports frequent denture failures, in some cases reaching 92.8%.[17–24] Taking this into consideration and based on their own clinical material, the authors decided to analyze the frequency and type of mechanical damage to conical crown–retained dentures as well as the change in retentive force over time. Dentures fabricated using a traditional casting technique were compared with those that had electroformed copings both on natural dentition and implants.

Method and materials

This clinical study involved 59 patients treated between 1996 and 2008 who wore 73 double crown–retained dentures fabricated using various technologies. There were 31 women (52.5%) and 28 men (47.5%), with a mean age of 49.5 years (minimum, 38 years; maximum, 74 years). The follow-up period was 62 months (minimum, 12 months; maximum, 108 months). The treated arches were assigned to the groups according to Kennedy classification: 36 (73.47%) Class I, 10 (20.4%) Class II, 1 (2.17%) Class III, and 2 (4.35%) Class IV; 49 arches (67.1%) had intact natural dentitions. All patients who lost abutment teeth because of periodontal, endodontic, or mechanical (eg, root fracture) complications or patients with bruxism or other parafunctional habits were excluded from the study.

Four groups of dentures were distinguished depending on fabrication technology: group I = primary and secondary crowns cast with a precious alloy (Au/Au), secondary crowns cast in one piece with denture framework; group II = primary crown cast with a precious alloy, secondary crown fabricated by use of the electroforming technique (Au/Galv); group III = primary crown cast with chromium-cobalt alloy, secondary crown made by electroforming (Cr-Co/Galv); and group IV = primary crown is a milled titanium abutment, secondary crown made by electroforming (Ti/Galv).

In all dentures except one in group II, denture base flanges were designed with extension into the facial vestibules and lingual sulci. The flanges were adjusted on insertion if necessary. In maxillary dentures of Kennedy Class I patients, the palate was covered with a complete palatal plate. In Kennedy Classes II, III, and IV and in patients with six to eight implants in the maxilla, the palate was completely or partially exposed.

All primary abutments were milled. In cases where secondary copings were electroformed, primary abutments—whether on teeth or implants—were milled with a 2-degree taper and chamfer-like finish line on the gingival level.

In cases where outer copings were cast, primary crowns or UCLA abutments on implants were milled with a 2- or 4-degree taper depending on their number and height, and without any preparation on the gingival level. In dentures from group I, secondary crowns were cast of precious gold alloy (Aurix L60, Safina) in one piece with the denture framework and veneered with commercially available acrylic resin denture teeth thinned and embedded in acrylic resin. In dentures from groups II, III, and IV, electroformed copings were luted onto frameworks cast of nonprecious alloy (Wironium, Bego). Frameworks were veneered with composite resin material (Chromasit, Ivoclar Vivadent or Gradia, GC).

Dentures were assessed based on clinical examination and macroscopic analysis of present defects. Dentures were inspected for the presence of veneering material

Table 1 **No. of dentures supported by implants, teeth, or implants and teeth**

	Implants	Teeth	Implants and teeth
Maxilla (n = 30)	7	20	3
Mandible (n = 43)	12	29	2

Table 2 **No. of dentures supported by implants, teeth, or implants and teeth and their various material connections**

	Implants	Teeth	Implants and teeth
Au/Au (n = 14)	10	3	1
Au/Galv (n = 42)	1	39	2
Cr-Co/Galv (n = 7)	0	7	0
Ti/Galv (n = 10)	8	0	2

cracks or chipping, denture base fractures, framework fractures, electroformed coping detachment, and distortion. The degree of retention was graded as: very good (grade 1) = denture exhibited definite resistance to removal; good (grade 2) = denture exhibited moderate resistance to removal but was stable in use; sufficient (grade 3) = patient was able to remove the denture not using his/her hands, eg, using the tongue or labial muscles; and insufficient (grade 4) = denture lost contact with the supporting area upon mouth opening.

The types of failure observed in the double crown–retained dentures were divided into the following groups: *(1)* loss of retention (significant reduction, eg, grade 3 or 4), *(2)* defects related to the secondary crown veneer, *(3)* decementation of the primary crown, and *(4)* other (denture framework fracture, detachment of the secondary telescope, base fracture, etc). Framework fracture required refabrication of the entire proshesis, while with other defects, necessary repairs were completed in the dental laboratory.

Tables 1 and 2 present numeric values for all evaluated dentures regarding the maxilla and mandible and type of support (teeth or implants) (Table 1) and material connections (Table 2). Table 3 presents the distribution of abutments

Table 3 Distribution of abutments according to Kennedy classification (dentate patients) and implant positions (implants or mixed dentition) in each group

	Group I (n = 14)	Group II (n = 42)	Group III (n = 7)	Group IV (n = 10)
Kennedy Class I	3	29	4	0
Kennedy Class II	0	7	3	0
Kennedy Class III	0	1	0	0
Kennedy Class IV	0	2	0	0
3 to 5 implants between mental foramena	7	0	0	4
6 to 8 implants (13–17, 23–27*)	3	0	0	4
Implants (36, 35, 33, 43, 45, 46*)	0	0	0	2
Mixed dentition	1[†]	3[‡]	0	0

*FDI tooth-numbering system.
[†]The patient had implants at sites 17, 16, 25, 26, and 27 and teeth at sites 15, 13, and 23.
[‡]One patient had implants at sites 25 and 26 and teeth at sites 16, 15, 11, 21, and 22; one patient had implants at sites 14, 11, 21, and 24 and teeth at sites 15, 13, 23, and 25; and one patient had implants at sites 34, 35, 36, 44, 45, and 46 and teeth at sites 33 and 43.

Table 4 Opposing arch condition in each group

	FPD/t	FPD/i	DCD/t	DCD/i	CD	ND
Group I	5	1	1	2	5	0
Group II	10	0	11	4	10	7
Group III	3	0	2	0	0	2
Group IV	0	0	2	6	1	1

FPD/t = fixed partial denture on teeth; FPD/i = fixed partial denture on implants; DCD/t = double crown–retained denture on teeth; DCD/i = double crown–retained denture on implants; CD = complete denture; ND = natural dentition.

according to Kennedy classification as well as the position of implants or implants and teeth in cases of both. Opposing arch conditions are presented in Table 4.

Results

The major objective of the failure analysis was to compare dentures fabricated with various

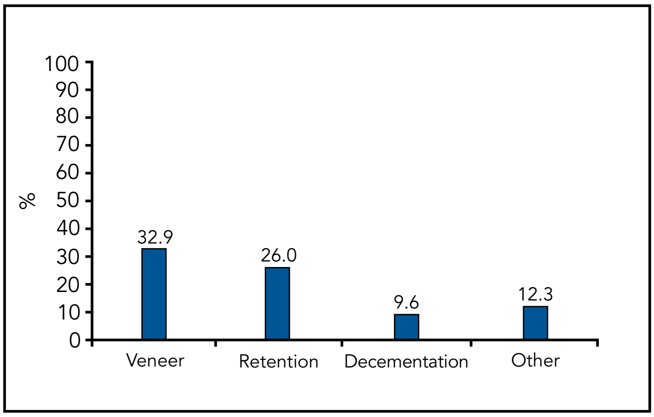


Fig 1 *Percentage of defects found in the evaluated dentures.*

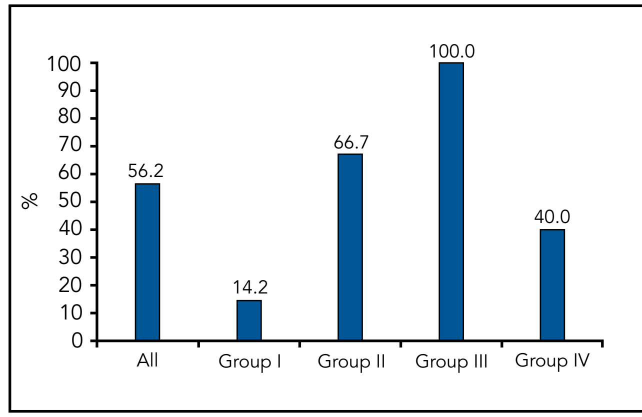
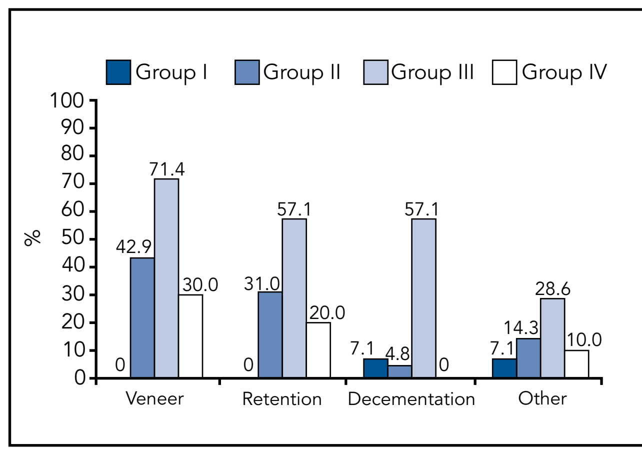


Fig 2 *Percentage of defective dentures in the study groups.*

Fig 3 *Percentage of specific defects in the study groups.*



technologies. Therefore, the analysis focused on the defects associated with denture construction and not on periodontal or endodontic complications. The rates of denture construction defects in all study groups are presented in Fig 1. Cracks or detaching of the veneering material were the most common mechanical defects (n = 24), with loss of denture retention being the second most common failure (n = 19). Decementation of the primary crown was rare (n = 7). Over half (56.2%) of the evaluated dentures showed some degree of mechanical damage. As shown in Fig 2, dentures in group III were characterized by the highest failure rate (100%). Mechanical defects in group II were observed in 66.66% of dentures. Despite the fact that the secondary crowns in group IV were also made by electroforming, the percentage of mechanical defects in this group as compared to groups II and III was much lower (40%). The lowest failure rate was observed in group I (14.2%).

Figure 3 shows the predominance of defect types in each group. In group I, only two dentures were defective (14.2%), including either decementation of the primary crown from the abutment tooth or denture impaction, which occurred twice (8 and 18 months after insertion of the prosthesis). In addition, for one patient

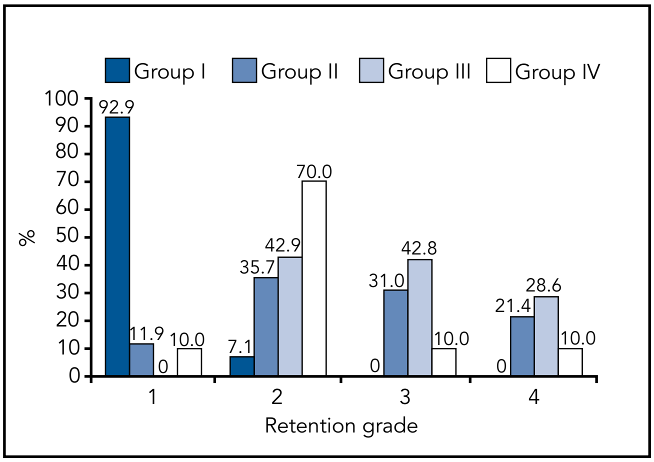


Fig 4 *Retention grades in the study groups.*

in this group, the retentive force of the prosthesis had to be reduced in the first, second, and third month after insertion. However, the higher degree of denture retention was not classified as a defect but rather as a normal property of the prosthesis that should have been addressed with initial adjustment since this finding could not be compared with the excessive retention developing over a longer period of denture life.

Veneer chipping from the secondary crowns and a reduction in denture retention were the most common defects in group II. The distribution of defects in group II was similar to the distribution in the entire study group.

In group III, veneer damage was noted in 71.43% of dentures, a drop in retentive force was found in 57.14%, and primary crown decementation or other defects in 85.7%. Thus, this group demonstrated the highest failure rate, exceeding 100% since the same denture exhibited multiple defects in many cases.

The possibility of primary crown decementation was not taken into consideration regarding the values shown in Fig 3 for group IV. This was done since these dentures were fabricated on titanium abutments screwed into the implants. The remaining types of defects in group IV occurred in a lower percentage than those in groups II and III despite the fact that the secondary crowns were also electroformed and luted onto the denture framework. Veneer defects and a reduction in retentive force were found in 30% and 20% of dentures, respectively, whereas other defects were noted in 10%.

The distribution of retention values in each group is presented in Fig 4. In group I, as many as 92.86% of dentures showed grade 1 retention; the other 7.14% exhibited grade 2 retention. In group II, grade 1 retention was noted in 11.9%, grade 2 in 35.7%, grade 3 in 30.95%, and grade 4 in 21.42% of dentures. In group III, no denture had grade 1 retention, grade 2 was noted in 42.86%, grade 3 in 42.8%, and grade 4 in 28.6% of dentures. In group IV, 70% of dentures showed grade 2 retention, while the remaining 30% exhibiting grades 1, 2, and 3 (10% each).

Discussion

The literature on the use of double crown–retained dentures reports numerous problems related to their endurance. During a long-term follow-up, 11% to 92% of dentures exhibited various defects, eg, veneer chipping or framework cracks.[17,19,20] The results reported are consistent with the findings in this clinical study with respect to mechanical defects that were observed only in dentures with secondary crowns fabricated by electroforming. Depending on the material used for fabrication of the primary crowns (gold alloy or chromium-cobalt alloy), veneer chipping was observed in 42.86% and 71.43%, whereas loss of retention was noted in 30.95% and 57.14% of dentures, respectively. Decementation of the primary crown was more common when a nonprecious alloy was used (57.14%) as compared to a precious one (4.76%). From a clinical point of view, the previous findings are not satisfactory, especially in comparison with the numerically significant (over 20% of cases) group of dentures with primary and secondary crowns fabricated by casting using a precious alloy, in which mechanical defects were not found. This can be explained by the more complicated denture construction when secondary crowns are fabricated by electroforming. In these types of constructions, there may be as many as six layers in the vicinity of the abutment tooth (ie, the primary crown, the secondary crown, glue, denture framework, bonding material, and veneer). With that many layers and junctions, there is a higher risk of errors. The degree of abutment tooth preparation has a great significance as well. To ensure the esthetic outcome of the prosthesis, the preparation has to be more aggressive, which may lead to endodontic complications.[25–27] On the other hand, the dental technician tends to maximize the space for the veneer material at the expanse of the framework thickness to obtain an optimal esthetic effect. This promotes strains that may lead to detachment and cracking of veneers, glue crumbling below the electroformed copings, and, as a consequence of their deformation, loss of adhesion to the primary crowns and detachment of the secondary crowns from the framework. Over time, the framework may crack because of material fatigue, and then the entire denture will need to be refabricated. The rigidity of the framework and secondary crowns also seems to have an indirect effect on the stability of retentive force. The greater rigidity of the secondary crown and the lower vulnerability to lateral load and to the action of the forces operating during nonsymmetric load distribution occurs in the denture on mastication. This hypothesis seems to be confirmed by the observations of dentures in the three study groups in which the secondary crowns were fabricated by electroforming. Their lower resistance to lateral forces (balancing forces) can result in permanent deformations, thus leading to a reduction in the contact area between the crowns and a decrease in retention. However, high rigidity of the cast crowns may also have negative consequences. In the process of wearing the prosthesis and resulting from multiple insertions and removals, dentures gradually "adjust" and the contact surface increases, thus increasing the adhesion interactions that in extreme cases may cause denture impaction. Although this was sporadic in this study group, it can be assumed that with a longer period of functioning of cast crowns, such situations are likely to be more frequent.

In all the dentures in group I, the secondary crowns and frameworks were fabricated as a homogenous cast. Since such a construction consists only of the framework and veneer material, there is only one junction. Although the follow-up period for this group was shorter, within this time of observation, dentures in group I were the least defective.

Worthy of note is the proportional distribution of defects in group IV. Despite the fact that the secondary crowns in group IV were also fabricated by electroforming, such as in groups II and III, defects were much less common. However, group IV contained only dentures supported by implants. This finding was quite surprising because patients with implants usually generate higher masticatory forces than ones with natural dentitions. Further, the majority of opposing arches in this group consisted of implant-retained dentures, which also exert greater loads. A comparison between implant-supported dentures with titanium abutments and tooth-supported dentures shows two basic differences, one of which refers to the abutments (primary crowns). In the case of implants, interarch space is usually greater than that between dentate processes, which is caused by ridge resorption after the loss of teeth. The abutments and thus the primary crowns can therefore be longer. Longer and narrower abutment teeth offer greater retention and stability. Also, the lateral forces released on mastication will demonstrate more favorable distribution along with a decrease in their component, which may have a destructive effect both on the electroformed copings and the glue that fixes them onto the framework. Narrower abutments on implants allow an increase in denture framework thickness, thus making it more rigid without compromising the esthetic outcome. The transverse cross section through the implant abutments is circular or elliptical, and therefore the cone on abutments is more similar to the ideal geometric cone than are the milled primary crowns on teeth. The other difference between dentures supported by implants and teeth is in abutment position. With implants, their position is planned for future prosthetic reconstruction, and in the majority of cases, unfavorable unilateral levers and other biochemically undesirable situations can be avoided, contrary to cases in which only a patient's dentition is involved.

The analysis of this clinical material suggests that cast dentures, although fabricated using older technology, are more reliable. No mechanical defects were found in any of the cast prostheses despite the fact that the majority of dentures were based on implants, which may lead to higher masticatory forces than those on natural dentition. Moreover, both according to the clinician and patients, the retentive force did not decrease over time. The only clinical problems observed in group I were the incidents of denture impaction after a certain period of use and decementation of the primary telescope in one case. From a clinical point of view, this was a minor problem compared to the failures observed in groups II and III, since neither denture repair nor laboratory intervention was needed. However, it may be troublesome for the patient to come for an additional appointment. Denture removal with a crown remover causes a substantial load to the abutments. This can cause decementation of the crown or post in the case of primary crowns fixed on the teeth and to abutment damage in the case of implants. This would explain one incident of primary telescope decementation that occurred in group I. In clinical observations, the dentures with electroformed copings were never found to be impacted. On the contrary, they more frequently exhibited loss of retention. The phenomenon of retention decrease may be explained by permanent deformations of relatively delicate secondary copings.

It seems that the incidence of defects depends on the type of denture construction. Abutment distribution probably does not play a critical role. Comparison of the percentage of defects in groups I and II would be a good example of this (see Fig 2). The percentage of defective dentures in these groups differed significantly (14.2% versus 66.66%, respectively), but abutment positions were similar. In group I, the majority of abutments (71.4%) were Kennedy Class I (for teeth) or between the mental foramena (for implants). Similar abutment distribution was found in 69% of dentures in group II. Despite the fact that dentures replacing bilaterally edentulous arches are exposed to high bending forces during mastication, there were very few defects in group I.

Factors responsible for denture failure varied among the groups. In group I, there was practically no veneer defects or excessive decrease in prosthesis retention, whereas in the other groups, such failures were predominant (electroformed copings). On the other hand, crown impaction was observed in group I but not in the remaining groups. A probable cause of this is the difference in the rigidity of the secondary crowns in group I (thicker and thus more rigid cast crowns) compared to the other groups (relatively thin and thus less rigid electroformed copings) and rigidity of the framework with which the crowns constitute a homogenous unit (group I) or are luted (groups II, III, and IV). Thus, it seems that the cast secondary crowns allow more reliable function of the dentures that they support. However, a 40-month follow-up seemed to demonstrate the advantages of the connections in which the secondary crown was fabricated by electroforming, whereas the milled titanium implant abutment functioned as the primary crown.

Conclusions

Analysis of the clinical material showed the lowest percentage of defective dentures when both the primary and secondary crowns were fabricated by casting using a precious alloy and the secondary crown constituted a homogenous cast with the denture framework. Dentures of this type exhibit the best and most stable retention over time. Dentures with secondary crowns made by electroforming on implants show a far lower defect rate than those fabricated with the same technique on natural teeth. Failures requiring refabrication of the entire prosthesis, such as framework fracture, occurred rarely and only for dentures with electroformed copings on natural dentition.

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