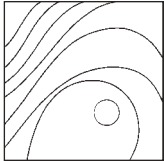


# A Follow-Up Study of up to 5 Years of Metal-Ceramic Crowns in Maxillary Central Incisors for Different Gingival Biotypes



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*The objective of this prospective clinical study was to evaluate the outcomes of metal-ceramic crown restorations in maxillary central incisors for different gingival biotypes in a Chinese population. One hundred single metal-ceramic crowns were fabricated for 100 patients (50 for thin gingival type and 50 for thick gingival type) from April 2007 to October 2007 and evaluated according to the World Dental Federation criteria at baseline and annually at all follow-up examinations for 5 years. Gingival recession was recorded at the same time, as well. The failure-free rate over the 5-year clinical trial for thin gingival type (78.0%) was significantly lower than that for thick gingival type (94.0%;  $P = .02$ ). Seven crowns were ranked as failures because of esthetic problems in patients with a thin gingival type. The restored teeth with a thin gingival type exhibited more gingival recession ( $1.09 \pm 0.22$  mm) than the control teeth ( $0.31 \pm 0.16$  mm;  $P = .01$ ). Gingival biotype had a significant effect on the outcomes of metal-ceramic crown restorations in maxillary central incisors. (Int J Periodontics Restorative Dent 2014;34:e85–e92. doi: 10.11607/prd.2024)*

Although all-ceramic restorations have become increasingly popular for restoring teeth, metal-ceramic crowns are still routinely used for fixed prosthodontics in developing countries because of their relatively esthetic finish and suitable price. The survival rate of metal-ceramic crowns and bridges has been shown to vary in the range of 68% to 83% over periods of 10 to 20 years.<sup>1–6</sup> Regarding survival of single crowns in different areas of the mouth, De Backer et al reported survival rates after 18 years of 80.3% for molars and 78.6% for premolars compared with 76.1% for the anterior teeth.<sup>2</sup> But the outcomes of metal-ceramic crown restorations in specific tooth positions such as the maxillary central incisors have not been demonstrated.

Olsson and Lindhe's report showed that the clinical appearance of healthy periodontal tissues differs from patient to patient in spite of the same tooth position.<sup>7</sup> The bulky, slightly scalloped marginal gingiva with short and wide teeth (Fig 1) on the one hand and the thin, highly scalloped marginal gingiva with slender teeth (Fig 2) on the other may serve to

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**Fig 1** Clinical appearance of thick gingival type.



**Fig 2** Clinical appearance of thin gingival type.

illustrate the existence of markedly different periodontal entities or so-called gingival biotypes.<sup>8</sup> Unlike thick gingiva, thin tissue is highly sensitive to trauma and inflammation and, thus, more susceptible to recession. Differences in gingival and osseous architecture have been shown to exhibit a significant impact on the outcome of restorative therapy.<sup>9</sup> At implant restorations, the gingival biotype has been described as one of the key elements decisive for a successful treatment outcome.<sup>10,11</sup> In particular, presence of a papilla between immediate single-tooth implants and adjacent teeth was significantly correlated with a thick-flat biotype.<sup>12</sup> However, there are few studies that have investigated the outcome of metal-ceramic crown restorations for different gingival biotypes. After tooth preparation, the abutment marginal finish line exhibits some degree of curve. The abutment finish line curvature can change with different gingival biotypes. In the case of thick gingiva,

the abutment finish line shows a gradual curve, whereas in the case of thin gingiva, the abutment finish line shows a sharper curve. This finish line curvature has been demonstrated to have a significant effect on the marginal fit of metal-ceramic crowns.<sup>13,14</sup> Marginal adaptation as well as the mechanical properties of metal-ceramic crowns have been proven to affect the outcome of restorations.<sup>5,6</sup>

The purpose of this prospective clinical study was to evaluate the outcomes of metal-ceramic crown restorations in maxillary central incisors for different gingival biotypes over a 5-year period in a Chinese population.

### Method and materials

From April 2007 to October 2007 at Stomatological Hospital of Tongji University, 100 single metal-ceramic crowns were placed on maxillary central incisors in 100 patients (43 men and 57 women; mean age:

45.2 years; range: 20 to 70 years). The criteria for patient selection were as follows: no significant history of bruxism or clenching of the teeth determined by interviewing the patients, age less than 70 years, no high caries activity (the same natural tooth had not been treated more than twice within the same year), no severe periodontal problems as evaluated by the periodontist (YW; ie, pocket depths  $\leq$  3 mm, no other signs of inflammation), and good oral hygiene (if periodontal status index code was  $>$  3, additional oral hygiene treatment and education were provided before inclusion). All patients were instructed to brush their teeth twice a day with the Bass method. The study protocol was approved by the ethics committee of Tongji University, Shanghai, China. Informed consent was obtained from all participants.

Before prosthodontic treatment, the gingival biotype was evaluated and categorized into thick or thin on a site level. This evaluation was based on the transparency of

the same periodontal probe (PCP UNC 15, Hu-Friedy) through the gingival margin while probing the sulcus at the midfacial aspect of central maxillary incisors.<sup>15</sup> If the outline of the underlying periodontal probe could be seen through the gingiva, it was categorized as thin; if not, it was categorized as thick. There were 50 patients with a thick gingival type and 50 patients with a thin gingival type.

All metal-ceramic crowns were placed by the same prosthodontist (JT). If the abutment teeth were not vital, a successful root canal treatment had to be accomplished at least 6 months before crown insertion. Eighty-two of the restored teeth were nonvital, and the remaining 18 teeth were vital. Twenty-one of the nonvital teeth received an adhesive buildup, 61 were restored with metal posts and cores of Co-Cr alloy (Wirobond C, BEGO). In all cases the peripheral margins of the teeth were prepared 0.5 mm subgingivally in the form of deep chamfers. Impressions were made using polyvinyl siloxane impression materials (Silagum, DMG), and single retraction cords (#1 Ultrapak, Ultradent) were inserted. All crowns were fabricated in the same dental laboratory in accordance with a standard procedure. The copings were casted using Co-Cr alloy (Wirobond C) and veneered with veneering porcelain (Vintage, Shofu). Crowns were cemented with glass-ionomer luting cement (Fuji II LC, GC). The technical functionality of the metal-ceramic crowns was evaluated prior to cementation according to World Dental Federation

(FDI) criteria.<sup>16</sup> Only restorations scoring IR.1 to IR.3 were inserted in the patients' mouths. The restorations deemed unacceptable were remade.

The examinations were prospectively designed at the time of cementation (baseline) and annually for 5 years. The metal-ceramic crowns were examined and rated in accordance with FDI clinical criteria for the evaluation of direct and indirect restorations.<sup>16</sup> The evaluation of restorations was categorized into three groups: esthetic, functional, and biologic criteria. Esthetic criteria were color stability, translucency, and anatomical form. Functional criteria comprised fracture resistance and retention, marginal adaptation, and patient acceptance. Biologic criteria were recurrence of caries, tooth integrity, and periodontal response. Each examination was performed by two clinicians (JC and JS). Evaluators were trained and calibrated with photographs and slides of several typical clinical situations, and they evaluated the crowns independently. If the grading differed between the two evaluators, a final grading was determined after discussion and re-examination. During the examination, evaluators also investigated the gingival recession of restored teeth and contralateral natural central incisors without any restoration (control teeth). The facial gingival recession was calculated by subtracting the clinical crown length at baseline from that measured at each follow-up.<sup>17</sup> The clinical crown length was measured to the closest 0.01 mm using a digital caliper (Absolute Digimatic 500, Mitutoyo).

The failure-free rate was calculated using the Kaplan-Meier method (SPSS version 17.0, SPSS). The gingival recession scores for the restored teeth were compared with those for the control teeth during each follow-up using the Student *t* test.

## Results

### Study group

At the 5-year recall (mean observation time: 63 months; range: 60 to 65 months; SD: 1.8 months), 31 and 40 patients were examined for thin and thick gingival type, respectively. Nine patients with thin gingival type were lost during the recall program at 5 years: Two patients died, five patients relocated too far away to attend recall appointments, and two patients changed their contact address without informing the recall team. Seven patients with thick gingival type were lost during the 5-year follow-up: One patient died, three patients relocated too distantly to attend recall appointments, and three patients changed their contact address without informing the recall team. At baseline (ie, examination prior to cementation), three crowns for thin gingival type were scored IR.5 because of their poor marginal adaptation (gap > 250 μm). These restorations were remade and subsequently scored IR.2.

### FDI criteria and gradings

The single FDI criteria and grades for metal-ceramic crowns with thin

**Table 1 Results of the clinical investigation for metal-ceramic crowns with thin gingival type according to FDI criteria\***

Assessment criteria	Baseline (%) n = 50			1 year (%) n = 48				2 years (%) n = 46				3 years (%) n = 41			
	1	2	3	1	2	3	5	1	2	3	5	1	2	3	5
<b>Esthetic properties</b>															
Color stability and translucency	8.0	24.0	68.0	6.3	22.9	68.7	2.1	6.5	21.7	67.4	4.3	2.4	22.0	70.7	4.9
Anatomical form	18.0	38.0	44.0	18.7	37.5	43.8		17.4	36.9	48.7		17.1	36.6	46.3	
<b>Functional properties</b>															
Fracture resistance and retention	100.0			100.0				100.0				100.0			
Marginal adaptation		18.0	82.0		14.6	85.4			13.0	87.0			12.2	87.8	
Patient satisfaction		36.0	64.0		33.3	64.6	2.1		32.6	63.1	4.3		36.6	58.5	4.9
<b>Biologic properties</b>															
Recurrence of caries	100.0			95.8	4.2			91.3	6.5	2.2		92.7	7.3		
Tooth integrity	100.0			100.0				100.0				100.0			
Periodontal response	20.0	70.0	10.0	4.2	37.5	58.3		4.3	34.8	60.9		4.9	34.1	61.0	

\*1 = excellent, 2 = good, 3 = sufficient, 4 = unsatisfactory, 5 = poor (replacement necessary).

**Table 2 Results of the clinical investigation for metal-ceramic crowns with thick gingival type according to FDI criteria\***

Assessment criteria	Baseline (%) n = 50			1 year (%) n = 48			2 years (%) n = 46			3 years (%) n = 41		
	1	2	3	1	2	3	1	2	3	1	2	3
<b>Esthetic properties</b>												
Color stability and translucency	18.0	48.0	34.0	16.0	50.0	34.0	16.7	50.0	33.3	17.8	48.9	33.3
Anatomical form	32.0	54.0	14.0	34.0	50.0	16.0	33.3	52.1	14.6	31.1	55.6	13.3
<b>Functional properties</b>												
Fracture resistance and retention	100.0			100.0			100.0			100.0		
Marginal adaptation	14.0	58.0	28.0	12.0	56.0	32.0	12.5	52.1	35.4	13.3	53.3	33.4
Patient satisfaction	14.0	54.0	32.0	16.0	50.0	34.0	16.7	54.2	29.1	15.6	48.9	35.5
<b>Biologic properties</b>												
Recurrence of caries	100.0			98.0	2.0		95.8	4.2		95.6	4.4	
Tooth integrity	100.0			100.0			100.0			100.0		
Periodontal response	22.0	66.0	12.0	16.0	56.0	28.0	14.6	54.2	31.3	13.3	51.1	35.6

\*1 = excellent, 2 = good, 3 = sufficient, 4 = unsatisfactory, 5 = poor (replacement necessary).

gingival type are displayed in Table 1. One, two, two, one, and one crowns were recorded as the failures at the 1-, 2-, 3-, 4- and 5-year recalls, respectively, due to esthetic shortcomings. In the criterion of color stability and translucency, these crowns were graded as 5 (poor; replacement necessary) because of a

gingival "black line" (Fig 3), and the patients simultaneously rated the criterion patient satisfaction as 5. At 8 and 38 months, the veneering porcelain of one metal-ceramic crown fractured and was replaced. After 11 months of function, one tooth restored with adhesive buildup fractured. This tooth subsequently was

restored with a metal post and core, and a new metal-ceramic crown was placed. One tooth restored with a metal post and core was extracted because of root fracture at 25 months after cementation. These patients were excluded from further examination, and the crowns were counted as failure events.

4 years (%) n = 35				5 years (%) n = 31			
1	2	3	5	1	2	3	5
2.9	20.0	74.2	2.9	3.2	19.4	74.2	3.2
20.0	42.9	37.1		19.4	41.9	38.7	
100.0			100.0				
	14.3	85.7		12.9	87.1		
	40.0	57.1	2.9	38.7	58.1	3.2	
88.6	8.6	2.8		83.9	9.7	6.4	
100.0			100.0				
5.7	37.1	57.2		3.2	45.2	51.6	



**Fig 3** The right central incisor, restored with a metal-ceramic crown, exhibits a gingival black line.

4 years (%) n = 35			5 years (%) n = 31		
1	2	3	1	2	3
14.3	45.2	40.5	15.0	45.0	40.0
35.7	52.4	11.9	32.5	50.0	17.5
100.0			100.0		
11.9	54.8	33.3	12.5	55.0	32.5
16.7	50.0	33.3	17.5	50.0	32.5
92.9	4.8	2.3	90.0	5.0	5.0
100.0			100.0		
14.3	52.4	33.3	15.0	50.0	35.0



**Fig 4** The metal-ceramic crown placed on the left central incisor shows porcelain fracture.

The results of the clinical investigation for metal-ceramic crowns with thick gingival type according to FDI criteria are showed in Table 2. One crown was replaced because of porcelain fracture after 15 months of function (Fig 4). At 28 and 39 months, one abutment tooth showed root fracture and was extracted.

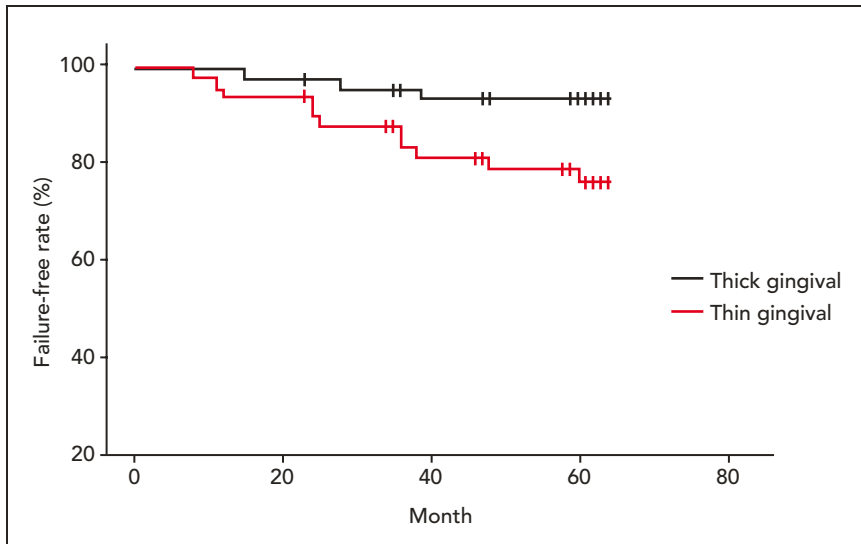
*Kaplan-Meier analysis*

The failure-free rate of the metal-ceramic crowns was 78.0% and 94.0% for thin and thick gingival types, respectively, up to 65 months of function (Fig 5). Log-rank test showed significant difference in equality of failure-free

distributions between the different gingival types ( $P = .02$ ).

*Gingival recession*

The mean gingival recession scores for metal-ceramic crowns and control teeth at baseline and at the 1-,



**Fig 5** Failure-free rates of the metal-ceramic crowns as determined by Kaplan-Meier analysis.

**Table 3** Mean (SD) gingival recession scores at metal-ceramic crowns and control teeth at each evaluation (mm)

	1 year	2 years	3 years	4 years	5 years
<b>Thin gingiva</b>					
Crowns	0.19 (0.12)*	0.28 (0.15)*	0.59 (0.21)*	0.84 (0.23)*	1.09 (0.22)*
Teeth	0.08 (0.06)	0.13 (0.08)	0.21 (0.11)	0.25 (0.13)	0.31 (0.16)
<b>Thick gingiva</b>					
Crowns	0.08 (0.05)	0.11 (0.10)	0.17 (0.13)	0.23 (0.21)	0.31 (0.21)
Teeth	0.07 (0.04)	0.09 (0.08)	0.13 (0.10)	0.19 (0.14)	0.24 (0.17)

\* $P < .05$ .



**Fig 6** The right central incisor, restored with a metal-ceramic crown, exhibits gingival recession.

2-, 3-, 4-, and 5-year evaluations are shown in Table 3. Regardless of gingival type, the score of gingival recession tended to be higher in restored teeth with metal-ceramic crowns than in control teeth. How-

ever, significant difference ( $P < .05$ ) in the gingival recession between crowned and control teeth was observed only for the thin gingival type (Fig 6) at each follow-up examination.

## Discussion

The goal of this present study was to investigate the effect of gingival biotype on the outcomes of metal-ceramic crown restorations. Other variables, such as restoration types and crown position, needed to be eliminated to the extent possible; therefore, only the single metal ceramic crown restorations in central incisors were evaluated. The associated crowns and partial dentures were excluded from this study.

In 2007, new clinical criteria for the evaluation of restorations were published in *Clinical Oral Investigations*.<sup>16</sup> The criteria and grading were proved by the Science Committee of the FDI in 2007 as standard criteria that should be applied when restorative materials and operative techniques are to be clinically investigated. In July 2008, a tool called e-calib (electronic calibration) was made available on the Internet to facilitate both training and calibration of the new FDI criteria. In 2010, the updated FDI criteria were published in the *Journal of Adhesive Dentistry*.<sup>18</sup> Because this study began in 2007, the FDI criteria of 2007 were applied in the present study, and evaluators were trained with photographs of several typical clinical situations instead of using e-calib.

There are many factors, such as porcelain firing shrinkage and substructure design, that affect the marginal fit of metal-ceramic crowns.<sup>19</sup> From Tao et al's study,<sup>13,14</sup> the finish line curvature also has been demonstrated to have a significant effect on the marginal fit of metal-ceramic

crowns. The greater the finish line curvature, the larger the labial marginal gap became. Further, the greater the finish line curvature, the more difficult the tooth preparation and the creation of the impression in the marginal area. For thin gingival types, the crowns with sharply curved finish lines more often lead to poorly fitting margins that may incite gingivitis. Unlike thick gingiva, thin tissue is highly sensitive to trauma and inflammation and, thus, more susceptible to recession.<sup>7</sup> In addition, thin gingival tissue tends to be delicate and almost translucent in appearance, contributing to an undesirable visibility of metal copings through the tissue, causing a grayish appearance at the gingival margin.<sup>20</sup> As a result, most failed crowns for thin gingival types were recorded because of an esthetic problem, especially a gingival black line and gingival recession. However, no crown was recorded as a failure because of an esthetic problem for thick gingival types. This explains why the failure-free rate of the metal-ceramic crowns was significantly lower for thin than for thick gingival types.

The failure-free rate over the 5-year clinical trial was 78.0% and 94.0% for thin and thick gingival types, respectively. This result could not be compared with earlier data because few studies had evaluated the successful treatment outcomes of single metal-ceramic crowns in maxillary central incisors. De Backer et al reported survival rates after 18 years of 76.1% for the anterior teeth compared with 80.3% for molars.<sup>2</sup> However, this

study did not investigate the survival rates at specific tooth positions such as central incisors and the effect of gingival biotype.

Compared with the thick gingival type, a lower percentage of crowns were rated as excellent for the thin gingival type during a period of 5 years, not only in the marginal adaptation criterion, but also in color stability and translucency and anatomical form. The teeth with thin gingival type often exhibit longer and more slender clinical crowns compared with those with thick gingival type. In daily practice, the longer the clinical crown, the more difficult the tooth preparation becomes and the more often the undercut or insufficient reduction in labial surface is created. If these factors are taken into account, the metal-ceramic crowns with thin gingival type more often lead to poor form and color.

Gingival recession was measured over the 5-year period in relation to the clinical crown length. The crown length might have changed owing to physiologic changes over time such as grinding, which might limit the accuracy of the performed measurements. For this reason, the contralateral natural central incisors were used as control teeth. Because thin gingiva is highly sensitive to trauma and more susceptible to recession than thick gingiva,<sup>8</sup> in order to eliminate the effect of impression techniques on gingival recession, the single retraction cord was applied for both gingival types; furthermore, the baseline clinical crown length was measured

after the metal-ceramic crown was cemented. Due to thin gingiva being more sensitive to inflammation and a poorer marginal fit of a metal-ceramic crown<sup>6,13</sup> compared with a thick gingival type, the restored teeth with a thin gingival type exhibited more gingival recession than the control teeth. This result was similar to the results of implant restorations reported by Evans and Chen.<sup>21</sup> A trend toward more gingival recession at immediate single-tooth implant restorations in patients with a thin-scalloped biotype was described. Gingival biotype had a significant effect on survival rate of the immediate single-tooth implant restorations.

This study investigated the outcomes of metal-ceramic crown restorations over a 5-year period. It has been shown that survival may decrease more sharply after 10 years, which could partly be explained by fatigue in the materials used, such as metal alloys, porcelain, and cement.<sup>2,6</sup> Biologic factors, retainer loosening, and recurrent caries can also decrease survival after 10 years. Therefore, the outcome of metal-ceramic crown restorations over a 10-year period for different gingival biotypes should be further investigated.

Tao and Han reported that the abutment finish line curvature had no significant effect on the marginal fit of all-ceramic crowns.<sup>14</sup> In the situation of the sharply curved finish line, all-ceramic computer-aided design/computer-assisted manufacture crowns should be suggested for use to improve the labial and lingual

marginal fit. Further study is needed to investigate the effect of gingival type on the treatment outcome of all-ceramic crowns.

## Conclusions

Gingival biotype had a significant effect on the outcomes of metal-ceramic crown restorations in maxillary central incisors. The failure-free rate of metal-ceramic crowns over the 5-year clinical trial for thin gingival type was significantly lower than that for thick gingival type.

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