



Precision of the milled full-arch framework fabricated using pre-sintered soft alloy: A pilot study

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PURPOSE. This study aimed to evaluate the marginal discrepancy of full-arch frameworks in implant-supported prostheses fabricated using pre-sintered soft alloy (PSA). **MATERIALS AND METHODS.** Full-arch metal frameworks were fabricated on the edentulous implant model using casting alloy (CA), fully-sintered hard alloy (FHA), and PSA (n = 4 in each group). To evaluate the misfit of the framework to the abutments, the absolute marginal discrepancy (AMD) values of the frameworks were measured in cross-sectional images that had been drawn as part of the triple-scan protocol. The AMD values were compared among the tested alloy groups using the Kruskal-Wallis test, with a post hoc Mann-Whitney U test ($\alpha=.05$). **RESULTS.** The FHA and PSA groups showed lower marginal discrepancies than the CA group ($P<.001$). However, the FHA group did not differ significantly from the PSA group. **CONCLUSION.** Soft alloy milling is comparable to hard alloy milling, and it is more precise than casting in terms of the marginal fit of implant-supported, full-arch prostheses. [*J Adv Prosthodont 2018;10:128-31*]

KEYWORDS: Precision; Full arch framework; Pre-sintered soft alloy; Marginal discrepancy; Triple scan technique

INTRODUCTION

The passive fit of a framework is an important prerequisite for the long-term success of implant-supported dental prosthesis.¹ The production of a passively-fitting full-arch framework for several implants is challenging because the implants do not tolerate movement due to the absent of a periodontal ligament.^{2,3} The misfit of the prosthesis to the abutment may cause biological or technical failures, such as soft tissue irritation, crestal bone loss, screw loosening, and

fracture.^{4,5}

One-piece casting using a casting alloy (CA) is considered the technique of choice for fabricating full-arch frameworks for implant prostheses because the method produces a stable and homogenous structure.⁶⁻⁸ When the framework does not fit passively, it can be segmented and reconnected by soldering or laser welding. However, adjustments are time-consuming and disrupt the homogeneity of the framework, and may result in new errors of adaptation.⁹ With the development of computerized technology, milling techniques can be used as an alternative for making the framework.¹⁰⁻¹² The milling process is less technique-sensitive and there is a decreased need for subsequent adjustment. However, when a fully sintered hard alloy (FHA) is used, the technique can be associated with rapid abrasions inflicted onto the milling bur, as well as long milling times.¹¹ To overcome these limitations of FHA, pre-sintered soft alloys (PSAs) have recently been developed.¹³ Soft-block milling and subsequent sintering associated with PSAs facilitate the fabrication of milled prostheses. The fit of single crown made from a PSA has been reported to be clinically acceptable.^{14,15}

Prosthesis misfits have been evaluated using various methods. Mechanical sectioning allows direct measurement of misfits, involving cross sectioning of the final restoration

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on the abutment and observation of the fit discrepancy using a microscope.¹⁶ The replica technique uses silicone replicas of the space between the intaglio of the restoration and outer abutment surface to measure the fit discrepancy.¹⁷ Microcomputed tomography can be used to visualize and measure the misfit of the restoration by making multiple projections of the restoration and reconstructing the projections with dedicated software.¹⁸ As a mathematical method, the mean internal gap can be calculated by applying the weight technique that uses the surface area of the abutment, and the weight and density of the silicone material.^{19,20} Prosthesis misfit can also be assessed by analyzing the resulting stress distribution induced to an underlying solid model when fitting the prosthesis on the abutments.²¹ Currently, the computer-aided digital approach allows for three-dimensional visualization of the space between the restoration and abutment, and facilitates various geometric analyses.²² This method includes digital scanning of objects, superimposition of images, and discrepancy measurement in specialized software.²³

The present study aimed to evaluate the marginal discrepancy of the full-arch framework in implant-supported prostheses fabricated using PSA. The marginal discrepancy was measured using 3-dimensional analyses and compared between CA and FHA. The null hypothesis was that there was no difference in the marginal discrepancy between the fabrication systems.

MATERIALS AND METHODS

The overall study procedure is described in Figure 1. The edentulous study model with 4 implants (USII, Osstem, Seoul, Korea) placed in the canine and 2nd premolar areas was prepared. Four prosthetic implant abutments (Freeform ST, Osstem, Seoul, Korea) were connected to each implant. In this study model, 12 implant-supported bar frameworks were fabricated using the different systems (CA, FHA, and PSA, $n = 4$ in each group) (Fig. 2). In the CA group, wax framework patterns were made and subsequently cast using a non-precious metal alloy (4-all, Ivoclar Vivadent, Schaan, Liechtenstein). In the FHA and PSA groups, the study model was scanned using a desktop scanner (Ceramill Map 400, Amann Girrbach, Koblach, Austria) and the bar framework was designed using dental software (Ceramill Mind, Amann Girrbach). In the FHA group, the metal frameworks were processed using solid metal blocks (M3, Medipion, Daejeon, Korea), whereas in the PSA group, they were processed using soft metal blocks (Ceramill Sintron, Amann Girrbach). Subsequently, the frameworks were sintered in an argon gas atmosphere at 1300°C in a sintering furnace (Ceramill Argotherm, Amann Girrbach). All the fabrication procedures for each group were performed according to the manufacturer's instructions.

Marginal discrepancy was evaluated using the triple-scan protocol (Fig. 3).²⁴ The first scan was of the study model alone, the second was of the fabricated frameworks alone, and the third was of the framework placed on the abut-

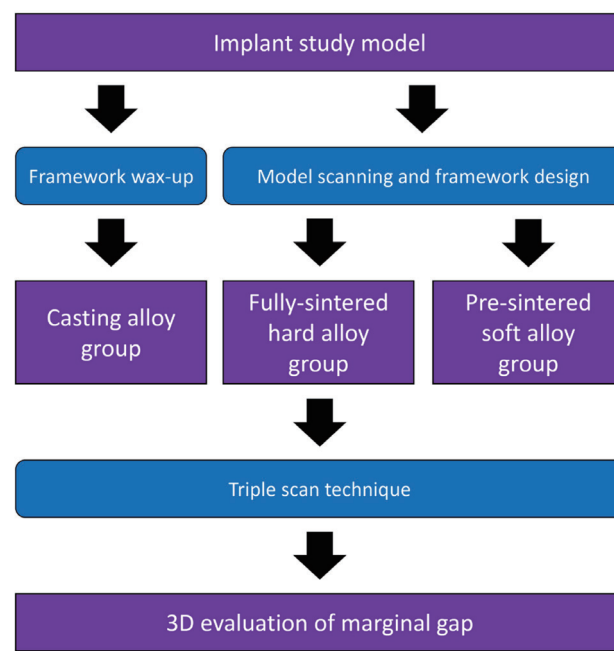


Fig. 1. Workflow of study.

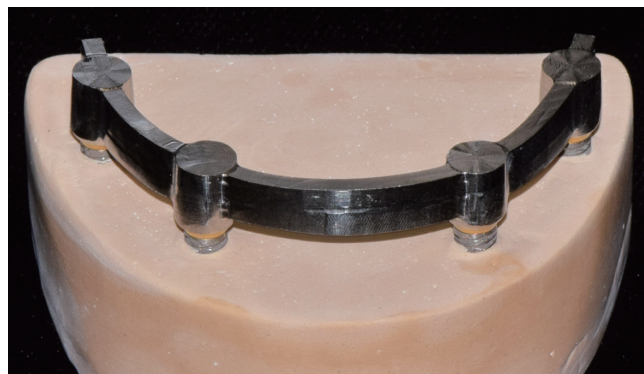


Fig. 2. Study model with implant-supported bar framework.

ments with the fixation at the right premolar part. The framework was fixed by one terminal abutment to expose the discrepancies of the opposite terminal abutment. All digitization was completed using a 3D scanner (Breuckmann SmartScan, AICON 3D Systems GmbH, Braunschweig, Germany) with a homogenous measuring-point distance of 5 μm , according to the manufacturer's instructions. The scan datasets were exported in surface tessellation language format to an image analysis software (Geomagic DesignX, 3D Systems, Rock Hill, SC, USA), where the first and second scan images were superimposed to the third scan image using an area-designated best-fit algorithm. After the superimposition process, the third scan image was deleted. The cross-sectional images were obtained at the left premolar abutment bucco-lingually and mesio-distally. Absolute marginal discrepancy (AMD) values, the distance between the most external points of the crown margin and the abutment

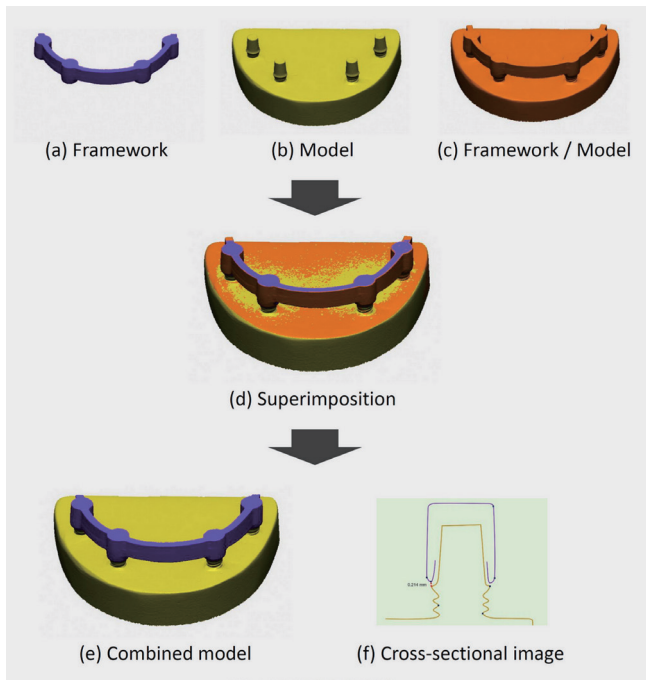


Fig. 3. Triple-scan technique of the marginal fit analysis. The framework image (a) and model image (b) are aligned with the framework/model image (c) to superimpose the images (d). The cross-sectional image (f) is obtained by virtual sectioning of the combined model (e).

finish line, were measured at the margins of the buccal, lingual, mesial, and distal regions. The triple-scan protocol and misfit measurements were performed by one trained investigator.

The AMD values were compared among the groups using the Kruskal-Wallis test, with a post hoc Mann-Whitney U test and Bonferroni correction. The significance level was set at .05.

RESULTS

Table 1 lists the AMD values at each measurement point in the three groups. The FHA group showed the lowest mean discrepancy, followed by the PSA and CA groups (Fig. 4). The FHA and PSA groups showed no significant difference; however, the CA group was significantly different from the other groups ($P < .001$). The standard deviation of the data from the FHA and PSA groups was lower than that of the CA group.

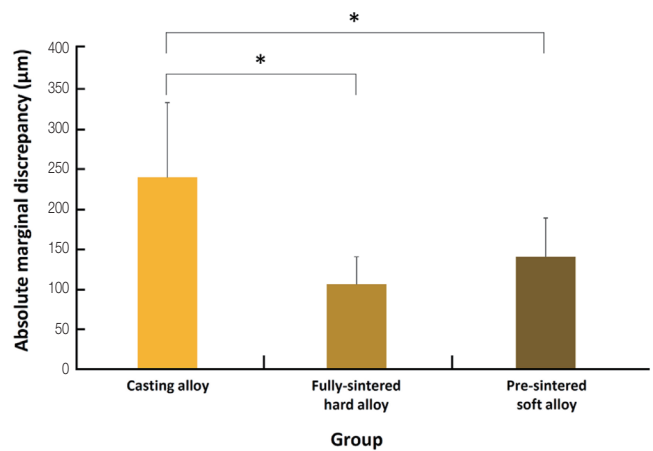


Fig. 4. Overall absolute marginal discrepancy in the three groups. *Significant difference.

DISCUSSION

This study was designed to investigate the marginal fit of the full-arch framework fabricated using the soft-metal milling method. The results from the PSA group were comparable to those from the FHA group and both groups presented a smaller discrepancy in marginal fit than the CA group; thus, the null hypothesis was rejected. The results of this study corresponded well with those found in an earlier marginal fit study, in which the milling method showed higher framework accuracy than the casting method.^{25,26} Meanwhile, Part *et al.*¹⁴ reported that single restorations made using soft alloy had a higher fit accuracy than those made using hard alloy. This finding conflicts with the results of the present investigation, perhaps because the size of the tested frameworks differed among the studies.¹⁸ Therefore, it may be that the effect of PSA use differs according to the framework size.

The triple-scan protocol was utilized in this study to measure the AMD. Digital measurement tools visualize restoration misfits 3-dimensionally, enabling further geometric analyses, such as color-coded discrepancy distribution and volume calculation of specific regions.^{23,27} For this reason, further experiments using various 3-dimensional analyses are recommended. Clinical studies on the fit accuracy of the full-arch frameworks fabricated using PSA are also needed to confirm the results of the present study.

Table 1. Mean and standard deviation of absolute marginal discrepancy at the various measurement points

	Buccal	Lingual	Mesial	Distal
Casting alloy	366.3 ± 67.7	137.7 ± 34.2	239.5 ± 20.5	216.2 ± 35.3
Fully-sintered hard alloy	144.4 ± 21.0	114.3 ± 14.9	60.1 ± 3.3	107.3 ± 19.6
Pre-sintered soft alloy	105.8 ± 26.7	189.6 ± 57.9	112.2 ± 10.9	155.5 ± 42.6

CONCLUSION

With the limitations of this *in vitro* pilot study, the full-arch frameworks fabricated using soft-alloy milling exhibited a marginal accuracy that was equivalent to those fabricated using hard-alloy milling. Soft-alloy milling is an alternative to hard alloy milling and casting.

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