Original Article

Effect of the scanning powder on the accuracy of the digital scanning process

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Abstract

Purpose: *The purpose of this study was to examine the effect of the scanning powder on the scanning accuracy result.*

Materials and methods: *Forty gypsum blocks (size: 6cm x 2cm x 2cm) were scanned by a 3Shape D900 desktop scanner before and after scanning powder sprayed with 3M High-Resolution Sprayer. Powder spraying was performed with different spraying time spans (1 sec, 3 sec, 5 sec, 7 sec). The STL files were then superimposed with analyzing software (Geomagic Control) to compare the thickness and the covering area.*

Results: *The mean thickness of the spraying powder for each spraying time group was 8.9 μm (SD ±1.5 μm) for 1 sec, 10.0 μm (SD ±2.2 μm) for 3 sec, 13.9 μm (SD ±3.5 μm) for 5 sec, and 13.3 μm (SD ±3.1 μm) for 7 sec. As for the mean area proportion for each spraying time group was 2.94% (SD ±1.32%) for 1 sec, 5.07% (SD ±2.76%) for 3 sec, 8.37% (SD ±3.35%) for 5 sec, and 8.65% (SD ±3.01%) for 7 sec.*

Conclusion: *Based on the findings of this investigation, both powder thickness and powder spraying covering area increased with a longer spraying time. The thickness of the powder ranged from 8.9 μm to 13.9 μm under reasonable spraying time, which may influence the scanning accuracy, though it is clinically acceptable.*

Key words: Accuracy, intraoral scanner, scanning powder

Introduction

Computer-aided design (CAD) and computer-aided manufacturing (CAM) has been incorporated into our daily dental works for several years. With the convenience of the CAD/CAM technology, patient's model may compose both examination and final prosthesis designs so as towards the completion of designated treatment plan, such measure may occur through outputting contrasting restorations in result of additive or subtractive manufacturing. The first article related to dental CAD/CAM technology was published by a French dentist Dr. Francois Duret in 1973[1].

The whole CAD/CAM system is composed of three elements, including (1) data acquisition unit (2) designing software

(3) computerized manufacturing device. Data acquisition digitizes patient's dentition or other information into the virtual environment. Dentists and dental technicians can then manipulate such data in a designing software. Actual interior condition of dentation can be simulate by the designing software follow by proper assessment treatment plan. Finally, the design can be performed through the manufacturing device[2].

Optical scanner is one of the data acquisition units used in dentistry, including the intraoral and desktop scanners. Scanning accuracy could vary by surface property of the scanned objects, camera projecting light wavelength and familiarly algorithm calculation data, due to optical scanning characteristics. Powder-free type intraoral scanners are getting popular in recent years, thereby face difficulties in optical properties caused by various oral environment factors (saliva, blood, translucent surfaces, metallic surfaces, etc.), accordingly surface property of the scanned object may affect the light reflected from the surface and cause errors of the scanning results[3,4]. It is suggested that a thin layer of scanning powder, titanium dioxide particles apply to the surface of the scanned object before scanning process can reduce the scanning error and increase the efficiency of the scanning in most cases[3,5]. However, the manufacturer (3M Seefeld, Deutschland) states that the layer should be as thin as possible since application distances and times may result in different thicknesses of the coating layer, which can cause scan errors.

The purpose of this study was to determine the effect of the spraying powder on the accuracy of digital impression and investigate the relationship between spraying time, thickness and covering area of the spraying powder applied.

Materials and methods

Forty type III yellow gypsum blocks (size: 6cm x 2cm x 2cm) were used as the testing samples. A reference scan was proceed with a desktop scanner (3Shape D900; 3Shape A/S) for each testing block before the standardized powder spraying procedure. The testing blocks were divided into four groups according to the spraying time, and each group included 10 testing blocks (n=10). With a spraying machine (3M High-Resolution Sprayer, 3M ESPE, Seefeld, Deutschland), High-Resolution Scanning Spray Powder (3M ESPE, Seefeld, Deutschland) was applied to each testing blocks under a different spraying time (1 sec, 3 sec, 5 sec, 7 sec). A standardized powder spraying procedure was prepared at the distance (2.5 cm) recommended by the manufacturer (Fig.1, Fig.2). A time limit relay was connected to the powder spraying machine to control the different powder spraying time (Fig.3). After the powder spraying, a test scan was performed with the 3Shape D900 desktop scanner for each testing block (Fig.4). The STL files of reference scan and test scan of each testing block were imported into the software (Geomagic Control X, 3D systems, Rock Hill, SC, USA) and superimposed through best fit algorithm, for analyzing the thickness and the percentage of powder covering area (Fig.5, Fig.6). The percentage of powder covering area was calculated by dividing powder covering area by superimposed area. Statistical analyses were performed with descriptive statistics and Pearson correlation.

Results

The mean thickness of the spraying powder for each spraying time group : 8.9 μm (SD ±1.5 μm) for 1 sec, 10.0 μm (SD ±2.2 μm) for 3 sec, 13.9 μm(SD

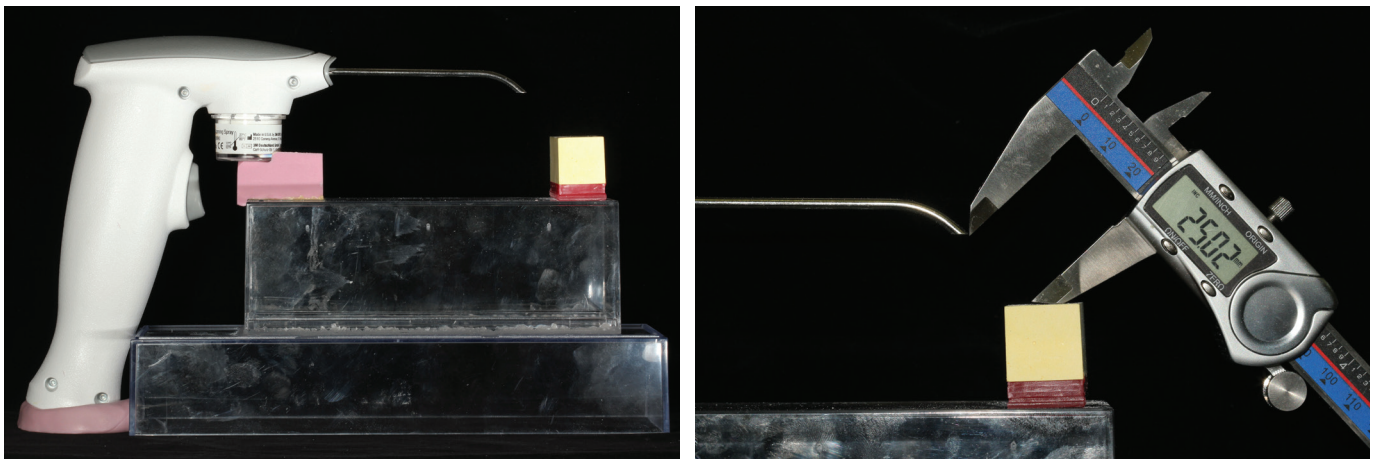

Figure 1. Standardized spraying distance and angle of a powder spraying device

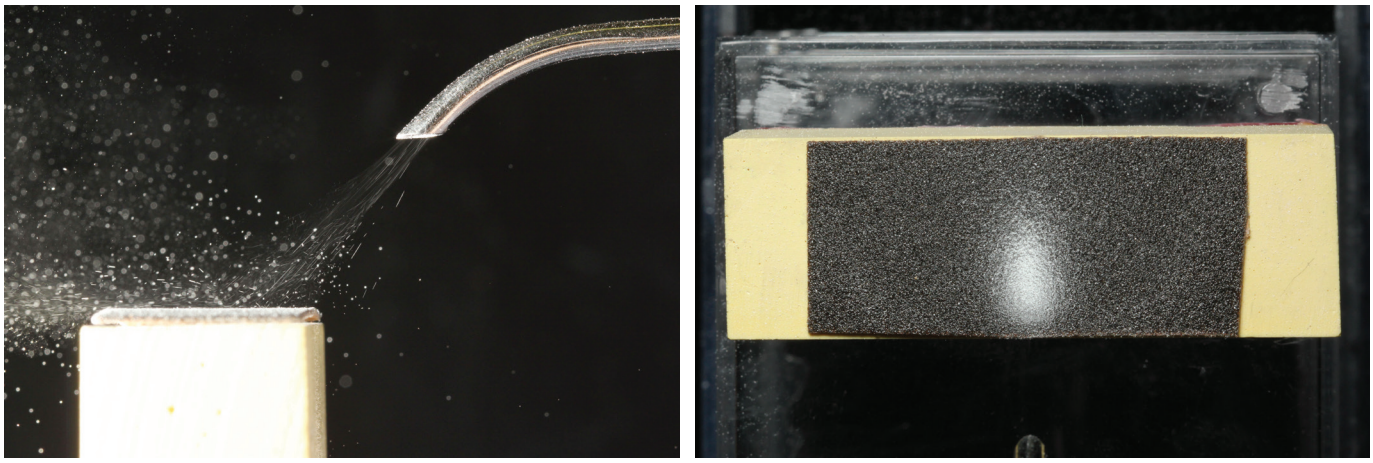

Figure 2. Standardized spraying with a powder spraying device

Figure 3. Time limit relay connected to the powder spraying machine

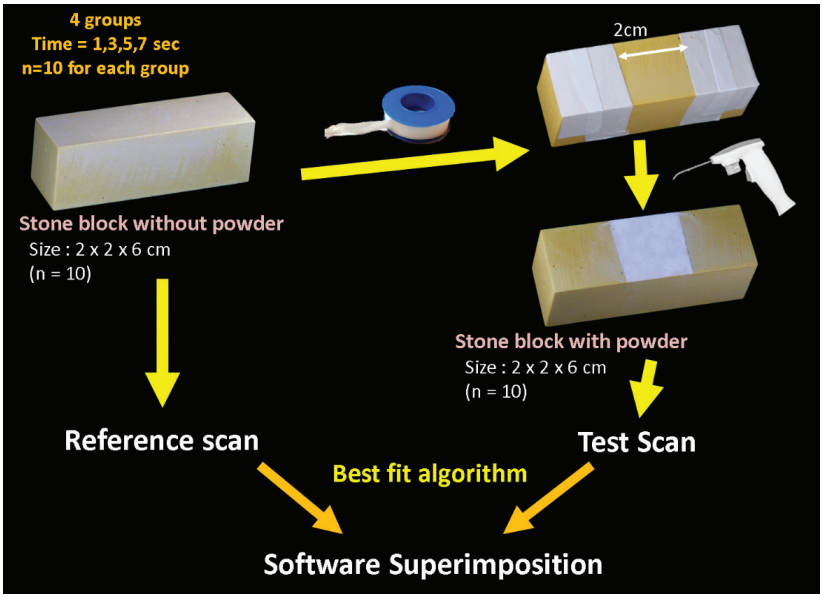

Figure 4. Overview of the experiment workflow

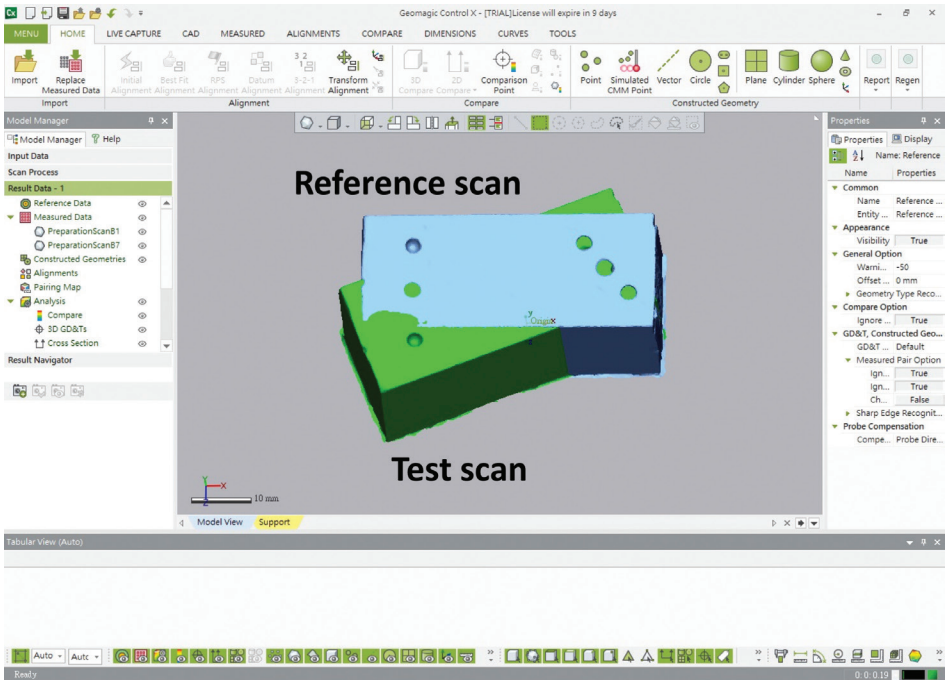

Figure 5. Superimposition of the reference scan and the test scan

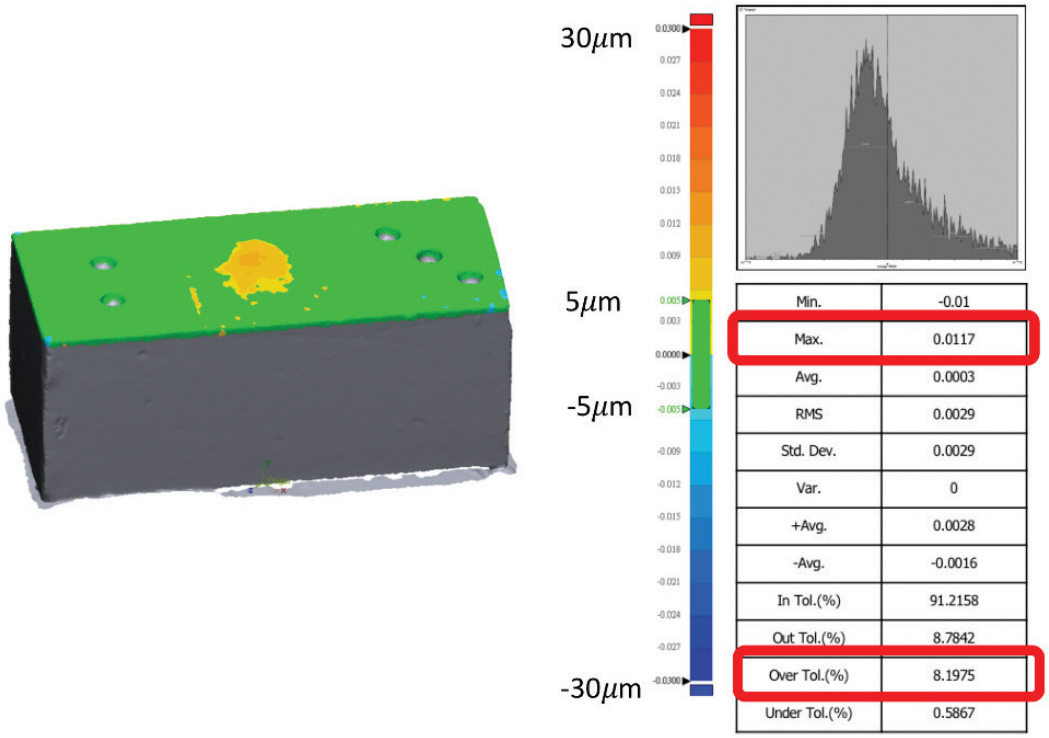

Figure 6. Best fit algorithm performed by the software (Geomagic® Control)

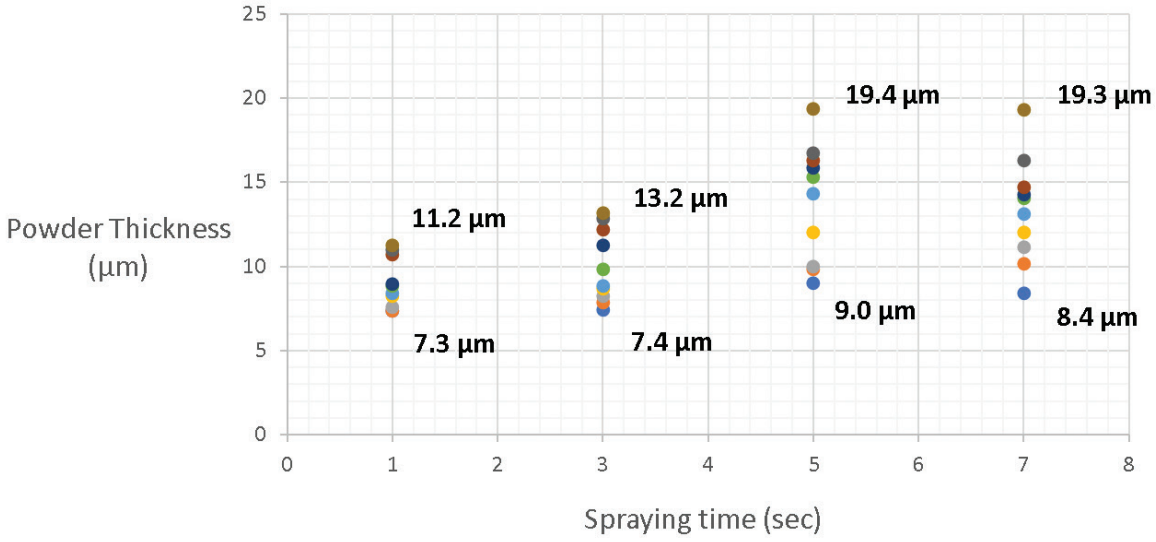

Figure 7. Powder thickness / Spraying time relation char

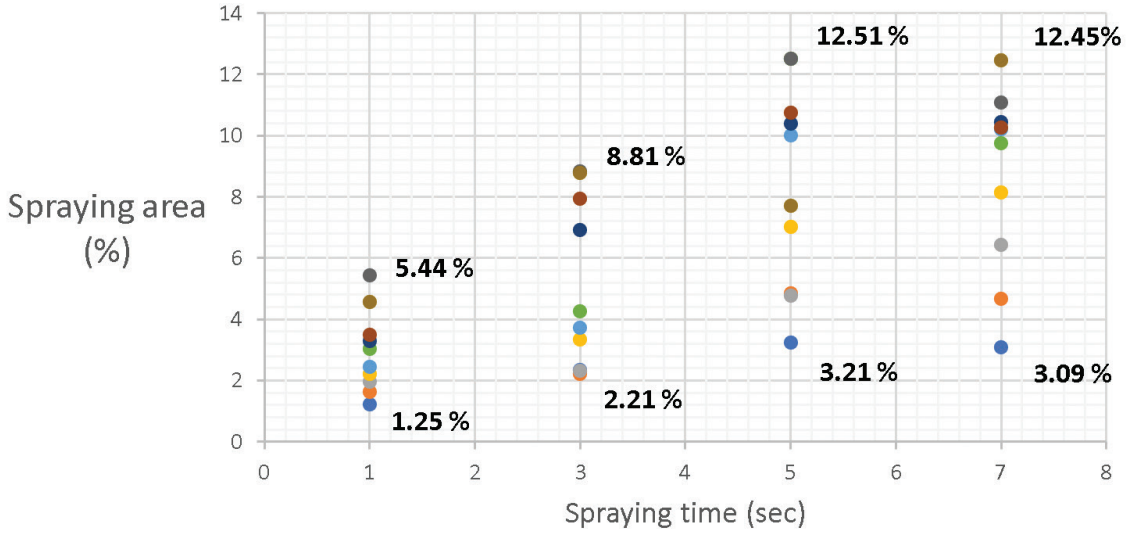

Figure 8. Spraying area/Spraying time relation chart

±3.5 μm) for 5 sec and 13.3 μm (SD ±3.1 μm) for 7 sec. The mean area proportion of the spraying powder for each spraying time group: 2.94% (SD ±1.32%) for 1 sec, 5.07% (SD ±2.76%) for 3 sec, 8.37% (SD ±3.35%) for 5 sec and 8.65% (SD ±3.01%) for 7 sec. (Fig.7, Fig.8). The Pearson correlation coefficient of the spraying time and the powder thickness was 0.576, indicating moderately correlated; The Pearson correlation coefficient of the spraying time and the powder area was 0.651, indicating moderately correlated; The Pearson correlation coefficient of the powder area and the powder thickness was 0.919, indicating highly correlated (Table 1).

Table 1. Pearson correlation of spraying time / area / heigh

Correlations				
		Time	Area	Height
Time	Pearson Correlation	1	.651**	.576**
	sig. (2-tailed)		<.001	<.001
	N	40	40	40
Area	Pearson Correlation	.651**	1	.919**
	sig. (2-tailed)	<.001		<.001
	N	40	40	40
Height	Pearson Correlation	.576**	.919**	1
	sig. (2-tailed)	<.001	<.001	
	N	40	40	40

**.Correlation is significant at the 0.01 level (2-tailed).

Discussion

Most of the intraoral scanners do not need powder spraying before intraoral scanning[2,6]. In some special situations, especially scanning the metal or highly polished surface, spraying the scanning powder can homogenize the surface property, therefore the light reflected from the surface can be more easily captured by the camera[7-9]. Some factors might influence the accuracy of the scanning results; e.g. the spraying powder is not evenly distributed, the spraying powder is contaminated by the saliva, and the thickness of the spraying powder may influence the scanning results[3].

According to a previous study, the thickness of the scanning powder may reach from 20 to 40 μm[7]. In our study, the thickness of the scanning powder was ranged from 8.9μm to 13.3μm, under difference spraying time groups. However, our study might underestimate the powder thickness by spraying powder on a flat and dry surface. There was no reference indicated how thick the spraying powder should be applied to achieve an adequate scanning condition, so the dentists can only judge the thickness by the color change of the surface. The powder spraying machine used in this study is driven by a motor, which produced an air-flow through a spraying tube and brought out the spraying powder. The longer the machine sprayed, more amount of spraying powder was out. That can explain the result from our study, the powder thickness was positive correlative to the spraying time.

In our study, the spraying covering area was also positively correlated with the spraying time. The spraying powder may cover more area as the spraying time increased. The standardized spraying device set up in our study target only a spot on the gypsum block to perform the powder spraying, but the powder still could float through the air and extended to the surrounding area, so the spraying covering area increased when the spraying time increased. Dentists usually judge whether scanning powder is adequately sprayed by the change of opacity above the teeth. Thus, we also performed the powder spraying on an artificial tooth with different spraying time, try to imitate the different appearance which may be caused by spraying the powder on a tooth (Fig.9). It was found that the appearances of 1 sec to 3 sec spraying are close to what would be judged as an adequate spray, thus the powder thickness would be around 10 μm according to the observations of this study.

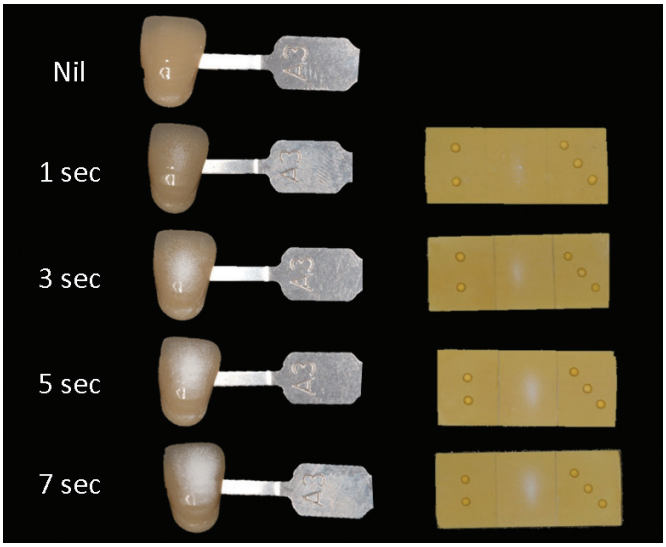

Figure 9. Powder display on artificial teeth and gypsum block for each spraying time group

Conclusions

Based on the finding of this investigation, both powder thickness and powder spraying covering area increased with longer powder spraying time. The thickness of the powder ranged from 8.9 μm to 13.9 μm under reasonable spraying time. The thickness of the powder may influence the scanning accuracy, but it is clinical acceptable.

References

1. Duret F, Blouin JL, Duret B. CAD-CAM in dentistry. J Am Dent Assoc 1988;117:715-20.
2. Alghazzawi TF. Advancements in CAD/CAM technology: Options for practical implementation. J Prosthodont Res 2016;60:72-84.
3. Kurz M, Attin T, Mehl A. Influence of material surface on the scanning error of a powder-free 3D measuring system. Clin Oral Investig 2015;19:2035-43.
4. Li H, Lyu P, Wang Y, Sun Y. Influence of object translucency on the scanning accuracy of a powder-free intraoral scanner: A laboratory study. J Prosthet Dent 2017;117:93-101.
5. Oh HS, Lim YJ, Kim B, Kim MJ, Kwon HB, Baek YW. Influence of scanning-aid materials on the accuracy and time efficiency of intraoral scanners for full-arch digital scanning: An in vitro study. Materials 2021;14:2340.
6. Su TS, Sun J. Intraoral digital impression technique: A review. J Prosthodont 2015;24:313-21.
7. Richert R, Goujat A, Venet L, Viguie G, Viennot S, Robinson P, Farges JC, Fages M, Ducret M. Intraoral scanner technologies: A review to make a successful impression. J Healthc Eng 2017;12:1-9.
8. Hack GD, Patzelt SBM. Evaluation of the accuracy of six intraoral scanning. J Am Dent Assoc 2015;10:1-5
9. Patzelt SB, Lamprinos C, Stampf S, Att W. The time efficiency of intraoral scanners: An in vitro comparative study. J Am Dent Assoc 2014;145:542-51.