3D Digital Evaluation for Direct Composite Restoration Using the Modified Stamp Technique

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Objective: *To evaluate the clinical performance of direct composite restorations using the modified stamp technique (MST) in vivo.*
Methods: *A total of 30 posterior teeth with undermining caries were randomly divided into two groups and then restored using the MST and conventional technique (CT), respectively. 3D images of the occlusal surface were obtained using an intraoral scanner (CEREC Omnicam, Dentsply Sirona, Charlotte, NC, USA) before and after treatment and the differences between these two 3D images were analysed with reverse engineering software. Statistical analysis was performed using a one-way analysis of variance (ANOVA) combined with a least significant difference (LSD) post hoc test using SPSS 20.0 software (IBM, Armonk, NY, USA).*
Results: *The statistical analysis revealed that the average root mean square (RMS) values of best fit alignment errors were significantly different between groups ($P < 0.01$). The average RMS values in the MST and CT groups were 0.0738 ± 0.0279 and 0.1638 ± 0.0682, respectively. The LSD post hoc test revealed that the value was significant smaller in the MST group than in the CT group.*
Conclusion: *The MST was effective in direct composite restoration. The morphological consistency of the occlusal surface using the MST was better than with the CT.*
Key words: *caries, conventional technique, direct composite restorations, modified stamp technique*
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Biomimetics is the main aim of dental restorative treatments, as dental practitioners commit to restoring the natural contour and function of the original tooth. It is important to achieve a harmonious occlusal and cusp–fossa relationship in posterior tooth cavity restoration. This goes beyond aesthetic considerations and functional requirements; however, rebuilding tooth morphology using a direct composite restoration technique is difficult, especially for dental students or residents, and requires experience and time.

To solve these problems, the stamp technique for direct composite restoration was introduced. In the posterior teeth, occlusal caries lesions may progress into the dentine without this resulting in macroscopic breakdown of the enamel surface[1]. In such cases, use of the stamp technique has been reported[2-6]. Flowable composite resin is used to form an occlusal stamp to capture the original occlusal anatomy prior to tooth preparation. After cavity preparation, the composite resin is placed as usual. Before light curing the final layer of composite, a piece of Teflon tape is laid on the tooth surface, then the stamp is placed back onto the tooth to restore the original occlusal anatomy. The advantage of this technique is that it restores the occlusal surface of the teeth more easily and quickly; however, as the opaque resin material is used to make a stamp and opaque Teflon tape is laid on the tooth surface, accurate placement of the stamp is difficult

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for beginners to achieve. To overcome this, a modified stamp technique (MST) has been proposed. A transparent bite registration material is used instead of flowable composite resin to form an occlusal stamp, and Teflon tape is not required. Since the stamp is optically transparent, it is not necessary to remove it before light curing. This new technique ensures the accurate restoration of the occlusal anatomy and avoids the formation of an oxygen-inhibited resin surface layer.

To evaluate the clinical performance of the MST, 3D scanning technology is used. 3D scanners can obtain 3D images of the occlusal surface before and after treatment, then the differences between the two images can be analysed using reverse engineering software.

Thus, the aim of the present study was to evaluate the clinical performance of direct composite restorations using the MST in vivo. The morphological consistency of the occlusal surface using the MST and conventional technique (CT) was compared using 3D scanning technology (CEREC Omnicam, Dentsply Sirana, Charlotte, NC, USA). The null hypothesis was that no difference would be found in the morphology consistency between the two methods.

Materials and methods

The protocol of the present clinical trial was approved by the Peking University Hospital of Stomatology Biomedical Institutional Review Board (PKUSSIRB-201840181). The inclusion criteria were as follows:

- premolars and molars;
- occult caries with clinically unnoticeable cavitation;
- normal pulp vitality;
- good oral hygiene;
- stable occlusion.

The exclusion criteria were as follows:

- teeth without normal occlusal morphology;
- pulpitis or apical inflammation;
- severe periodontal disease;
- poor oral hygiene;
- unstable occlusion.

After application of the inclusion and exclusion criteria, 30 teeth were included. The teeth were randomly divided into two groups according to the technique to be used: the MST group was subjected to the modified stamp technique and the CT group to the conventional technique. After examination and shade selection (Fig 1a), an intraoral scanner was used to obtain a 3D image of the preoperative occlusal surface as image A. Isolation was performed using rubber dam (Fig 1b), then a vibrating spatula (Compothixo, Kerr Dental, Orange, CA, USA) with transparent bite registration material (Kristall A70, Müller-Omicron, Lindlar, Germany) was used to form the stamp of the affected tooth in the MST group (Figs 1c and d). After local anaesthesia, the cavity was prepared (Fig 1e), then 35% phosphoric acid was used for selective etching for 30 seconds (Fig 1f). Next, the cavity was rinsed and dried. A two-step self-etching bonding agent (Clearfil SE Bond, Clearfil, Kuraray, Kurashiki, Japan) was applied according to the manufacturer's instructions. The cavity was then restored incrementally using composite resin (Z350, 3M ESPE, St Paul, MN, USA) up to 1 mm from the occlusal surface (Fig 1g). Each increment was polymerised. After placement of the last increment of composite, a conventional composite modelling instrument was applied to form the occlusal morphology in the CT group, whereas the stamp was placed back onto the teeth to form the morphology in the MST group. Compothixo was then applied for 15 seconds in the MST group (Fig 1h). After light curing (Fig 1i), the rubber dam was removed. The occlusion was checked using 250-µm articulating paper. Finishing and polishing procedures were carried out using a diamond bur followed by rubber points (Fig 1j). Finally, the 3D image of the postoperative occlusal surface was obtained as image B. All composite restorations were carried out by the same dental practitioner.

Reverse engineering software was used to analyse the differences between the 3D images. STL data of image A and B were input into the reverse engineering software Geomagic 12. Surface registration was used. Once the models were registered, a best fit alignment was performed between two datasets (Fig 2). The root mean square (RMS) values of best fit alignment errors were recorded. The RMS value was calculated using the following equation:

RMS = Lower RMS values indicated higher 3D agreement of the superimposed data.

To eliminate the error caused by the measurement method, a blank control group was formed, comprising eight teeth (four premolars, four molars) from four volunteers (mean age 30.5 years). An intraoral scanner was used to obtain two 3D images of each tooth. The 3D data of the two images were input in Geomagic Studio 12 (Geomagic, Morrisville, NC, USA) using the aforementioned method of measurement. Follow-ups took place at 3, 6, 12 and 24 months. Failure was defined as loss or fracture of the restoration, pulp problems or any Charlie or Delta scores according to the modified United States Public Health Service (USPHS) criteria[7]. Statistical analysis was performed using a one-way

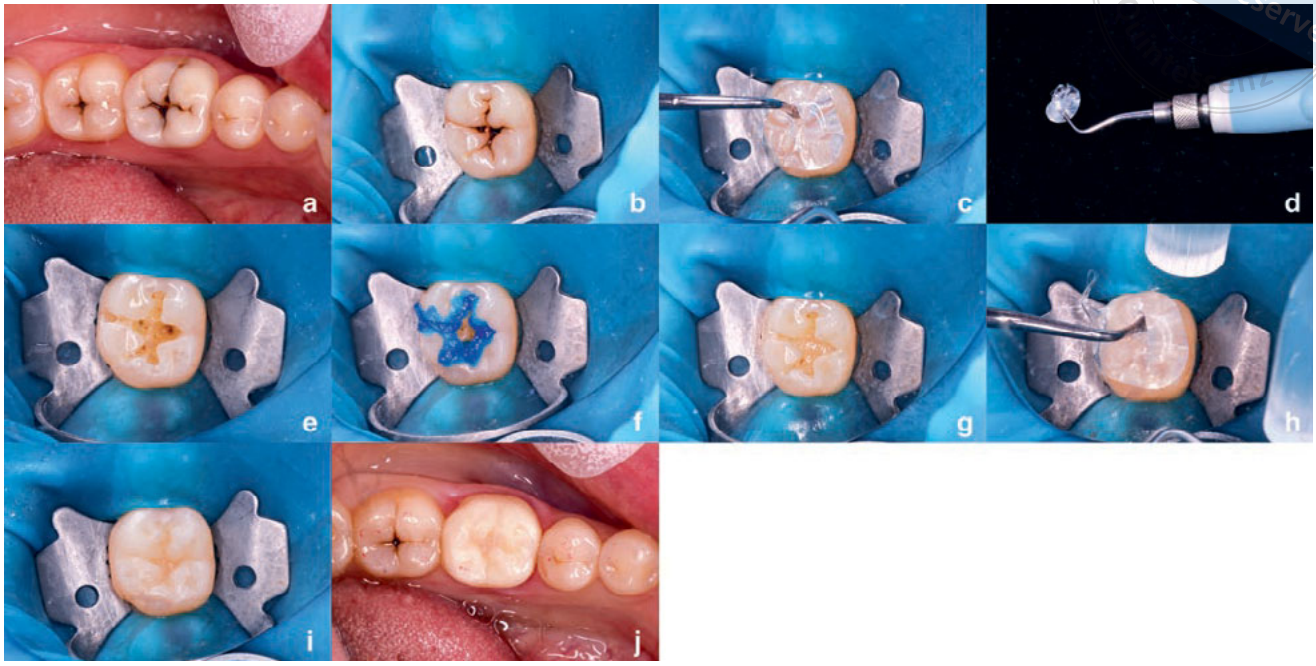

Fig 1 MST for Class I cavity of the mandibular left first molar: **(a)** preoperative photograph; **(b)** rubber dam isolation; **(c)** use of transparent bite registration material to form the stamp of the tooth; **(d)** Compothixo with transparent bite registration material; **(e)** cavity preparation; **(f)** selective etching; **(g)** the cavity was filled incrementally to 1 mm below the occlusal surface; **(h)** the stamp was placed back onto the teeth to form the morphology and Compothixo was applied for 15 seconds; **(i)** after light curing; **(j)** final outcome.

analysis of variance (ANOVA) combined with a least significant difference (LSD) post hoc test using SPSS 20.0 software (IBM, Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

The results of the statistical analysis are presented in Table 1. The analysis revealed that the average RMS values of best fit alignment errors were significantly different between groups ($P < 0.01$). The average RMS values in the MST and CT groups were 0.0738 ± 0.0279 and 0.1638 ± 0.0682, respectively. The LSD post hoc test revealed that the value was significantly smaller in the MST group than in the CT group.

The results of the follow-up examinations are shown in Table 2. One patient was lost to follow-up. Three of the teeth were followed up for the full 24 months. No patients reported discomfort or pain and the restoration survival rate was 100%.

Discussion

The results of the present study rejected the null hypothesis; the morphology consistency of the occlusal surface using the MST was better than using the CT.

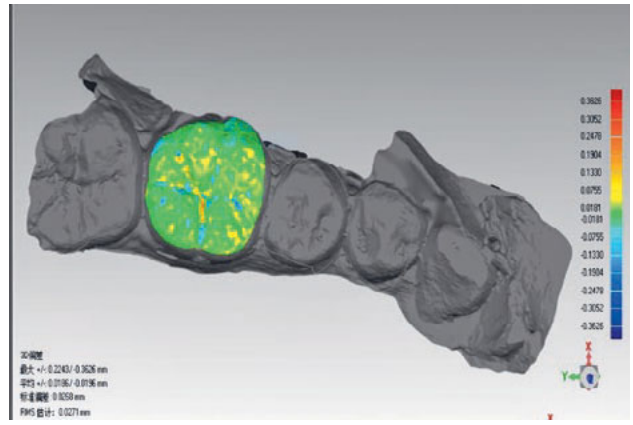

Fig 2 3D evaluation using reverse engineering software Geomagic 12.

Although the use of transparent bite registration material to make a stamp has been previously reported[8], the present study is the first to evaluate the MST. A transparent stamp and Compothixo were the core components. It was easy to accurately place the stamp made from transparent bite registration material onto the occlusal surface. The material is regularly used to make bite registrations or mock-ups in indirect restorations. It had sufficient strength and good light transmission

Table 1 Mean ± standard deviation of RMS values of best fit alignment errors.

Group	n	Mean ± standard deviation	*P* value
Control	8	0.0258[a] ± 0.0088	< 0.01
MST	16	0.0738[b] ± 0.0279	
CT	14	0.1638[c] ± 0.0682	

P < 0.05 indicates statistically significant differences. Means with different superscript letters indicate significant differences using an LSD post hoc test.

Table 2 Descriptive follow-up data.

Variable		MST group	CT group
Number of teeth		16	14
Mean age (y)		29.4	27.5
Tooth type	Molar	13	12
	Premolar	3	2
Time of follow-up	3 months	7	4
	6 months	6	3
	12 months	0	6
	24 months	2	1
Lost to follow-up		1	0
Number of failures		0	0

and therefore did not need to be removed before light curing. Moreover, the stamp on the composite resin decreased the interference of oxygen during curing. The presence of oxygen throughout light irradiation resulted in the formation of an oxygen inhibition layer (OIL) at the surface of the composite. The OIL might impact clinical performance; for example, it could cause surface staining[9]. Compothixo is a kind of vibrating spatula with a vibration frequency of 140 Hz. Previous investigations have demonstrated that vibrating instruments can alter the viscosity of composite resin cement during seating of inlay restorations[10-14]. In the present study, Compothixo was used to provide vibrations while seating the stamp. It was helpful in altering the viscosity of the composite resin, which facilitated accurate placement of the stamp.

The present study has shown that the MST accurately restored the original occlusal anatomy of teeth and achieved a harmonious cusp–fossa relationship with the antagonist tooth. Compared to the CT, the morphological consistency of the occlusal surface was superior when restored using the MST. This result verified the advantages of the replication technique over the free-hand technique in morphological restoration. The MST seemed to be a simple way of achieving a biomimetic posterior direct composite restoration and was suitable for use with teeth that had caries but also had an intact occlusal contour. Due to the occlusal registration method utilised, the MST reduced the time required for shaping, polishing and occlusal adjustments. Even dental students or residents lacking in clinical experience can rebuild tooth morphology with ease using this technique.

In the present study, 3D analysis software was used to analyse the differences in morphology. This analysis fully reflected the deviations of all points in the selected surfaces, enabling a more comprehensive evaluation[15]. Previous studies had shown that 3D analysis was more reliable than conventional methods[16,17] and has thus been increasingly used[18,19]; however, 3D analysis has also induced errors[20]. In the present study, a control group was formed to evaluate the influence of cumulative error of the 3D analysis procedure. The results showed that the RMS value in the control group was significantly smaller than in the other groups ($P < 0.01$). This suggested that the difference between the images was mainly due to the treatment rather than error of the analysis procedure and indicated that 3D analysis was feasible and effective for the present study.

One of the limitations of this study was the short observation period. Further studies are required to evaluate the long-term clinical performance of this new technique. In addition, occlusal caries lesions frequently result in breakdown of the enamel surface. In such cases, it is impossible to use the stamp technique, which limits its application. Furthermore, a larger sample size is required.

Conclusion

Within the limitations of this in vitro study, it was concluded that the MST is effective in direct composite restoration. Compared with the CT, the morphological consistency of the occlusal surface was superior using the MST.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Kun QIAN conceived, designed and performed the experiments and drafted the manuscript; Drs Qi Lin WANG and Jie PAN contributed to the study design and interpretation of the results.

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