Two inlay processing techniques effects on the mechanical function of resin inlays★

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Abstract

BACKGROUND: Composite resin functions as a practical resin restoration material with beautiful outlook, modifying its mechanical properties has become a hot spot in research.

OBJECTIVE: To prepare resin specimens with two kinds of inlay curing machines: CERAMAGE and TESCERA, and to compare the mechanical properties of these specimens.

METHODS: The resin specimens supporting two machines were cross-matched with these machines and then divided into four groups: Group A was Tescrea resin prepared with TESCERA machine; group B was Tescrea resin prepared with CERAMAGE machine; group C was Ceramage resin prepared with CERAMAGE machine; group D was Ceramage resin prepared with TESCERA machine. The standard specimens were determined for compressive strength, hardness and flexural strength.

RESULTS AND CONCLUSION: The compressive strength and hardness in group A were higher than those in other three groups, and group B exhibited higher compressive strength and hardness than groups C and D ($P < 0.05$). The flexural strength in groups C and D was higher than that in groups A and B ($P < 0.05$), there was no significant difference between groups C and D, neither betweens group A and B. The experimental findings indicate that TESCERA inlay machine and Tescera resin achieve the optimal mechanical properties.

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INTRODUCTION

Composite resin has been widely applied as a both beautiful and practical inlay repair material. However, the resin's mechanical properties are inferior to traditional metal materials[1]. Therefore improvement of mechanical properties is recognized as a hot spot.

Many scholars investigated the inlay curing conditions and they found that a condition under high temperature and high pressure can improve the mechanical properties of inlays[2]. Many inlay processing systems and its supporting resins are emerging. A variety of processing technologies also confuse physicians regarding how to match the resin and the inlay machines to achieve an optimal outcome.

This study sought to compare the compressive strength, hardness and flexural strength of the specimens prepared with two inlay processing technologies and their matching resins, *via* a cross-matching approach, in a broader attempt to provide laboratory evidence for clinical selection of inlay processing technology.

MATERIALS AND METHODS

Design

A comparative study.

Time and setting

Experiments were conducted from March to October in 2010 at the Affiliated Hospital of Qingdao University Medical College, China.

Materials

The main materials and equipments are introduced as follows:

Materials and equipment	Source
Tescera resin, TESCERA inlay machine	Bisco Company, USA
Ceramage resin, CERAMAGE inlay machine	Shofu Company, Japan
Electronic micro-hardness tester	Shanghai Tai Ming Optical Instrument Co., Ltd., China
Precise universal testing machine	Shimadzu Company, Japan

Methods

Experimental grouping

Test specimens at three sizes of compressive strength, surface hardness and flexural strength were divided into four groups, each group contained five specimens for surface hardness, ten ones for the other two properties. Group A: Tescera resin prepared with TESCERA inlay machine; B group: Tescera resin prepared with CERAMAGE inlay machine; C group: Ceramage resin prepared with CERAMAGE inlay machine; D group: Ceramage resin prepared with TESCERA inlay machine.

Preparation and test of compressive strength specimens

Test specimens at 4 mm diameter and 8 mm height were filled with resin materials at 2 mm thickness, and cured with inlay machine. After curing, specimens were polished and prepared into standard test specimens. The resultant specimens were crushed into pieces with a universal testing machine at 1 mm/min speed, to record the maximal force during compression process. The compressive strength was calculated and the mean value was obtained. Compression strength = $F/\pi r^2$ [F: force value (N); r: radius (mm)][3].

Preparation and test of surface hardness specimens

Test specimens at 6 mm length, 5 mm width, 4 mm height were filled with resin materials at 2 mm thickness, and cured with inlay machine. After curing, specimens were polished and prepared into standard test specimens. The resultant specimens were loaded with electronic micro-hardness tester at 500 N/S speed for 15 seconds. Each test specimen in each group was randomly selected 8 points for reading the value, the mean values were calculated.

Preparation and test of flexural strength specimens

According to the ISO 4049: 2000 standard[4], standard test pieces at 25 mm length × 2 mm width × 2 mm height were prepared. Then specimens were soaked in distilled water at 37 ℃ in the dark for 24 hours, then loaded on a universal testing machine at 1 mm/min speed, the distance between two branching points was 20 mm. The maximum loading value was recorded when specimens fracture occurs. Flexural strength was calculated according to the following formula: Flexural strength = $3FL/2BH^2$. F: maximum loading value (N), L: distance between two branching points (mm), B: specimen width (mm), H: specimen height (mm)[5].

Main outcome measures

The compressive strength, surface hardness and flexural strength of test specimens were observed.

Statistical analysis

Data were analyzed with SPSS 12.0 software for the analysis of variance and Tamhane's T2 test. A $\alpha = 0.05$ was considered statistically significant difference.

RESULTS

Comparison of compressive strength, surface hardness and flexural strength in each group of specimens (Table 1)

Table 1 Comparison of compressive strength, surface hardness and flexural strength in each group of specimens ($\bar{x}\pm s$, MPa)

Group	Compressive strength	Surface hardness	Flexural strength
A	299.32±15.28	680.9±18.9	134.04±12.86
B	233.12±16.44[a]	598.4±20.5[a]	130.25±11.89
C	230.79±8.79[a]	553.5±16.8[ac]	159.47±15.56[bc]
D	255.82±13.75[a]	570.4±17.6[ac]	164.18±22.74[bc]

[a]$P < 0.01$, [b]$P < 0.05$, *vs*. A group; [c]$P < 0.05$, *vs*. B group. A: Tescera resin + TESCERA inlay machine; B: Tescera resin + CERAMAGE inlay machine; C: Ceramage resin + CERAMAGE inlay machine; D: Ceramage resin + TESCERA inlay machine

DISCUSSION

Surface hardness and compressive strength

The surface hardness and compressive strength in group A were higher than those in group B ($P < 0.05$), mainly as a result of the difference between two inlay machines. The processing of TESCERA inlay manufacturing machine is divided into two steps: first, the resin is initially cured under a high pressure and light condition, and porcelain reflective beads in curing cup allow diffuse reflection of curing light, so the resin can be illuminated in all directions, thus ensuring the uniformity of cure and avoiding the emergence of stress within the material. Then resins were again cured under the conditions of high temperature, high pressure, light, and oxygen-free water bath for secondary processing. High temperature and high pressure enhance the moving force of residual free radical and monomer in curing resin, further improving the responsiveness. The residual monomer in the filling body is reduced, thus fully curing the resin[6]; pressurization treatment also lowers the probability of residual air bubbles in the resin, the resin structure becomes more dense, while avoiding stress concentration due to the existence of bubbles, and reducing the risk of fracture[7]; oxygen-free water bath makes the material surface more completely cured. These favorable conditions can protect the mechanical properties of materials as much as possible.

The processing of CERAMAGE inlay manufacturing machine is relatively simple, only one step: a wide range of light in all directions is utilized to ensure each aspect of the materials have taken place curing reaction, in addition, a curing light at a intensity higher than normal photosensitive resin curing light can improve extent of curing the resin. As high pressure and oxygen-free environment is absent, the curing temperature is lower than that of TESCERA[7-8]. Under such curing conditions, CERAMAGE inlay machine only meets the requirements of Ceramage resin curing, and cannot function as the activator and catalyst of Tescera resin reaction, leading to insufficient Tescera resin curing and reducing its mechanical properties.

These two indices in group D and C group showed that, Ceramage resin prepared with TESCERA inlay machining exhibited higher compressive strength and surface hardness than that prepared with CERAMAGE inlay machine, but the difference was not statistically significant.

Group A also showed a higher compressive strength and surface hardness compared with group D ($P < 0.05$), and there was no significant difference between group D and group C. This is evidence of a higher mechanical property of specimens processed with Tescera resin and TESCERA inlay machine than that processed with Ceramage resin and CERAMAGE inlay machine, under the curing conditions required by two materials. This is mainly due to differences in the compositions of two materials: they are both mixed packing materials, with similar particle size, but the filling ratio of Tescera resin was higher than Ceramage resin (81% versus 73%). The higher the filling ratio is, the better the mechanical properties of materials are[9].

Flexural strength

The flexural strength showed no significant differences between group A and group B, indicating that low curing conditions of CERAMAGE inlay machine cannot affect its flexural strength. Also no significant difference was found between group C and group D regarding compressive strength, surface hardness and flexural strength, indicating that the CERAMAGE inlay machine can provide sufficient curing conditions for Ceramage resin, although TESCERA inlay machine offers better curing conditions, the improvement of its mechanical properties is limited.

The flexural strength of group A was lower than that of groups C and D ($P < 0.05$), but its value was close to dentinal flexural strength (flexural strength of vital dentin is mainly

140‒170 MPa[10-11] and Carter *et al* [12] reported that the flexural strength of pulpless dentin was 14% lower than that of vital teeth dentin), so Tescera resin can meet the requirements of flexural strength of dental filling materials.

Based on the evaluation of compressive strength, surface hardness and flexural strength, the mechanical properties of inlays processed with Tescera resin and its matching machine (TESCERA) are higher than that processed with Ceramage resin and matching machine (CERAMAGE).

CONCLUSION

(1) TESCERA inlay machine and its matching resin can get an inlay with good mechanical properties. (2) Clinically processed inlays can meet the requirements of the materials curing without deliberately high curing conditions.

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两种嵌体加工技术对树脂嵌体机械性能的影响★

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摘要

背景：复合树脂作为一种既美观又实用的嵌体修复材料，其机械性能的改进成为研发的热点。

目的：用 CERAMAGE 与 TESCERA 两种嵌体固化机制作树脂试件，比较两种加工技术对嵌体材料机械性能的影响。

方法：选取两种机器的配套树脂，与两种机器进行交叉配对，分成 4 组：A、B 两组用 Tescera 树脂分别与 TESCERA 嵌体机和 CERAMAGE 嵌体机配对；C、D 两组用 Ceramage 树脂分别与 CERAMAGE 嵌体机和 TESCERA 嵌体机配对，分别制作标准试件，测试试件的表面硬度，抗压强度和挠曲强度。

结果与结论：在表面硬度，抗压强度上，A 组高于其他 3 组；B 组高于 C、D 两组($P < 0.05$)。在挠曲强度上，C、D 两组高于 A、B 两组($P < 0.05$)，C、D 组间及 A、B 组间差异无显著性意义。结果表明，用 TESCERA 嵌体机加工其配套树脂，所得试件的机械性能最佳。

关键词：树脂嵌体；表面硬度；抗压强度；挠曲强度；复合树脂

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