Effect evaluation of different inlay restorations

Running title: Inlay restorations

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Abstract: Objective This study aimed to evaluate the clinical performance of gold alloy inlays, porcelain inlays and Ceramage polymerization porcelain inlays in restoring molar defects. **Materials and methods** Gold alloy inlays, Ceramage polymerization porcelain inlays and porcelain inlays were used to restore 59, 54 and 51 molar defects, respectively. All restorations were evaluated 6, 18 and 30 months after restoration according to the modified standards proposed by the American Public Health Association. **Results** No significant differences in inlay discoloration, marginal adaptation, secondary caries and food impaction were observed among these groups ($P > 0.05$). Both gold alloy inlays and Ceramage inlays were significantly more resistant to fractures than porcelain inlays ($P < 0.05$). **Conclusions** Gold alloy inlays, Ceramage inlays and porcelain inlays all produced satisfactory restorative effects on molar defects, although some differences were observed. An appropriate method should be determined according to patient conditions.
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Keywords: gold alloy inlays; Ceramage polymerization porcelain inlays; porcelain inlays; molar defect

Interproximal caries in molars is a common clinical disease. Resins and dental amalgams are widely applied in clinical practice as filling materials for the treatment of this condition. Despite easy manipulation and relatively low costs, these materials often lead to treatment failure because of incorrect operation or their inherent drawbacks. Adjacent loss often causes filling overhang, filling fracture or unsatisfactory adjacency relation, which lead to food impaction. Food impaction causes pain and inconvenience to patients (Ying, 2008). Food compaction can also induce gingival tumefaction and dental pain because food can be inserted vertically between the adjacent surfaces under biting pressure or fill dental cusps during mastication (Ye et al., 2007; Jiang and Li, 2008). A statistical study on food impaction showed that the incidence of food impaction exceeds 90% at certain age stages. Long-term food impaction is highly likely to induce oral health-threatening periodontal diseases, such as gingival papillitis, periodontitis, proximal dental caries and pulpitis. Although inlay treatment for food impaction has been proposed, its clinical application is limited by problems such as inlay manufacturing, technique and bonding. Given the rapid development of material science and the continuous advancement of manufacturing process, this treatment method has become more extensively used in clinical practice, and good restoration results have been achieved. Compared with traditional amalgam and resin restorations, inlay repair shows advantages in super-precision, marginal adaptation, microleakage, secondary caries and overhang formation in the treatment of molar defects (Xu, 2003; Tan, 2009). Inlays of different materials exhibit different characteristics.

In this study, patients with dental defects were treated with Ceramage polymerization porcelain inlays, gold alloy inlays and porcelain inlays, and followed up for 30 months to compare the restorative effects of the different inlays.

1. Materials and methods

1.1 Patients

A total of 115 patients (164 teeth) who received restoration treatment at Jinan Stomatology Hospital between January 2010 and July 2012 were enrolled. The patients included 60 males and 55 females with ages ranging from 20 years to 68 years. The inclusion criteria included good periodontal conditions of the affected tooth and of the adjacent teeth, no pathological loosening or inflammation and no periodontal pocket formation. To guarantee the consistency of the obtained results, all selected affected teeth were vital teeth with a molar class II cavity and in a normal occlusal relation with the corresponding jaw tooth. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Jinan Stomatology Hospital. A written informed consent form was obtained from all the participants.

1.2 Methods

The patients were divided randomly into three groups: Ceramage polymerization porcelain inlay group (including 38 patients and 59 teeth), porcelain inlay group (35 patients and 54 teeth) and gold alloy inlay group (32 patients and 51 teeth). All groups were

followed up from six months to 30 months.

Tooth preparation for gold alloy inlays included the following main points. The cavity should have a flat bottom and straight walls with a prepared angle between 4 ° and 6 °. The dovetail neck should be > 1.5 mm in diameter. The angle between the cavity wall and the tooth proximal surface should be > 60 °, with the occlusal surface having a thickness between 1.5 and 2.5 mm. The buccolingual side of the cavity proximal to the occlusal surface should be extended to the self-cleaning area with the gingival wall flush with the pulpal wall. In the tooth preparation for Ceramage and porcelain inlays, the diameter of the narrow part of the occlusal surface should be greater than half the buccolingual tooth diameter, with a thickness between 2 and 3 mm, apart from the aforementioned requirements.

After tooth preparation, impressions were made using 3M machine-mixed polyether rubber impression materials. Gold alloy inlays (containing 86.2% gold, 11.5% platinum, 1.5% zinc and 0.3% tantalum; Heraeus, Germany), Ceramage inlays (Ceramage, Japan) and porcelain inlays (IPS Empress II; Ivoclar, Liechtenstein) were manufactured. After try-in and occlusal adjustment, the inlays were adhered using 3M dual-cured resins.

1.3 Curative effect evaluation criteria

All indices for clinical curative effect evaluation were based on further consultations six, 18 and 30 months after restoration. Evaluations were performed by the same physician. The restorative effects of the prostheses were evaluated based on the revised standards proposed by the American Public Health Association (Gemalmz and Ergin, 2002) (Table 1).

2. Statistical analysis

All data were analysed using SPSS 15.0 software. Chi-square tests were performed.

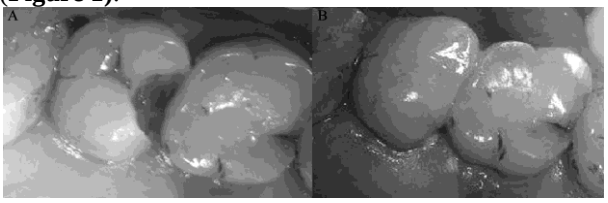
3. Results

3.1 General data

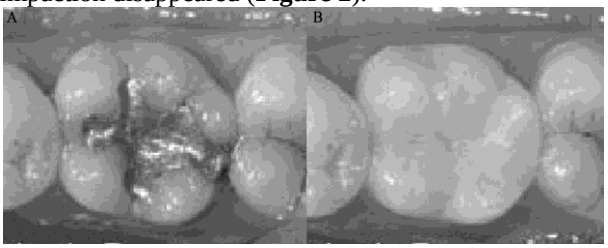
According to the follow-ups after restoration, one Ceramage inlay and one gold alloy inlay shed, whereas one porcelain inlay caused pulpitis. One patient presented secondary caries and one patient showed tooth fracture. In the Ceramage inlay group, six inlays discoloured to level B. In the porcelain inlay group, six inlays presented fractures. Statistical analysis did not show significant differences in marginal adaptation, adjacency relations and secondary caries among the groups ($P > 0.05$). Both gold alloy and Ceramage inlays showed better dental prosthetic integrity than porcelain inlays ($P < 0.05$). Although the Ceramage inlays exhibited a slightly inferior colour than the porcelain inlays, no significant difference was observed ($P > 0.05$). The gold alloy inlays showed good restoration performance, but they were only applicable for patients who did not require much for aesthetics (Table 2).

3.2 Case analysis

Case 1 A 45-year-old female patient visited the doctor's office in August 2010, and examination showed that her 16th tooth had a medial juxtamedullary defect with slight tenderness based on probing. A mesial interproximal Ceramage inlay was designed. Necrotic tissue removal, pulp protection, cavity rebasing and cavity form preparation were performed, and an impression was made. Temporary inlay material was used as a temporary filling. After manufacturing, the inlay was tried in and adhered. A good clinical effect was achieved and the patient was satisfied (**Figure 1)**.

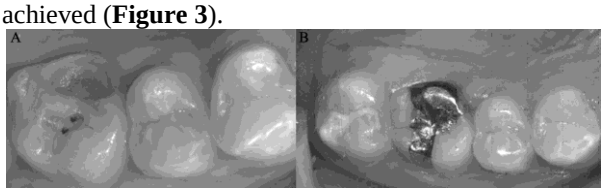


Case 2 A 28-year-old female visited the doctor's office in December 2010. The patient originally received a silver amalgam filling in tooth 36 but suffered from distal interproximal food impaction, thus requiring a second restoration. A porcelain inlay was designed. After the silver amalgam was removed, the cavity form was prepared and an impression was made. Temporary inlay material was used for a temporary filling. After manufacturing, the inlay was tried in and adhered. According to the patient, the prosthesis achieved a good aesthetic effect and felt comfortable. The patient visited regularly, and food impaction disappeared (**Figure 2**).



Case 3 A 35-year-old male visited the doctor's office in February 2011. He suffered from superficial caries of the dentin in tooth 26. Examination did not show loosening or dental pulp disease, and a gold alloy inlay was designed. Necrotic tissues were removed and a cavity form was prepared. Temporary inlay material was used as a temporary filling. After manufacturing, the inlay was tried in and adhered. According to the patient, the prosthesis felt smooth and comfortable. He visited regularly, and a good curative effect was

achieved (**Figure 3**).



4. Discussion

This study showed that all the groups exhibited excellent restorative effects in terms of prosthetic marginal adaptation, adjacent relation and secondary caries. All the inlays achieved satisfactory effects after 30 months of use. Both gold alloy inlays and porcelain inlays are subject to super-precise prostheses that achieve tooth adaptation by precise impression and casting techniques. For a polymerization porcelain inlay, its extraoral model is prepared using layered construction technique, which can reduce the contraction of materials during polymerization. The addition of porcelain material enables the resistance of inlay to heating, pressure and illumination, thereby ensuring excellent marginal adaptation (Vandewalle et al., 2004). The application of resin bonding technique also reduces the dissolution of bonding material by the saliva after operation, as well as the incidences of microleakage and secondary caries (Vandewalle et al., 2006).

Given that polymerization porcelain contains abundant minute porcelain ingredients, it appears translucent. Its translucency is similar to that of natural teeth. However, in an oral environment, the resin matrix in polymerization porcelain is susceptible to plastic deformation, partial transgranular fracture and slight abrasion (Vandewalle et al., 2004), which can decrease its translucency. Polymerization porcelain is also relatively easy to stain. Both these factors influence the colour of the material. Silicon–lithium crystals and lithium phosphate crystals are the main phases of IPS Empress II porcelain. They have similar radiant characteristics that can benefit light diffraction (Höland et al., 2000). IPS Empress II porcelain exhibits better translucency, which is highly similar to that of natural teeth, thus is suitable for the manufacture of prosthesis with higher aesthetic requirements (Deng et al., 2009; Liu and Guo, 2009). In the present study, the porcelain inlays achieved a slightly higher success rate (100%) than the Ceramage inlays (95%). Gold alloy inlays are only applicable to patients who do not require much for aesthetics because of their innate metal colour.

IPS Empress II porcelain inlays have high fragility (Zhao et al., 2007). Their actual intensity in clinical practice is lower than that in laboratory tests (Wang and Wang, 2009; Wang et al., 2012). The results in this study were consistent with those in the literature. Under great bite force, six porcelain inlays presented fractures with a success rate of 88%, which was lower than that of the gold alloy group (98%) and the polymerization porcelain group (95%), showing significant differences ($P < 0.05$). Ceramage polymerization porcelain is a porcelain-like resin system that contains 73% minute porcelain ingredients and has an anti-transverse strength of 146 MPa, which is more powerful than that of porcelain (74 MPa) (Lv, 2000; Wang, 2008). This feature of Ceramage polymerization porcelain effectively buffers biting pressure. In the 30-month follow-up of this study, only one tooth was observed to exhibit cracks. This tooth presented partial shedding after fracture.

Two patients also presented complete inlay shedding six and 18 months after restoration, respectively. The underlying reasons for the shedding occurrences are as follows: 1) an unsatisfactory retention form with an excessively large abduction angle at the time of cavity form preparation caused the inlay to be separated from the tooth upon large bite force and shed; and 2) incomplete moisture isolation (the inlay was not completely dried at the time of bonding) or saliva contamination decreased cohesion and led to inlay shedding. For these patients, a cavity form was renewed and moisture isolation was strictly performed at the time of bonding, after which shedding no longer occurred.

Postoperative tenderness is a frequent symptom in vital tooth restorations. In this study, hot and cold tenderness occurred in eight patients after restoration but disappeared within 12 months. Only one patient developed aggravated pulpitis after porcelain inlay restoration, and the underlying reasons were analysed. The patient had a short dental crown from which the removed dental tissues were relatively large. Indirect pulp capping and rebasing for the protection of the dental pulp were not performed for the juxtamedullary dentine. Both reasons were attributed to pulpitis. Considering that porcelain inlays require high-quality tooth preparation, the selection of a gold alloy inlay or overlay crown for patients with a short interalveolar space can achieve a better restorative effect.

Tooth fracture is an important cause of restoration failure. In this study, one patient exhibited tooth fracture 25 months after restoration. This patient had a large defect area. At the time of cavity form preparation, the patient had a high and steep tetarcone and frail surrounding tooth tissues. Chewing with the affected tooth eventually caused tooth fracture, which resulted in restoration failure. Thus, when a cavity form is prepared in clinical practice, thin walls and frail tips must be removed. For affected teeth with large defect areas, onlay or overlay crowns should be designed.

Porcelain inlays have the disadvantage of unsatisfactory marginal adaptation, thus they can induce microleakages (1.32 ± 0.21) (Li et al., 2006;

Chen and Wu, 2010). Under this condition, bacteria may invade through the microleakage site to form secondary caries, which can lead to food impaction. Food impaction can cause prosthetic loosening and shedding, and result in restoration failure. In this study, porcelain inlays exhibited less effective marginal adaptation (93.8%) than the other two types of inlays. Furthermore, one patient presented secondary caries, which was classified as molar class II cavity and occurred in the distal proximal neck. This site is a place where secondary caries easily occurs because of relatively poor moisture isolation and self-cleaning.

Gold inlays possess rather stable chemical performance and are not decomposed or corroded in an oral environment. They do not cause adverse stimulation to gums or periodontia and exhibit excellent biocompatibility (Erpenstein et al., 2001; Chen et al., 2011). Their mechanical function is highly similar to that of dental enamel. Gold alloy prostheses are resistant to fractures and do not cause excessive abrasion to jaw teeth. Thus, they protect healthy tooth tissues. This study showed that gold alloy inlays had an achievement rate of no less than 98%, which was higher than that of any other type of inlays.

Thus, gold alloy inlays, Ceramage polymerization porcelain inlays and porcelain inlays exhibited good restorative effects on molar defects. However, gold alloy inlays were more advantageous in function and durability than the other types. Thus, gold alloy inlays are more suitable for patients with great bite force and insufficiently deep cavity. However, porcelain inlays and polymerization porcelain inlays are better in meeting aesthetic requirements. Porcelain inlays are costly, difficult to manipulate and more suitable for patients with sufficient tooth preparation space. Polymerization porcelain inlays are easy to manipulate but have poorer abradability and intensity. Thus, successful inlay restoration is closely correlated to the correct selection of clinical indications and the execution of strict operative techniques.

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References

[1] Chen JJ, Yang DF, Huang J, Cao Q, Li HH. Clinical application of golden inlay for the restoration of molars defect. Chinese and Foreign Medical Research. 2011, 9(2):22-23.
[2] Chen T, Wu FM. Comparative study of microleakage about four different inlays. Stomatology. 2010, 30(11):661-663.
[3] Deng ZX, Zhang CB, Wu S, Bai SZ, Gan YN. Clinical evaluation of E-max porcelain inlay. Chinese Journal of Aesthetic Medicine . 2009, 10(18):1496-1498.
[4] Erpenstein H, Kersehbaum T, Halfin T. Long-term survival ofcast-goldinlays in a specialized dentalpractice. Clin Oral lnvestig. 2001, 5(3):162-166.
[5] Gemalmz D, Ergin S. Clinical evaluation of all-ceramic erowns. J Prosthet Dent. 2002, 87(2):189-195.
[6] Höland W, Schweiger M, Frank M, Rheinberger V. A comparison of the microstructure and properties of the IPS Empress 2 and the IPS Empress glass-ceramics. J Biomed Mater Res. 2000, 53(4):297-303.
[7] Jiang KL, Li DD. Clinical application of Silver amalgam inlay indirect repair. Chinese Journal of Conservative Dentistry. 2008, 18(12):686.
[8] Li Y, Li TS, Song R. Study of marginal microleakage about inlays. Chinese Journal of Conservative Dentistry. 2006, 16(12):692-694.
[9] Liu HC, Guo H. The clinical application of Porcelain repair technology VIII. Clinical application of Porcelain inlay. Chinese Journal of Stomatology. 2009, 44(5):308-309.
[10] Lv XY. Wear study of dental restoration materials with a new study-system in vitro. Chinese journal of stomatology. 2000, 35(5):388-390.
[11] Schwartz JI, Söderholm KJ. Effect of Filler size, water and Alcohol on hardness and Laboratory Wear of Dental Composites. Acta Odontol Scand. 2004, 62(2):102-106.
[12] Song R, Wang G, Li Y, Zhang S, Li TS. A comparative study of marginal microleakage by using six different cements in casting inlay. Chinese Journal of Conservative Dentistry. 2006, 16(5):282-284.
[13] Tan JG. Latest clinical advance of esthetic inlay. Chinese Journal of Practical Stomatology. 2009, 2(12):719-720.
[14] Vandewalle KS, Ferracane JL, Hilton TJ, Erickson RL, Sakaguchi RL. Effect of energy density on properties and Marginal intergrity of posterior resin composite restorations. Dental Materials. 2004, 20(1):96-106.
[15] Wang J. Clinical application of reasonable and effective by Repair the new material - polymerization porcelain. Chinese Journal of Practical Stomatology. 2008, 1(1):50-51.
[16] Wang Y, Zhao P, Wang MZ, Liu W. Comparative study of Au alloy inlays and porcelain inlays in restoting molar defect. Chinese Journal of Aesthetic Medicine. 2012, 21(4):652-653.
[17] Wang YK, Wang YJ. Clinical observation of the Different materials inlay used to repair defect of posterior teeth. Journal of Practical Stomatology.

2009, 25(2):289-290.
[18] Xu JW. Prosthodontics, Version 4. Bei Jing: People's Medical Publishing House. 2003, 42-43.
[19] Ye N, Wei KW, Wu BL. 4 years of clinical curative effect of Posterior tooth composite resin repair all kinds of hole-shape. Chinese Journal of Conservative Dentistry. 2007, 17(5):286-288.
[20] Ying D. Clinical analysis of restoring vertical food impaction with composite resin inlay and directly resin filling. Chinese Journal of Conservative Dentistry. 2008, 18(4):229-231.
[21] Zhao Q, Zhang ZT, Li CY. Application of inlay crown in the restoration of tilted mandibular molar. Journal of China Medical University. 2007, 36(4):449-450.
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Table 1. Clinical evaluation criteria for inlays.

Evaluation item	Grade	Clinical evaluation criterion
Prosthetic color	A	The color, brightness, and translucency of the prosthesis are consistent with those of the adjacent teeth.
	B	Although the color, brightness, and translucency of the prosthesis are not consistent with those of the adjacent teeth, the variations in the brightness do not go beyond the normal range.
	C	The color, brightness, and translucency of the prosthesis are not consistent with those of the adjacent teeth and the variations in the brightness go beyond the normal range.
Prosthetic integrity	A	The prosthesis is integral without cracks or a fracture.
	B	The prosthesis is observed with cracks but without a complete fracture.
	C	The prosthesis fractures completely or sheds.
Marginal adaptation	A	The probe is not blocked and there is no interspace between the prosthesis and the abutment tooth.
	B	The probe is blocked and there is a slight interspace between the prosthesis and the abutment tooth which allows the probe to enter, but the dentine is not exposed.
	C	The probe can enter the interspace and the dentine is exposed.
Postoperative tenderness	A	No tenderness or incidental cold and hot tenderness occurs, and symptoms improve or disappear after restoration.
	B	Cold and hot tenderness occurs, which aggravates or even develops to pulpitis and periapical periodontitis after restoration.
Marginal secondary caries	A	Deepened color is not observed in the surrounding tooth tissues of the prosthesis and the probe does not detect coarseness.
	B	Deepened color is observed in the surrounding tooth tissue of the prosthesis and the probe detects coarseness.
Food impaction	A	The prosthesis contacts the adjacent teeth closely and no food impaction occurs.
	B	The prosthesis does not contact the adjacent teeth closely and food impaction occurs.
Gingiva	A	Healthy gingiva without shrinkage or probe hemorrhage.
	B	Changes in gingival color and texture are observed with probe hemorrhage.
	C	Gingival shrinkage.

Table 2. Comparisons of the restoration effects among groups 30 months after restoration

		Polymerization porcelain inlay (n = 59)				Gold alloy inlay (n = 54)				Porcelain inlay (n = 51)			
		6 months	18 months	30 months	%	6 months	18 months	30 months	%	6 months	18 months	30 months	%
Prosthetic color	A	59	59	56	95%	54	54	54	100%	51	51	51	100%
	B			3									
	C												
Prosthetic integrity	A	59	58	56	95%	54	54	53	98%	51	50	45	88% #
	B		1	1							1	3	
	C			1				1				2	
Marginal adaptation	A	59	59	57	96.6%	54	54	53	98%	51	50	48	93.8%
	B			2				1			1	2	
	C												
Postoperative tenderness	A	59	59	59	100%	54	54	54	100%	51	51	50	98%
	B											1	
Marginal secondary caries	A	59	59	59	100%	54	54	54	100%	51	51	50	98%
	B											1	
	C												
Food impaction	A	59	59	58	98%	54	54	54	100%	51	51	50	98%
	B			1								1	
Gingiva	A	59	59	58	98%	54	54	54	100%	51	51	51	100%
	B			1									
	C												

Grade A represents success and grades B and C represent restoration failures; # indicates a significant difference between the porcelain inlay group and any other group ($P < 0.05$).