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ORIGINAL ARTICLE

Comparative characteristics of restoration criteria according to Ryge when filling with various glass ionomer filling materials

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Abstract

Background: According to modern concepts, the marginal fit of restorations, the presence or absence of microleakage, are the main factors determining the longevity of restorations.

Objective: Evaluation of the safety and effect of various filling glass ionomer cements on the marginal fit of fillings and the development of secondary caries.

Materials and methods: 39 patients were enrolled in the study, aged 3 to 13 years (6.56 ± 2.7 years). The split-mouth technique was used. Glass ionomer cements Ketac Molar and Cemion were used as filling materials.The restorations were assessed after 6 and 12 months using the Ryge criteria. 79 restored teeth were examined, including 36 temporary teeth (45.6%) and 43 permanent teeth (54.4%).

Statistical processing was performed using SPSS software (Armonk, NY: IBM Corp) version 19.0.

Results: After 12 months of observation, the preservation of fillings was observed in 89.7% of cases when using Ketak molar and in 43.6% of cases when filling with Cemion. Marginal adaptation of fillings after six months showed that 83.3% of restorations of temporary and 90.5% of permanent molars Ketak were assessed Alpha, Cemion restorations were assessed Bravo in 44.4% of temporary teeth and 28.6% on permanent teeth, and 4.8% of permanent teeth received a Charlie rating. Recurrent caries with filling with Cemion after 12 months was detected in 55.6% of temporary teeth and 57.1% of cases on permanent teeth. When filling with Ketak molar on primary teeth, recurrent caries was observed in 27.8% of cases, on permanent teeth - 14.3%.

Conclusion: "Ketac Molar (3M ESPE, Germany) display good clinical performance over a period of 12-months. It is preferable for pediatric dental care able to maintain its properties for a long time, which is important for the prevention of complications of the carious process in children.The use of GIC Ketak molar for restoration of carious defects of chewing teeth improves the quality of filling by 2.06 times compared to GIC Cemion, reduces the risk of complications, stabilizes the clinical condition and patient satisfaction with the restoration over 12 months of observation.Evaluation of the restoration of Bravo for caries and Charlie or Delta for marginal adaptation indicates the need for manipulation.

Keywords: Glass ionomer cements,GIC Ketac Molar,GIC Cemion, clinical performance, marginal adaptation, restoration criteria, ART

Introduction

According to modern concepts, the marginal fit of restorations, the presence or absence of microleakage, are the main factors determining the service life of the restoration[1,2].

Evaluation of the effect of filling materials and methods of their use on the dental status and the development of new technologies for filling carious cavities is an urgent task of scientific and practical dentistry. Currently, insufficient qualimetric studies of the quality of materials and methods of their use in filling carious cavities are carried out [3,4].

The creation of new materials for filling often outpaces the measures for standardization and regulation of their quality. A comprehensive assessment of dental technologies is the key to high

clinical effectiveness of the materials and methods used in dentistry. Of particular importance is the transition from purely technological quality standards to clinical evaluation criteria [4,5].

The balance of ongoing processes of de- and remineralization determines the preservation of the unity of hard dental tissues. A shift in balance towards demineralization contributes to the development of a carious defect [6,7]. The traditional approach to caries treatment is reduced surgical model of caries management, which is associated with a loss of hard dental tissues [8].Surgical model of caries management is associated with painful manipulations, which negatively affects the emotional state of the patient and requires various types of local anesthesia [9,10].

Analysis of modern literature data shows that caries is a manageable disease [11].

Currently, the principle of minimally invasive intervention has been adopted as a priority in modern dentistry [12], [13].

This is a modern concept for solving dental caries problems taking into account the etiological factor and pathogenetic mechanisms.

The ART method is based on a modern concept of preparing carious cavities with minimal intervention and maximum preservation of healthy dental tissues. ART is used in cases where planned dental treatment is impossible due to the lack of capacity or accessibility of a dental clinic [14,15].

In addition, ART can be used in schools as a public measure to combat caries in a large number of children. ART can be used for both primary and permanent teeth. Due to the introduction of the concept of minimally invasive treatment in dentistry, the criteria for choosing a restorative material, especially for direct restorative treatment, have changed significantly [16].

Due to errors made during processing and filling of the cavity, the recurrence of the lesion at the border of the filling and natural tooth tissues develops - recurrent caries. Secondary caries and marginal defects are the most common reasons for replacement reported in the literature [7, 17].

Ideal restorative dental cements should have excellent mechanical properties, chemical stability, esthetics, good processing properties, biocompatibility, antibacterial properties and, preferably, bioactivity [18,19].

There are different interfaces between the hard tooth tissue, the restorative material and the adhesive and/or the luting resin/cement layer. Each interface can worsen and potentially change the marginal adaptation [20].

The interaction between restorative materials and dental tissues is a complex and pressing issue in dental materials science. Glass ionomer cements (GIC) are capable of chemical interaction with dental tissues; it is even suggested that they are capable of biomineralization of dentin, can replace lost dentin and imitate its properties [21].

The bioactivity of glass ionomers is primarily manifested in the ability of their polymer component to form adhesive and chemical compounds with hard dental tissues and the ability of the mineral component to release fluorides in a prolonged manner [21].

In pediatric dentistry, the choice of filling materials is very important for the restoration of primary teeth. The main requirements for them are: lack of toxicity and biocompatibility; adhesion to hard dental tissues; strengthening of the remaining tooth structure; ease of placement; low cost [16].

Currently, glass ionomer cements (GIC) meet these parameters. According to a number of authors, if the diametrical tensile strength of glass ionomer cements were an order of magnitude higher, they would become ideal filling materials for pediatric dentistry [22, 23].

Glass ionomer cements, in particular, have attracted attention due to their unique properties and have undergone significant improvements compared to other dental materials.

The final decision on the acceptability of a dental restorative material for use in the oral cavity can only be made on the basis of clinical observation. This article attempts to present a systematic approach to the clinical evaluation of restorative materials by posing a series of yes or no questions. The system allows decisions to be made on marginal adaptation, restoration and maintenance of anatomical shape, protection against caries recurrence, and, in the case of materials used in frontal restorations, colour matching and marginal colour change [24].

Objective: Evaluation of the safety and effect of various filling glass ionomer cements on the marginal fit of fillings and the development of secondary caries.

Materials and Methods

Clinical examination and further treatment were carried out at the dental clinics of YSMU and ACRA from 2017 to 2023 in 39 somatically healthy patients aged 3 to 13 years.

The study population consisted mainly of boys, accounting for 61.5%. The average age was 6.56±2.7 years, of which 46.15% were children with primary dentition (average age 4.39±1.15 years). Patients with mixed dentition accounted for 53.8% (average age 8.43±2.1 years). The treatment of children and adolescents was carried out after obtaining informed consent from their parents for medical intervention.

All participants signed a consent form in accordance

with the Declaration of Helsinki. The Ethics Committee of Yerevan State Medical University approved the study (Approval No. 2 dated 18 October 2018).

The split-mouth technique was used[25].

A rotary brush with cleaning paste was used to remove biofilm and pellicle from the tooth surface. Hard dental tissues were prepared using the ART method. Dryness of the surgical field was achieved using cotton rolls. Adhesive preparation, application and polymerization of the material were performed according to the manufacturer's instructions. Glass ionomer cements Ketac Molar (3M ESPE, Germany) and Cemion (VladMiVa, Russia) were used as filling materials. Finishing and polishing of the filling were performed using finishing diamond heads with very fine grain size and polishers. Six and 12 months after restoration, they were assessed using a probe and a flat buccal mirror (Hu-Friedy Manufacturing Co., Chicago, USA). To assess the condition of the restoration in the oral cavity, the following criteria for assessing restorations proposed by the US Public Health Service (USPHS) guidelines, better known as the Ryge criteria, were used: marginal adhesion of the restoration, the presence of recurrent caries and/or caries in the area of unsealed fissures adjacent to the restoration and other caries-susceptible areas. All restorations were assessed separately for each criterion [26].

Evaluation criteria:

A (alpha): excellent - 4 points

B (Bravo): good - 3 points

C (Charlie): satisfactory - 2 points

D (Delta): unsatisfactory - 1 point

Based on these criteria, a clinical decision was made whether the filling was acceptable or unacceptable. In the group of acceptable results, a distinction was made between a very good result ("alpha") and a clinically acceptable result ("bravo"), in which the filling differs to a certain extent from the ideal appearance, however, no reliable decrease in its quality was clinically detected. In the group of unacceptable results, a differentiation was made between a preventive indication for filling replacement ("Charlie") and an immediate indication for intervention ("Delta"). The procedure for evaluating the filling according to the Ryge criteria began with an assessment of its marginal fit.

The marginal fit of the filling to the cavity edge was examined with a dental probe. If a smooth transition from the hard tooth tissue to the filling material was observed or visible errors were detected in the marginal area, but a marginal gap was not detected, the marginal fit was assessed as “alpha”. If the tip of the probe penetrated the gap between the filling material and the hard tooth tissue, the marginal gap was recorded and the “bravo” criterion was applied. If a marginal gap was detected, the depth of the defect was examined and whether dentin or lining was exposed. If this happened, the state of the marginal fit was classified as “Charlie”. If a fracture or partial or complete loss of the filling was detected, the “delta” criterion was applied. To establish the presence of secondary caries, the tooth was examined with a mirror and a probe. Secondary caries (criterion, "bravo") was diagnosed if the probe was retained along the edge of the filling, and the hard tissue of the tooth in this area was softened. Secondary caries was also diagnosed if there was a change in the color of the tooth along the edge of the filling, which indicates the presence of hidden caries or demineralization of the enamel.

A total of 79 restored teeth were examined, including 36 primary teeth (45.6%) and 43 permanent teeth (54.4%). The assessment was performed 6 and 12 months after filling.

Statistical analisis

Statistical processing of the obtained results was performed using parametric statistics methods using SPSS software (Armonk, NY: IBM Corp) version 19.0. Categorical variables were described using absolute and relative frequencies, and continuous variables were described using summary statistics (mean, standard and mean deviations, minimum and maximum, one-sample Student's t-test). For quantitative values, when comparing different groups, a two-sample Student's t-test was used. Correlations between parameters were calculated using the Pearson correlation test. When testing hypotheses, a p-value less than 0.05 was a sufficient condition for rejecting the null hypothesis.

Results

The assessment of the quality of filling of carious cavities after 12 months of observation revealed the preservation of fillings in 89.7% of cases when using Ketak molar glass ionomer cement and in 43.6% of cases when using Cemion glass ionomer cement. The average assessment of the marginal adhesion of filling materials and the development of recurrent caries according to Ryge is presented in table 1.

Table 1. Average Ryge rating of restorations

Criteria	Restoration material	After 6 month	After 12 month
Marginal adaptation	KETAK molar	3,87±0,3*	3,3±0,98*
	CEMION	3,4±0,8*	1,95±1,3*
Secondary caries	KETAK molar	3,95±0,2**	3,7±0,6**
	CEMION	3,46±0,9*	2,85±1,2*

* p≤0,001

** p=0,011

The obtained results were analyzed according to the evaluation criteria proposed by Ryge. The obtained results are presented in table 2 and diagram 1.

Table 2. Evaluation of marginal fit according to Ryge criteria in percent

Evaluation criteria	KETAC molar		CEMION	
	month	month	month	month
Alfa	87,2%	59%	53,8%	17,9%
Bravo	12,8%	25,6%	4,1%	17,9%
Charlie	-	5,1%	2,6%	7,7%
Delta	-	10,3%	2,6%	53,8%

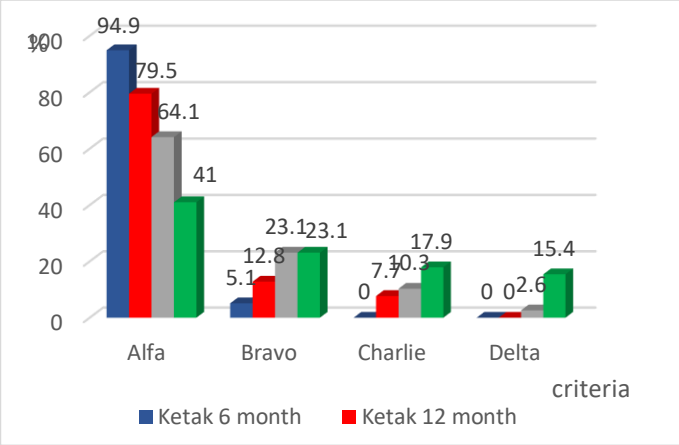

Figure1.Assessment of recurrent caries according to Ryge criteria in percentage

Evaluation of restorations after 6 months

Analyzing the data of the clinical evaluation of fillings according to Ryge after 6 months, 100% preservation of fillings in all examined teeth (both temporary and permanent) was revealed.

Evaluation of the marginal adaptation of fillings after six months of observation showed that 83.3% of temporary and 90.5% of permanent molar restorations of Ketak GIC were rated excellent (Alpha) and satisfied the test results - "there is no visible gap, the filling fits tightly to the tooth tissues along the entire periphery" (p≤0.001).

Evaluation of the marginal adaptation of Cemion GIC restorations after 6 months on temporary teeth corresponded to a good indicator (Bravo) in 44.4%, on permanent teeth, 28.6% received a Bravo rating, and 4.8% received a Charlie rating (satisfactory) (p≤0.001).

In primary teeth filled with Ketac molar GIC, the Recurrent caries parameter was rated as good (Bravo) in two patients (11.1%), while in the case of Cemion GIC filling, recurrent caries was observed in 33.4% of cases (6 patients): good (Bravo) and satisfactory (Charlie) ratings were observed in three patients (16.7% in each case) (p≤0.001).

When assessing the restorations of permanent teeth, the recurrent caries parameter was not detected in the case of Ketac molar GIC filling, while in the teeth filled with Cemion GIC, recurrent caries was observed in 33.4% of cases (7 patients): of these, 28.6% (6 teeth) were rated as good (Bravo), and 4.8% (1 tooth) – satisfactory (Charlie) (p≤0.001).

Evaluation of restorations after 12 months

After one year, the greatest number of unsatisfactory results were also observed when filling carious defects with Cemion glass ionomer cement: in 44.4% of cases, fillings fell out in primary teeth and in 61.9% in permanent teeth. The Bravo index was estimated at 22.2% of primary teeth and 14.3% of permanent teeth. The Charlie criterion was detected in 11.1% of primary teeth and 4.8% of permanent teeth (p≤0.001).

The lowest number of negative results after 12 months of observation was noted in the group of patients where Ketak molar glass ionomer citrate was used as a filling material: there was no filling on 1 tooth of permanent teeth (4.8%), the Bravo criterion was observed on 6 teeth (28.6%). All fillings on baby teeth were preserved, in 22.2% of cases they were assessed as Bravo, in 11.1% - as Charlie (p≤0.001). Recurrent caries with Cemion filling after 12 months was detected on 10 temporary teeth (55.6% of cases) and on 12 permanent teeth (57.1% of cases). When filling milk teeth with Ketak molar glass ionomer cement, recurrent caries was observed in 27.8% of cases (on 5 teeth), and in permanent teeth – 14.3% (on 3 teeth) (p≤0.001).

After 12 months, the number of good, satisfactory and unsatisfactory results increases. The greatest decrease in quality is determined by the criterion of "marginal fit". The difference in the comparison groups becomes clearly visible.

Comparative analysis of the obtained data revealed a statistically significant difference between all parameters of marginal adaptation (MA) and recurrent caries (K) when using glass ionomer cements Ketak molar and Cemion: MA after 6 months $t = 3.3$, $p = 0.002$; after 12 months $t = 5.8$, $p \leq 0.001$; K after 6 months $t = 3.6$, $p = 0.001$; after 12 months $t = 4.5$, $p \leq 0.001$.

After 6 and 12 months of filling with Ketak molar glass ionomer cement, an average direct correlation was found between the studied parameters of marginal adaptation and recurrent caries: $r = 0.606$, $p \leq 0.001$ and $r = 0.473$, $p = 0.002$, respectively.

When using Cemion glass ionomer cement, a strong

correlation was noted between the parameters of marginal adaptation and recurrent caries after 6 months ($r = 0.837$, $p \leq 0.001$); after 12 months, an average direct correlation was found between these parameters ($r = 0.569$, $p \leq 0.001$).

The best preservation is demonstrated by restorations with Ketak molar glass ionomer cement on both temporary and permanent teeth. In primary teeth, a direct average correlation was observed for the preservation of the filling material ($r=0.588$, $p=0.01$).

When filling with Cemion glass ionomer cement, a statistically significant difference was observed between the preserved and lost fillings in both primary and permanent teeth ($t=3.7$, $p=0.002$ and $t=5.7$, $p\leq0.001$, respectively).

To illustrate the application of the Ryge criteria, we present clinical cases.

Clinical case 1.

Patient K.I., 3 years old, follow-up examination 12 months after filling.

Objectively: tooth 55 was restored with Ketak molar glass ionomer cement. The filling on the chewing surface is in excellent condition (Alpha score), smooth transition from the hard tissue of the tooth to the filling material. Secondary caries is absent. Probing and percussion are painless. Thermal test is negative.

Tooth 65 was restored with Cemion glass ionomer cement(Fig. 2). The filling on the chewing surface of the teeth is in good condition (impaired marginal fit - Bravo score (good), probe getting stuck. Secondary caries is absent. Probing and percussion are painless. Thermal test is negative.

Figure 2. Condition of fillings on teeth 55 and 65.

Clinical case 2.

Patient T.M., 5 years old, follow-up examination 12 months after filling.

Objectively: tooth 85 was restored with Ketak molar glass ionomer cement. The filling on the chewing surface of the teeth is in good condition (impaired marginal seal - Bravo score (good), probe stuck (fig.3 a). No secondary caries. Probing and percussion are painless. Thermal test is negative.

Tooth 75 was restored with Cemion glass ionomer cement. Partial loss of the filling on the chewing surface (Delta score), impaired marginal seal, presence of secondary caries (Bravo score). Probing is slightly painful at the border with the filling, percussion is painless. Thermal test is negative (fig.3 b). Repeated restoration of the chewing surface is required.

Figure 3. Condition of fillings on teeth 75 (b) and 85 (a).

According to the assessment of the condition of the fillings according to the Ryge clinical criteria, the majority of restorations (89-93%) were clinically of excellent quality, anatomically restoring the tooth surface, without signs of damage to the integrity or disruption of the marginal fit of the filling, which ensures both full protection of the tooth tissue and restoration of the aesthetic and functional value of the tooth.

Discussion

Analyzing the results of clinical studies presented by glass ionomers, it can be concluded that the Ketac Molar material (3M ESPE, Germany) is preferable for pediatric dental care. This representative of the glass ionomer family is the most convenient for a pediatric dentist in a clinical setting. It is able to maintain its properties for a long time, which is important for the prevention of complications of the carious process in children [18, 27]. The use of Ketac Molar glass ionomers for the restoration of carious defects of chewing teeth improves the quality of filling by 2.06 times compared to Cemion glass ionomers, reduces the risk of complications, stabilizes the clinical condition and patient satisfaction with the restoration over 12 months of observation. No statistically significant difference was found between the criteria for making clinical decisions. We assumed that differences would be noted if a high proportion of unsatisfactory restorations were included in the sample. Whenever a restoration receives a Bravo rating for caries and a Charlie or Delta rating for marginal adaptation according to the Ryge criteria, it should be assessed as requiring intervention. A dichotomy arises as to whether the restoration can be restored or whether it requires complete replacement.

Declarations Conflicts of interest and financial disclosures.
The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval.
The Ethics Committee of Yerevan State Medical University approved the study (Approval No. 2 dated 18 October 2018).

Informed consent
Informed consent was obtained from all individual participants included in the study.

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