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# Effect of TUG-BACK on tightness of filling root canal apex

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**Abstract**

AIM. To evaluate the effect of tug-back on the apical seal of root canal fillings.

MATERIALS AND METHODS. Root canal treatment and filling were performed in 20 removed single-root teeth. The teeth were divided into 2 groups, with and without the tug-back effect. The cuts were made at the level of 1 and 3 millimeters from the apical constriction. The microstructure of the samples was studied using a JEOL JSM-6610LV scanning electron microscope.

RESULTS. The amount of siler at the level of 1mm from the apex in the group with the tug-back effect averaged 25.05%, and in the group without the tug-back effect – 30.9%. At the 3 mm level, these figures were 28.98% and 33.19%, respectively. The number of pores in teeth with a tug-back effect at the level of 1 mm was 10.5% of the circumference of the root filling, and in teeth without a tug-back – 19.4%. At the 3 mm level in teeth with tug-back – 4.7%, without tug-back – 12.4%.

CONCLUSIONS. Presence of tug-back effect does not improve tightness of root channel apical part.

**Keywords:** root canal, tightness, endodontics, tug-back

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# Влияние TUG-BACK эффекта на герметичность пломбирования апикальной части корневого канала

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**Резюме**

ЦЕЛЬ ИССЛЕДОВАНИЯ. Оценить влияние tug-back эффекта на герметичность апикальной части корневой пломбы.

МАТЕРИАЛЫ И МЕТОДЫ. В 20 удаленных однокорневых зубах была проведена обработка и пломбирование корневых каналов. Зубы разделили на две группы – с наличием и без tug-back эффекта. Спилы были сделаны на уровне 1 и 3 миллиметра от апикального сужения. Микроструктура образцов исследовалась на растровом электронном микроскопе JEOL JSM-6610LV.

РЕЗУЛЬТАТЫ. Количество силера на уровне 1мм от апекса в группе с tug-back эффектом составило в среднем 25,05%, а в группе без tug-back эффекта – 30,9%. На уровне 3мм эти показатели были 28,98% и 33,19% соответственно. Количество пор в зубах с tug-back эффектом на уровне 1 мм составило 10,5% от окружности корневой пломбы, а в зубах без tug-back – 19,4%. На уровне 3 мм в зубах с tug-back – 4,7%, без tug-back – 12,4%.

ВЫВОДЫ. Наличие tug-back эффекта не улучшает герметичность апикальной части корневой пломбы.

**Ключевые слова:** корневой канал, герметичность, эндодонтия, tug-back

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## INTRODUCTION

According to the Russian Dental Association, supported by numerous epidemiological studies, approximately 30% of dental visits are related to endodontic treatment [1; 2]. One of the key factors influencing the success of endodontic therapy is the quality of root canal filling. Given the impossibility of completely sterilizing the complex root canal system, the tightness of obturation may be a decisive factor in the treatment outcome. However, high-quality root canal filling, which is usually assessed radiographically, does not always prevent the development of chronic periodontitis [3]. The progression of secondary apical periodontitis is associated with the activity of intracanal microorganisms that release toxins through endodontic spaces into the surrounding periodontal tissues. In such cases, maintaining the seal of the apical portion of the root filling may significantly enhance the success of endodontic treatment.

It is well known that vital pulpectomy leads to acute inflammation of the periodontal ligament and bone, caused by the formation of a lacerated wound at the apical constriction and accompanied by edema. V.V. Afanasyev established that the first signs of periapical tissue regeneration appear approximately 30 days after endodontic treatment [4]. Increased tissue fluid pressure in the apical region of the tooth root may interfere with the polymerization of sealer at the apex of the root canal.

According to contemporary endodontic protocols described in academic literature, during the selection of a master cone for lateral condensation technique, it is recommended to achieve a slight binding of the cone tip in the canal, known as the tug-back effect. It is believed that this approach provides an apical seal by creating a “plug” of gutta-percha at the apical constriction.

## AIM

The aim of the study was to evaluate the influence of the tug-back effect on the sealing ability of the apical portion of the root canal filling.

## MATERIALS AND METHODS

A pilot comparative laboratory study was conducted on 20 extracted single-rooted teeth (incisors, canines, and premolars) with straight root canals, preserved anatomical integrity of the root, and intact apical constriction. The teeth were randomly assigned into two groups of 10 samples each. Teeth with cracks, fractured instruments, or inadequate filling quality were excluded and replaced prior to the study.

In all specimens, a straight-line access cavity was prepared, followed by mechanical instrumentation and obturation of the root canals. In Group 1 (with tug-back effect), root canal shaping was performed manually using K-files and H-files following the Step-Back technique. In Group 2 (without tug-back effect), shaping was carried out using rotary instruments (Profile system) with the Crown-Down technique. In both groups, canals were instrumented up to size ISO 35 master file and irrigated following a standardized irrigation protocol (3% NaOCl, 17% EDTA, distilled water). Root canal obturation in both groups was performed using lateral condensation of gutta-percha with 2Seal epoxy resin sealer.

Master cones were pre-calibrated with a gauge ruler (Maillefer) and trial-fitted in the canal. The presence of tug-back was confirmed clinically; if absent in Group 1, samples were reassigned to Group 2, and vice versa. As a result, Group 1 included teeth shaped to ISO size 35 with confirmed tug-back for the master cone, and Group 2 included teeth without tug-back.

Immediately after obturation, the teeth were mounted on a stand and placed in an ultrasonic bath, ensuring they did not touch the walls or bottom, and were immersed halfway into an isotonic solution. The bath was activated for 5 minutes, followed by storage in the solution for 24 hours. After complete sealer setting, radiographs were taken to evaluate root canal filling quality.

Longitudinal sections were prepared at 1 mm and 3 mm from the apical constriction. As the samples were dielectric, a 20 nm conductive platinum layer was sputter-coated using a JFC-1600 sputter coater to prevent charging. Microstructural analysis was performed using a JEOL JSM-6610LV scanning electron microscope in secondary and backscattered electron modes at the Shared Research Equipment Center of Tver State University. The microscope operated at an accelerating voltage of 5–15 kV under high vacuum conditions.

Statistical analysis was performed using StatTech v.2.6.5. Data with normal distribution were compared between groups using the student’s t-test. Non-normally distributed data were analyzed using the Mann–Whitney U-test.

## RESULTS

The amount of sealer within the structure of the root canal filling was determined during the study (Table 1).

At 1 mm from the apex, the sealer percentage in the tug-back group was 25.05%, compared to 30.9% in the non – tug-back group. At 3 mm, these values increased to 28.98% and 33.19%, respectively. The percentage of voids at 1 mm in the tug-back group was 10.5% of the root filling circumference, compared to 19.4% in the non–tug-back group. At 3 mm, the void percentages decreased in both groups: 4.7% in the tug-back group and 12.4% in the non–tug-back group. However, no statistically significant differences were found between the groups for any of the evaluated parameters.

## DISCUSSION

In root canals without the tug-back effect, the tip of the gutta-percha master cone remains loose within the canal. As a result, more space is left for sealer, the volume of which, according to modern endodontic protocols, should not exceed 5% when using the lateral condensation technique (Fig. 1).

Theoretically, binding of the cone tip indicates the formation of a “plug” that completely seals the root canal lumen at the apical level (Fig. 2).

**Table 1.** Assessment of the tightness of the root seal depending on the presence of the tug-back effect

**Таблица 1.** Оценка герметичности корневой пломбы в зависимости от наличия tug-back эффекта

| Indicator | Categories | Me | Q1–Q3 | *n* | *p* |
|---|---|---|---|---|---|
| Number of pores at the 1 mm level (n°) | Absence of tug-back | 69.96 | 45.00–95.45 | 17 | **0.158** |
| | Presence of tug-back | 39.5 | 0.00–91.70 | 16 | |
| Number of pores at the 3 mm level (n°) | Absence of tug-back | 44.8 | 12.69–57.00 | 17 | **0.240** |
| | Presence of tug-back | 17 | 0.00–41.37 | 16 | |
| Amount of sealer at the 1 mm level from the apex (%) | Absence of tug-back | 30.9 | 25.70–40.20 | 17 | **0.165** |
| | Presence of tug-back | 25.05 | 16.00–35.73 | 16 | |
| | **Categories** | **M±SD** | **95% DI** | ***n*** | ***p*** |
| Amount of sealer at the 3 mm level from the apex (%) | Absence of tug-back | 33.19±10.73 | 27.68–38.71 | 17 | **0.316** |
| | Presence of tug-back | 28.98±13.00 | 22.06–35.91 | 16 | |

*Note:* determine the indicators of statistical significance at $p < 0.05$

*Примечание:* различия показателей статистически значимы при $p < 0.05$

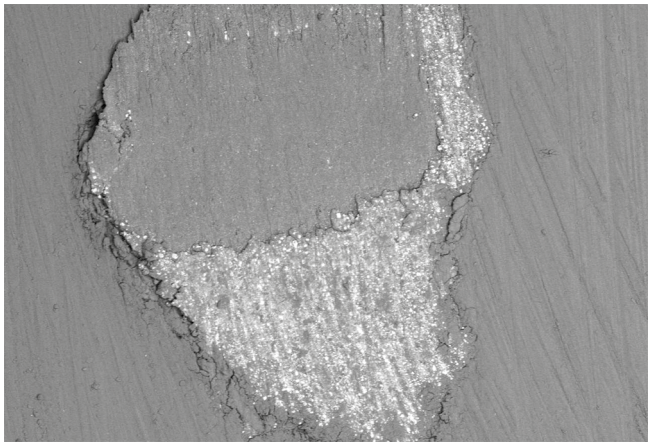

**Fig. 1.** The space filled with sealer around the pin without a tug-back effect

**Рис. 1.** Пространство, заполненное силером вокруг штифта без tug-back эффекта

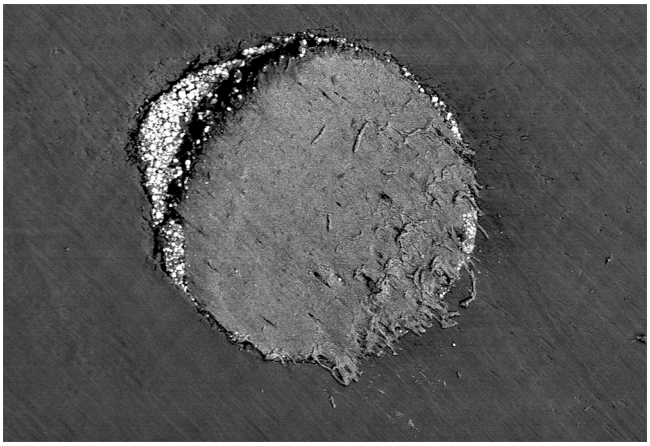

**Fig. 2.** The “cork” effect, in the presence of a tug-back effect

**Рис. 2.** Эффект «пробки», при наличии tug-back эффекта

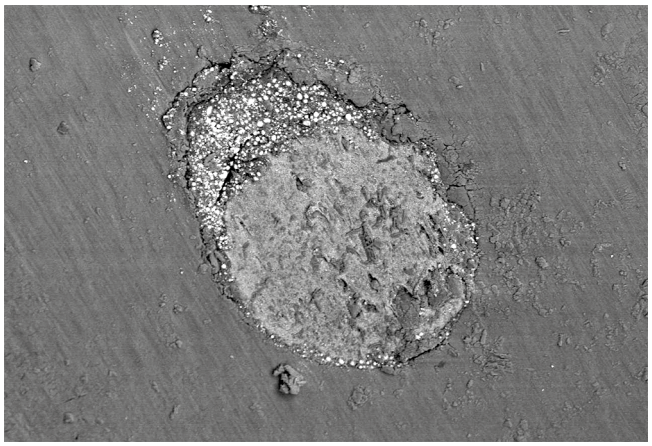

**Fig. 3.** The absence of a “cork” effect in the presence of a tug-back effect

**Рис. 3.** Отсутствие эффекта «пробки» при наличии tug-back эффекта

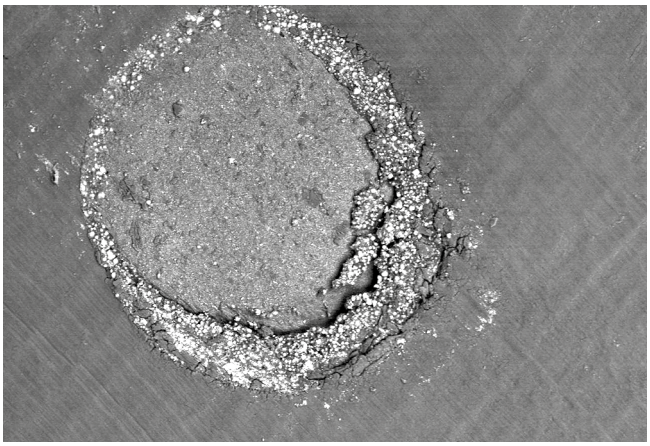

**Fig. 4.** Minimum amount of strength in the absence of a tug-back effect

**Рис. 4.** Минимальное количество силера при отсутствии tug-back эффекта

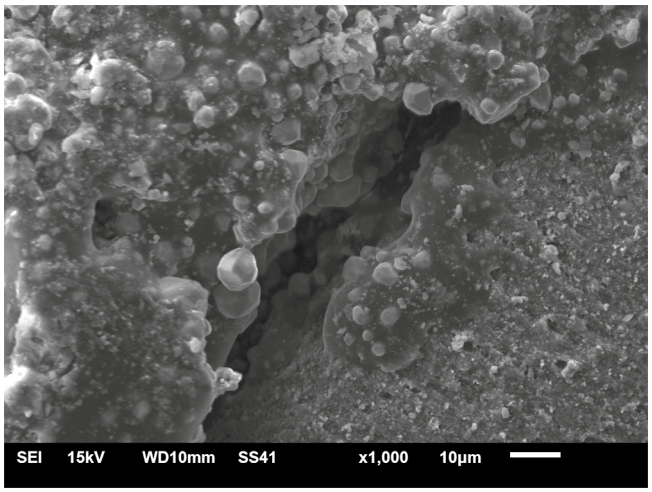


**Fig. 5.** Particles of sealer filler free from the matrix

**Рис. 5.** Частицы наполнителя силера, свободные от матрицы

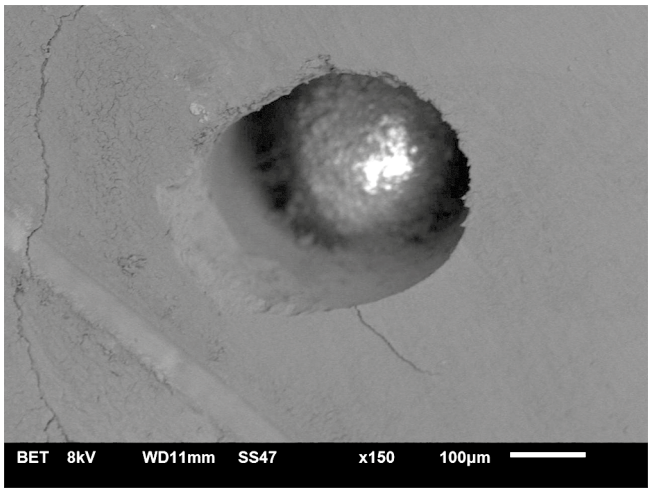


**Fig. 6.** The tip of the gutta-percha pin, free from the sealer

**Рис. 6.** Кончик гуттаперчевого штифта, свободный от силера

However, in clinical practice, this ideal obturation pattern is not always achieved. When the root canal is prepared up to an ISO size 35 master file, the tug-back effect at the apex may occur due to the gutta-percha cone contacting the canal walls at only 2–3 prominent points rather than along the entire canal circumference (Fig. 3). This suggests an insufficient apical preparation diameter to achieve the expected obturation of the apical constriction. Conversely, some teeth without the tug-back effect demonstrated a minimal amount of sealer around the master cone tip (Fig. 4).

In a simulated model of periapical tissue edema following primary endodontic treatment, fluid penetration into the structure of the root canal filling was observed. Micrographs of some tooth sections revealed gaps between the sealer and dentin, as well as filler particles located on the surface of the polymerized epoxy resin (Fig. 5). The loose arrangement of filler particles indicates the presence of fluid during the polymerization process.

Sections were also obtained in which the tip of the gutta-percha cone tightly sealed the canal lumen at the apical constriction and was free of sealer at the apical end (Fig. 6). However, the intracanal portion of the root filling was fully polymerized. This finding provides practical evidence supporting the theoretical possibility of obturating the apical constriction with a gutta-percha master cone to isolate the intracanal filling mass and promote better polymerization.

## CONCLUSION

The study revealed that the presence of the tug-back effect during the preparation and filling of single-rooted, single-canal teeth does not consistently improve the sealing ability of the apical portion of the root canal filling. This is likely due to insufficient apical enlargement of the root canal. Numerous studies have shown that the cross-sectional shape of the apical constriction in anterior teeth is often not geometrically round and tends to be oval in approximately 60% of cases. The larger dimension of the constriction corresponds to the recommended apical preparation diameter, which is ISO size 60 for maxillary incisors and ISO size 40 for mandibular incisors, canines, and premolars [5–8].

A promising area for further research would be to assess the influence of the cross-sectional configuration of the prepared root canal on the sealing ability of the apical portion of the root canal filling.

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