Scanning Electron Microscopic Evaluation and Comparative Efficacy of MTAD, Smear Clear, and Dent Wash in Smear Layer Removal

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INTRODUCTION

The success of root canal therapy mainly depends on thorough debridement and disinfection of root canal system and three dimensional obturation. Inspite of the vast options available in Hand and Engine driven root canal instruments, intricate areas like fins and other variations in the root canal system still remain inaccessible to the instrumentation techniques.[1] Hence irrigation solutions play a major role in cleaning and disinfecting the root canal.

Mc Comb and Smith[1] in 1975 observed that smear layer was produced on the instrumented root canal dentin. Smear layer consists of superficial layer and a deeper layer packed into dentinal tubules, approximately 1 – 2 µm and 40 µm in thickness respectively[2]. The inorganic material of the smear layer is made up of tooth structure and some non specific inorganic contaminants. The organic component of smear layer is comprised of heat coagulated proteins, necrotic or viable pulp tissue, odontoblastic processes, saliva, blood cells and micro organisms.

Chemically, smear layer is considered to be an avenue for invasion. Viable bacteria may use smear layer for sustaining their growth and activity. The presence of a smear layer inhibits the penetration of intracanal irrigants and medications into the dentinal tubules. Following the removal of smear layer, bacteria in the dentinal tubules can be easily destroyed. Removal of smear layer also allows greater penetration of the root canal sealers into the dentinal tubule openings aiding an intimate adaptation of the obturating materials with the prepared canal walls.[2,3]

Various agents like organic acids, chelating agents, ultrasonics and lasers have been used for the removal of smear layer. Among these, the chelating agent, ethylene diamine tetra-acetic acid (EDTA) in its different physical forms and formulations is the most commonly used agent for smear layer removal. In this study Dent Wash, composed of 17% EDTA in solution form, MTAD a mixture of tetracycline isomer, 4.25% citric acid, and detergent (Tween 80) and Smear Clear a

mixture of 17% EDTA solution including cationic (cetrimide) and an anionic (Polyoxyethylene (10) iso-octylcyclohexyl ether) surfactant are compared.

Aim :

The aim of the present study is to evaluate and compare the ability of MTAD, Smear Clear and Dent Wash in removing the smear layer by scanning electron microscopic examination.

Materials and methods :

Sixty recently extracted maxillary and mandibular single – rooted human teeth with relatively straight roots were used. Immediately after extraction, the teeth were washed under tap water and were cleaned with a hand scaler to remove any calculus or soft tissue debris. The teeth samples were then stored in normal saline at room temperature. The coronal part of the teeth was separated using a diamond disk at the level of the cementoenamel junction. The patency of the canals was verified by passing a #10 file through the canal space so that the file passed till the tip was visible. This distance minus 1 mm was taken as working length. A small blob of softened wax was placed at the apex of each tooth to simulate the natural apical counter pressure and to prevent any flow of irrigants. To aid splitting of the samples the external surface of each root was grooved longitudinally, on mesial and distal side using a diamond disk.

All the teeth were prepared by Protaper instrument system to an apical size of F3. In Group I only normal saline was used as irrigant during instrumentation and as final rinse. In Groups II, III, IV normal saline and 1.3% sodium hypochlorite were used alternately as irigants during instrumentation. The irrigants were delivered using 28 guage, needles that penetrated to within 1-2 mm form the working length in each canal.

In all the Groups, instrumentation was followed by rinsing the canal with 10 ml of sterile distilled water to minimize potential interactions with any of the test irrigants used as final rinse. All teeth in the three groups were subjected to 5 ml of the respective test irrigants as the final rinse.

All the teeth were randomly divided into 4 groups containing 15 teeth each.

The following table shows the irrigant used during instrumentation and the test irrigants used as the final rinse in each group.

Table :

Group	**Irrigating solution during root canal preparation**	**Final rinse solution for removal of smear layer**
I	Normal saline	Normal saline
II	Normal saline and 1.3% sodium hypochlorite used alternately	MTAD

III	Normal saline and 1.3% sodium hypochlorite used alternately	Smear Clear
IV	Normal saline and 1.3% sodium hypochlorite used alternately	EDTA

Group I Normal Saline :

Normal Saline was used during and after instrumentation.

Group II: MTAD :

1 ml of MTAD was delivered to within 2 mm of the working length using a 28 gauge needle. MTAD was left in canal for approximately 5 minutes after which remaining 4 ml solution was used to rinse the canal.

Group III. Smear Clear :

The roots were flooded with 5 ml of Smear Clear solution using a 28 gauge needle. Solution was left in canal for approximately 2 minutes as per the manufacturer's instruction.

Group IV EDTA :

The root canals were flooded with 5 ml of liquid EDTA delivered using a 28 gauge needle. EDTA was left in canal for approximately 2 minutes as per the manufacturer's instruction. A #15 reamer was used in an up and down motion to mechanically agitate, to enable direct contact of irrigation solutions with the root canal wall. In all the Groups, after final rinse, the canals were irrigated with 10 ml of sterile distilled water to terminate any solvent action of the test irrigants and to remove any precipitate that may have formed. All the canals were then dried with sterile paper points. Later, each dried specimen was split into two with chisel and mallet along the prepared groove. One half of each specimen was discarded and the other half was prepared for scanning electron microscopic examination.

Photomicrographs were taken at X5000 magnification and 10KV. Three photomicrographs were taken for each specimen at 3 different levels i;e coronal, middle and apical. They were scored for presence and absence of smear layer at coronal, middle and apical portion of each canal as per the following criteria :

Criteria for removal of Smear Layer :

Score 1 : No smear layer. No smear layer on the surface of the root canals : all tubules were clean and open.

Score 2 : moderate smear layer. No smear layer on the surface of root canal, but tubules contained debris.

Score 3 : Heavy smear layer. Smear layer covered the root canal surface and the tubules.

RESULTS :

Statistical Analysis:

All the analysis was performed using SPSS version 14. A p-value of <0.05 was set to be statistically significant. Mean value comparison among the groups was done using ANOVA followed by post hoc Tukey's HSD test.

Comparison of smear layer removal among the three materials at Coronal third

Table 1 :

Site	Group	N	Mean	Std. Deviation	p-value	Post-hoc test
Coronal 1/3 rd	Control (1)	15	2.73	0.46	**<0.001**	**1 < 2** **1 < 3** **1 < 4**
	MTAD (2)	15	1.20	0.41		
	Smearclear (3)	15	1.27	0.46		
	EDTA (4)	15	1.27	0.46		

Comparison of smear layer removal among the three materials at middle third

Table 2 :

Site	Group	N	Mean	Std. Deviation	p-value	Post-hoc test

Middle 1/3 rd	Control (1)	15	2.80	0.41	**<0.001**	**1 < 2** **1 < 3** **1 < 4**
	MTAD (2)	15	1.20	0.41		
	Smearclear (3)	15	1.33	0.62		
	EDTA (4)	15	1.40	0.63		

Comparison of smear layer removal among the three materials at Apical third

Table 3:

Site	Group	N	Mean	Std. Deviation	p-value	Post-hoc test
Apical 1/3 rd	Control (1)	15	2.80	0.41	**<0.001**	**3 < 2** **4 < 2** **4 < 3** **1 < 2** **1< 3**
	MTAD (2)	15	1.27	0.46		
	Smear Clear (3)	15	1.93	0.80		
	EDTA (4)	15	2.60	0.51		

DISCUSSION :

The success of root canal therapy depends on effective instrumentation, irrigation, eradication of microbes and three dimensional obturation. Instrumentation of root canals produces smear layer on the walls, composed of dentin, remnants of pulp tissue, odontoblastic processes and bacteria [3]. Because of the complexity of the root canal system containing intercanal connections and apical ramifications it is impossible to achieve complete disinfection of the root canal system with the current instrumentation systems alone. Adding to the complexity, smear layer limits the penetration of irrigants, medicaments, and sealers into the dentinal tubules causing reduction in their efficacy against the microorganisms. [3,4,5,6,7]. It therefore seems prudent to remove the smear layer from the root canal walls.

Various agents like organic acids, chelating agents, ultrasonics and lasers have been used to remove the smear layer. Amongst these, the chelating agent, ethylene diamine tetra-acetic acid (EDTA) in its different physical forms and formulations is the most commonly used agent for smear layer removal [8]. The present study was carried out to evaluate and compare the ability of a MTAD, a mixture of tetracycline isomer, 4.25% citric acid, and detergent (Tween 80)); Smear Clear a mixture of 17% EDTA solution including cationic (cetrimide) and an anionic (Polyoxyethylene (10) iso-octylcyclohexyl ether) surfactant and Dent Wash, composed of 17% EDTA in solution form, in removing the smear by scanning electron microscopic examination.

Sixty recently extracted maxillary and mandiubular single – rooted human teeth were used in this study. All teeth were decoronated at the level of cementoenamel junction and divided into four groups of 15 teeth each. They were prepared by Protaper NiTi instrument system to an apical size of 30. In Group 1(positive control group), distilled water was used as an irrigant during instrumentation and as final rinse. In Group 2, Group 3 and Group 4, normal saline and 1.3 % sodium hypochlorite were used alternately as irigants during instrumentation. In Group 2/MTAD, Group 3/Smear Clear and in Group 4/ 17% EDTA was used as the final rinse.

The specimens were then prepared for Scanning Electron Microscopic (SEM) examination. Photomicrographs were taken at X5000 maginification at 3 different levels, coronal, middle and apical thirds. Photomicrographs were evaluated for presence or absence of the smear layer using a scoring system [9] .

Results of the present study showed that in Group 1, the positive control group, showed heavy smear layer over the entire length of the root canal walls. Mohmoud Torabinejad et al[10] in 2003, Franklin R. Tay et al[11] in 2006 showed that when distilled water was used as the irrigant dentinal walls showed no removal of smear layer.

In Group 2, where a combination of NaOCl and MTAD was used, most root surfaces in coronal, middle and apical thirds had no smear layer. The coronal and middle third areas showed complete smear layer removal in 80% of smaples. In apical third, 73 % of samples showed complete smear layer removal. In the rest of the samples only moderate amount of smear layer was observed. None of the samples showed heavy smear layer. These findings are in agreement with the study of Mahmoud Torabinejad et al. in the ten samples irrigated with 1.3 % NaOCl and MTAD, they found 27 out of 30 root canal surfaces having complete smear layer removal. Moderate smear layer was observed in the remaining samples[12]. The results obtained in the present study are also same as Faruk Haznedaroglu et al [13] (2001) who revealed that application of tetracycline hydrochloride resulted in complete removal of smear layer. The cleaning ability of tetracycline based MTAD can be attributed to its ability to chelate calcium[14]. Further tetracyclines are broad spectrum antimicrobials and can bind directly to the demineralized dentinal surfaces and is released over extended period of time.

In Group 3, where a combination of sodium hypochlorite and 17 % ethylene diamine tetra acetic acid was used, coronal and middle third areas showed complete absence of smear layer in 73% of samples. In coronal third 27% of samples showed moderate smear layer. In middle third 20% of samples showed moderate and 7 % samples showed heavy smear layer. In apical third 33 % of samples showed complete absence of smear layer and 40% of samples showed moderate smear layer and 27% of samples showed heavy smear layer. The present study showed that Smear Clear is not effective in complete removal of smear layer in the apical third.The result of the present study is in corroboration with study conducted by Sedigheh Khedmat et al[15] who showed that

when Smear Clear was used as final rinse most of the specimens showed moderate smear layer on the coronal, middle and apical thirds. Another study conducted by Lea et al [16] showed that when Smear Clear was used as final rinse, out of the 24 root canal surfaces tested, 12 surfaces showed no smear layer and 12 surfaces showed moderate smear layer. Smear layer removal action of ethylene diamine tetra acetic acid can be attributed to its chelation action on the root canal. The moderate smear removal observed in the apical third may be due to incomplete penetration of ethylene diamine tetra acetic acid in the apical area of the root canal.

In Group 4, where a combination of sodium hypochlorite and 17% Ethylene diamine tetra acetic acid was used, in the coronal third 73% of samples and in middle third 67% of samples showed complete absence of smear layer. In coronal and middle third 27 % of samples showed moderate smear layer. In the apical third 40% of samples showed moderate smear layer. 6 % of samples in middle third and 60% of samples in apical third showed heavy smear layer. In apical third none of the samples showed complete smear layer removal.

The findings of the present study corroborate with Sedigheh Khedmat et al [15] who also found that when 17% EDTA was used as final rinse, no smear layer was detected on the surface of most of the specimens in coronal and middle thirds, but a moderate smear layer was observed in the apical third of most of the specimens.

O'Connell et al[8] conducted a study to compare the ability of various salts of EDTA 15% concentration of alkaline salt, 15% concentration of acid salt and 25% sodium hypochlorite. They showed that all salts of EDTA were capable of removing the smear layer from coronal and middle thirds of the instrumented root canals but were less effective in apical third. None of the solutions were effective in completely removing the smear layer at any level. The results of the present study also show that EDTA is less effective in apical third of the root canals.

Smear layer removal action of EDTA can be attributed to its chelation action on the root canal. The moderate smear removal observed in the apical third may be due to incomplete penetration of EDTA in the apical area of the root canal. In contrast, a study conducted by Lea et al[16] showed that when 2.5% sodium hypochlorite and 14.3% of EDTA were used during cleaning and shaping all the root canal walls were free of debris and smear layer.

On comparison of smear layer removal in coronal third and middle third, no statistically significant difference was found among Group 2 (MTAD), Group 3 (Smear Clear) and Group 4 (EDTA).

In a study conducted by Torabinejad et al [10] using MTAD and 17%EDTA as final rinse, no significant difference was observed in the coronal and middle thirds in the remaining debris. In the apical third MTAD produced significantly cleaner surface than EDTA. Lea et al [16] observed that Smear Clear and EDTA were equally effective in smear layer removal when used as final rinse in all the areas of the root canal. Sedigheh Khedmat etal [15] found no significant difference between Smear Clear, 10% citric acid and 17%EDTA in smear layer removal at all levels of root canals.

On comparison of smear layer removal in apical third, a statistically significant difference was found among all the groups. The results of the present study showed that smear layer removal in apical third was better in Group 2(MTAD) when compared to Group 1(control) and Group 4(EDTA). These results are in agreement with those of Mahmoud Torabinejat et al who showed more effective removal of smear layer by MTAD as compared to EDTA in the apical area.

On comparison of smear layer removal in apical third, a statistically significant difference was found between Group 2 and Group3. In the present study there was no significant difference in the smear layer removal from coronal and middle third between Smear Clear and EDTA. But in the apical third it was observed that a statistically significant difference was found between Group 3 and Group 4.

Abou-Rass and Patonai [17] confirmed that reduction of surface tension of endodontic solutions improved their penetration into narrow apical regions of the root canals and promote intimate contact with the dentinal walls.. This can be attributed to the presence of two additional surfactants in Smear Clear which reduces the surface tension. Further it was shown by Luciano Giardino et al[18], Smear Clear has less surface tension than EDTA. Lower surface tension of Smear Clear could have allowed deeper penetration of Smear Clear.

In the apical region of the root canal, due to its anatomy, penetration of irrigants is often difficult resulting in reduced effect of the irrigant solutions. In this respect, the present study showed that Group 2 performs better than Group 3 (Smear Clear) and Group 4 (EDTA). This may be attributed to synergistic action of citric acid, doxycycline along with a detergent, present in MTAD.

CONCLUSION

Thus, it was observed from the present study that the use of MTAD as a final rinse, leads to more complete removal of smear layer than Smear Clear and EDTA at all the three levels of the root canal.

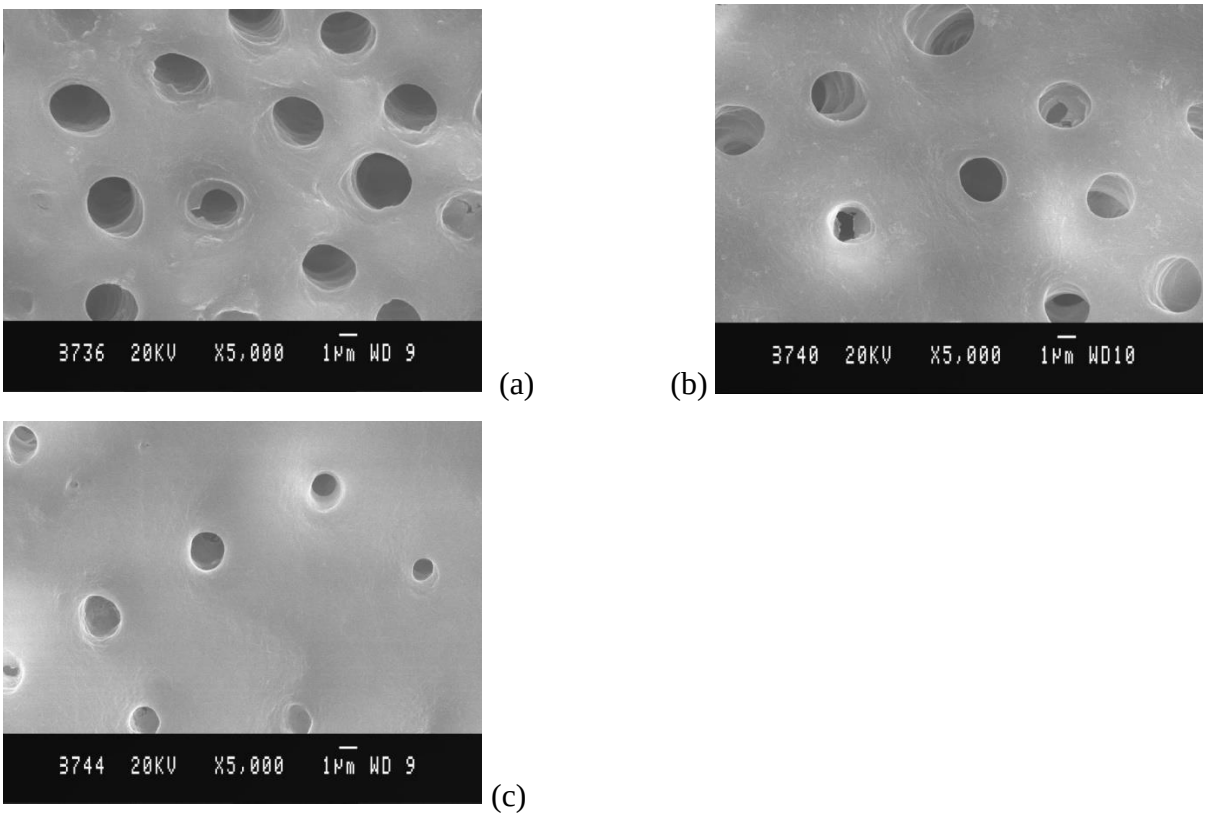
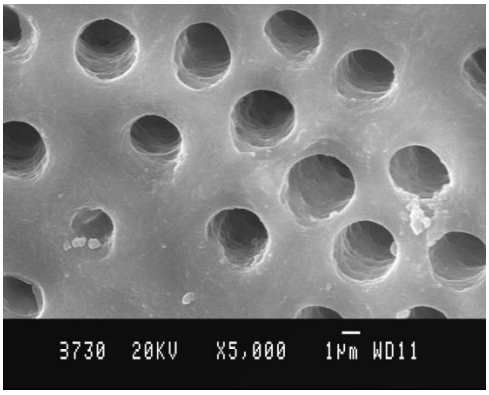
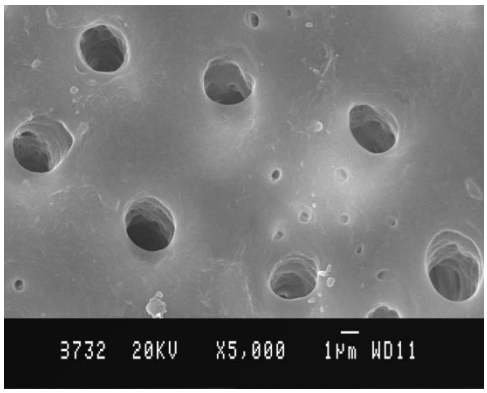


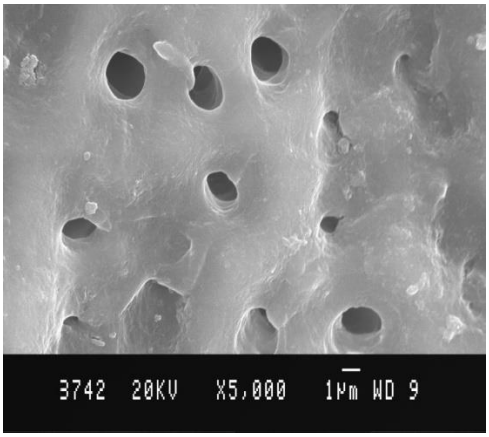
Fig1. SEM photomicrocraph of Group 2 (MTAD) at coronal (a), middle(b) and apical(c) thirds.



(a)



(b)



(c)

Fig2. SEM photomicrocraph of Group 3 (Smear Clear) at coronal (a), middle(b) and apical(c) thirds.

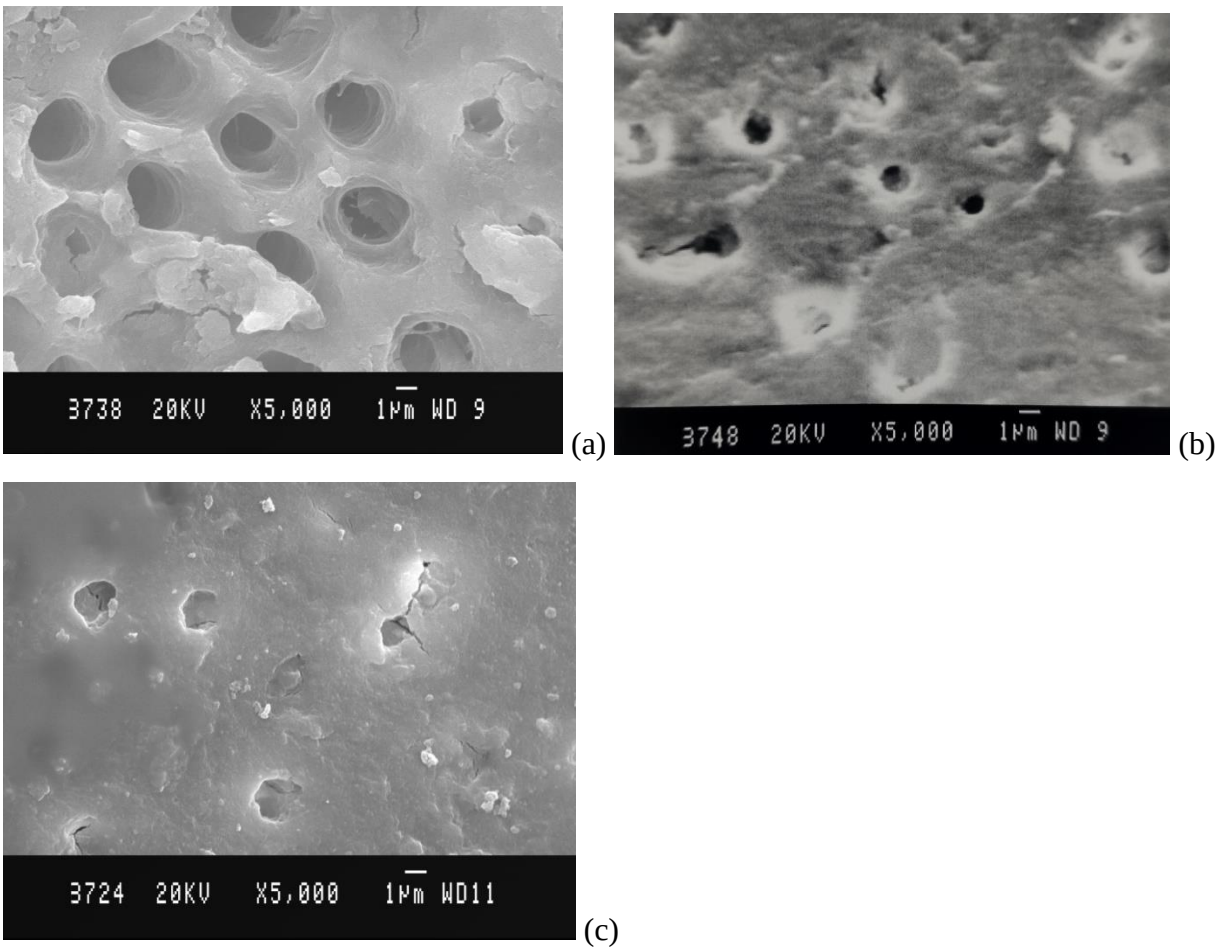


Fig 3. SEM photomicrocraph of Group 4 (EDTA) at coronal (a), middle(b) and apical(c) thirds

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