ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

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End-Morphology of Orthodontic Toothbrush Filaments: A Stereomicroscope Analysis: Cross-Sectional Research

Ortodontik Diş Fırçalarının Kıl Ucu Morfolojisi: Bir Stereo Mikroskop Analizi: Kesitsel Araştırma

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ABSTRACT Objective: The aim of this study was to examine and evaluate the form of filaments of four manuel orthodontic toothbrushes by stereomicroscope analysis. The existing literature lacks findings on the end morphology of orthodontic toothbrush bristles. **Material and Methods:** Eight samples from four different orthodontic toothbrush brands (Glimo Orthodontic Oral Care, Pearldent Ortho, Tepe Implant Orthodontic, Curoprox Ortho) were collected. After determining tuft numbers, two tufts from each toothrush head from the opposite sides collected by using a carbon disk and filaments from each sample were attached on a bristle paper with transparent tape. A total of 16 tufts were independently evaluated by an observer using a stereomicroscope (Zeiss Stemi 508, Germany) at 8x magnification. Bristle end morphologies were classified as acceptable and non-acceptable according to the Silverstone and Featherstone scale. Pearson's chi-square test was employed to analyze differences between toothbrush types. In instances where the estimated values did not reach sufficient levels, Monte Carlo simulation was used. The level of statistical significance was set at 0.05. **Results:** The bristle ends morphologies of Glimo and Pearldent toothbrushes were found to be 100% non-acceptable. There was a significant difference between toothbrush brands in terms of the distribution of bristle tip morphologies. (p=0.000). Specifically, 75.6% of Tepe brand filaments were deemed acceptable, while Curaprox exhibited an acceptable filament percentage of 48.2%. **Conclusion:** Among the evaluated toothbrush brands, Tepe emerged as the most acceptable orthodontic toothbrush, with 75.6% of filaments meeting the acceptable criteria. Conversely, Glimo and Pearldent displayed no acceptable bristle tip morphology.

Keywords: Orthodontic appliances; toothbrushing; microscopy

ÖZET Amaç: Bu çalışmanın amacı, 4 adet manuel ortodontik diş fırçasının filament formlarının stereo mikroskop analizi ile incelenerek değerlendirilmesidir. Güncel literatür taramasına göre; ortodontik diş fırçalarının kıl ucu morfolojisine dair bulgu yer almamaktadır. **Gereç ve Yöntemler:** Dört farklı ortodontik diş fırçası markasından (Glimo, Ortodontik Ağız Bakım, Pearldent Orto, Tepe İmplant Ortodontik, Curaprox Ortho) sekiz örnek toplandı. Demet sayıları belirlendikten sonra karbon disk kullanılarak her bir diş fırçalama başından karşılıklı ikişer demet toplandı ve her numuneden gelen filamentler şeffaf bantla Bristol kâğıdı üzerine yapıştırıldı. Toplam 16 demet stereo mikroskop (Zeiss Stemi 508, Almanya) kullanılarak 8x büyütmede bir gözlemci tarafından bağımsız olarak değerlendirildi. Kıl ucu morfolojileri Silverstone ve Featherstone sınıflandırmasına göre kabul edilebilir ve kabul edilemez olarak değerlendirildi. Farklı diş fırçası türlerine ilişkin bulgular arasındaki farklılıklar Pearson ki-kare testi ile analiz edildi. Tahmin edilen değerlerin yeterince büyük olmadığı durumlarda Monte Carlo simülasyonu kullanıldı. İstatistiksel anlamlılık düzeyi 0,05 olarak tanımlandı. **Bulgular:** Glimo ve Pearldent diş fırçalarının kıl ucu morfolojileri %100 kabul edilemez bulunmuştur. Kıl ucu morfolojilerinin dağılımı açısından diş fırçası markaları arasında anlamlı fark vardı (p=0,000). Buna göre; Tepe markasında filamentin %75,6'sı kabul edilebilir, Curaprox'ta %48,2 filament kabul edilebilir olarak bulunmuştur. **Sonuç:** İncelenen diş fırçası markaları arasından %75,6 kabul edilebilirlik oran ile en kabul edilebilir diş fırçası markası Tepe oldu. Diğer taraftan, Glimo ve Pearldent için kabul edilebilir kıl ucu morfolojisi görülmedi.

Anahtar Kelimeler: Ortodontik gereçler; diş fırçalama; mikroskopi

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Fixed orthodontic appliances can cause some complications such as enamel demineralization, dental carries and gingivitis.[1] Previous studies have indicated a higher incidence of white spot lesions in orhodontic treatment groups compared to untreated control groups.[2,3] Although periodontal condition and oral hygiene are better in patients that received orthodontic treatment due to the proper alignment of the teeth, duration of the treatment may cause undesirable side effects.[4] Despite these concerns, tooth brushing remains the most effective method for preventing oral diseases.[5]

For this purpose electronic and manual tooth brushes are widely used with a variety of innovative toothbrush designs, encompassing modifications in the handle, head, and bristles, available in the market.[6,7]

Gundavarapu et al. emphasized that proper bristle design and effective tooth brushing methods are crucial for plaque removal.[8] American dental association reported that ideal bristles should not be sharp-edged or rough.[9,10] Similarly with these reports Levrini et al. suggested that it should be preferred to use round ended bristles in order to avoid soft tissue trauma and abrasion of dental hard tissues.[11] Silverstone and Featherstone were created a scale in 1988 for defining the form of tooth brushes.[12] While existing literature has extensively studied, electronic and manual tooth brushes according to bristle desing there is a lack of findings spesifically addressing orthodontic tooth brush bristles.

The aim of this study was to examine and evaluate the form of filaments of four manual orthodontic tooth brushes that available in market using stereomicroscope analysis. The hypothesis posited that bristle design would vary between brands according to the Silverstone and Featherstone scale.

MATERIAL AND METHODS

This study was conducted on Akdeniz University, Faculty of Dentistry, Clinical of Orthodontics, Antalya, Türkiye. In this study 8 samples of 4 different orthodontic toothbrush brands (Glimo Orthodontic Oral Care Toothbrush, Pearldent Ortho, Tepe Implant Orthodontic, Curoprox Ortho) were procured from various Turkish markets (Table 1). The total number of tufts were evaluated. After determining tuft numbers, two tufts from each toothrush head from the opposite sides collected using a carbon disk with low speed and filaments from each sample were affixed to a bristle paper with transparent tape. All specimens were independently evaluated by an observer using a stereomicroscope (Zeiss Stemi 508, Germany) at 8x magnification. The evaluations were conducted at two weeks intervals by a single researcher (BCT) who was not involved in the preparation of the samples, based on the Silverstone and Featherstone scale. Prior to study, 20 brush bristles that would not be included in the study were randomly chosen by the researcher and Cohen's Kappa of was calculated (κ=0.90).

A total of 16 tufts were assessed by the researcher, determining the acceptability or non-acceptability of filaments in each tuft according to the Silverstone Featherstone scale (Figure 1). The per-

TABLE 1: The manufacturer names and number of tufts and bristles of toothbrushes examined in the study.

Toothbrush	Manufacturer	Colour	Lot number	Number of tufts	Number of bristles per a tuft	Total bristles
Glimo Orthodontic Oral Care Toothbrush Soft	Haltron, İstanbul, Türkiye	Green	GB30032013	33	38	1254
		Purple	GB30032013	33	38	1254
Pearldent Ortho Soft	DentaRAM, İstanbul, Türkiye	Purple	408654	44	60	2640
		Yellow	408654	44	60	2640
Tepe Implant Orthodontic Soft	TePe Oral Hygiene Products Ltd., Malmö, Sweden	Green	50320460909	20	45	900
		Pink	50320460909	20	45	900
Curoprox Ortho Ultra Soft	Curaden, Kriens, Switzerland	Purple	391298	39	140	5460
		Blue	391298	39	140	5460

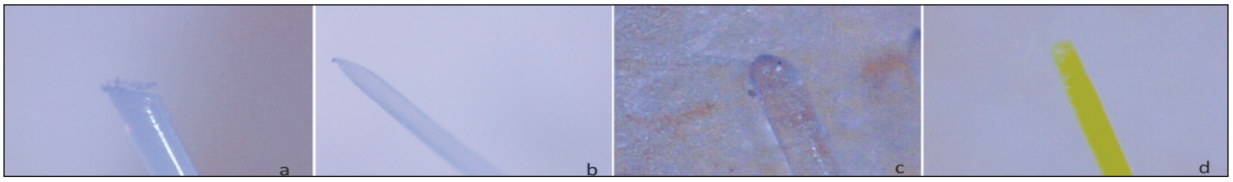

FIGURE 1: Examples of the evaluation of bristle end morphologies of the toothbrushes at 8x magnification according to the Silverstone and Featherstone classification. **(a)** Glimo; non-acceptable; **(b)** Pearldent: non-acceptable; **(c)** Tepe: acceptable; **(d)** Curaprox: non-acceptable

centage of accepted and non-accepted filaments was then calculated.

STATISTICAL ANALYSIS

All of the data were analyzed with IBM SPSS software version 22.0 (IBM, Armonk, NY, USA). The differences between the findings pertaining to different types of toothbrush were analyzed with Pearson's chi-square test. In cases where estimated values did not reach sufficient levels, Monte Carlo simulation was employed. The level of statistical significance was set at *0.05*.

RESULTS

The data on bristle end morphologies of the examined toothbrushes, categorized as acceptable and non-acceptable according to the Silverstone and Featherstone scale, are presented in Table 2 and Figure 2.

Accordingly, the bristle tip morphologies of Glimo and Pearldent toothbrushes were found to be 100% non-acceptable. For Tepe's first evaluated toothbrush (green), 74.4% exhibited acceptable bristle tip morphology, while the second one (pink) demonstrated 76.7% acceptability. Regarding Curaprox, the first toothbrush (purple) had 48.6% acceptable bristle tips, and the second one (blue) was deemed acceptable at 47.9%.

The average acceptable and non-acceptable percentages of all toothbrush brands are shown in Table 3. There was a significant difference between toothbrush brands in terms of the distribution of bristle tip morphologies. (p=0.000). According to this; in Tepe

TABLE 2: Distribution of bristle tip morphologies classified as acceptable and non-acceptable according to the toothbrush brands.

			Acceptable			Non-acceptable		
Toothbrush brands	**Sample**	**Bundle**	**n**	**%**	**Mean %**	**n**	**%**	**Mean %**
Glimo	Green	1	0	0	0	38	100	100
		2	0	0		38	100	
	Purple	1	0	0	0	38	100	100
		2	0	0		38	100	
Pearldent	Purple	1	0	0	0	60	100	100
		2	0	0		60	100	
	Yellow	1	0	0	0	60	100	100
		2	0	0		60	100	
Tepe	Green	1	34	75.6	74.4	11	24.4	25.6
		2	33	73.3		12	26.7	
	Pink	1	35	77.7	76.7	10	22.3	23.3
		2	34	75.6		11	24.4	
Curaprox	Purple	1	68	48.6	48.6	72	51.4	51.4
		2	68	48.6		72	51.4	
	Blue	1	67	47.9	47.9	73	52.1	52.1
		2	67	47.9		73	52.1	

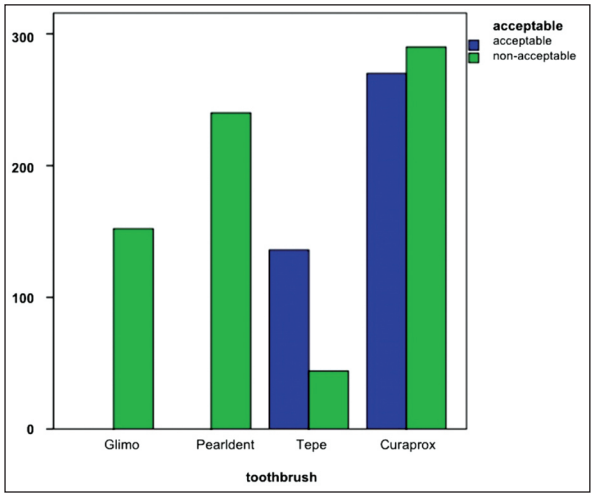

FIGURE 2: Graphical representation of the distribution of bristle end morphologies, evaluated according to Silverstone and Featherstone classification.

TABLE 3: Statistical comparison of the distribution of acceptable and non-acceptable bristle tip morphologies according to toothbrush brands.

	Acceptable		Non-acceptable		
	n	%	n	%	p-value*
Glimo	0	0	152	85.9	0.000
Pearldent	0	0	240	72.1	
Tepe	136	75.6	44	24.4	
Curaprox	270	48.2	290	51.8	

*Chi-square.

brand, 75.6% filament was acceptable, 24.4% was non-acceptable; in Curaprox, 48.2% filament was found to be acceptable and 51.8% was non-acceptable. Among the toothbrush brands, the most acceptable toothbrush brand was Tepe. Glimo and Pearldent were not have any acceptable bristle tip morphology.

DISCUSSION

The orthodontic patients mostly prefer orthodontic toothbrushes due to their special configuration for removing plaque on brackets and bands. However there are conflicting findings in comparison between conventional and orthodontic toothbrushes. Some researchers suggest that there is not any difference on plaque removal between conventional toothbrushes and orthodontic toothbrushes whereas others report better plaque removal by using orthodontic toothbrushes.[13-15]

This study was conducted to evaluate four different brands of orthodontic toothbrushes according to the Silverstone and Featherstone scale. Tepe-branded orthodontic toothbrushes demonstrated the highest acceptability, while Glimo and Pearldent were deemed non-acceptable based on the scale. The second-highest bristle configuration rated acceptable was found in Curaprox. Our results suggest that Tepe branded orthodontic toothbrushes were the safest option for preventing abrasive dentin wear and gingival recession.

The bristle configuration of Pearldent was tapered end which is not recommended by the American Dental Association. The percentage of acceptable bristle configuration based on the Silverstone Featherstone scale was 0%. On the other side, Hamza et al. suggested that tapered end bristles are less abrasive than round end ones regardless of the applied brushing force.[16] They attribute this observation to the spacing between tufts, explaining that rounded bristles occupy more space, causing less flexion with a denser surface.

Another innovative alteration involves the design of a multilevel bristle configuration. Glimo and Curaprox have multilevel bristle designs for enhancing tooth brushing effectiveness. It was reported that multilevel designed toothbrushes are more effective in removing plaque from interdental areas.[17] However, in contrast to this finding, Farook et al. reported that flat trim toothbrushes were more effective in plaque removal for orthodontic patients.[18] The acceptable bristle configurations for multilevel orthodontic toothbrushes as Curaprox and Glimo were 48.2% and 0% respectively.

In a clinical study, it was reported that low cost tooth brushes were as effective as other popular branded tooth brushes. However, they did not assess the dentin abrasion and gingival recession.[19] In our study, we found 0% acceptable bristle configuration according to the American Dental Association for less popular brands like Pearldent and Glimo. Considering the definition of user-friendly toothbrushes, which should effectively remove plaque without damaging to oral tissues, we suggest that economic factors alone should not be the sole consideration.[20]

The bristle configuration of Tepe-branded orthodontic toothbrush was found to be the most suitable, with a percentage of 75.6% according to Silverstone and Featherstone scale. In contrast our findings, in a previous study it was reported 1% acceptable bristle end for the same toothbrush.[21] We attribute this difference to potential changes in the production process over the years.

To eliminate potential variations in the manufacturing process, we assessed two orthodontic toothbrushes for each brand. Additionally, we examined the tufts from the far corners of the head to ensure standardization, particularly with multilevel and flat surface toothbrushes.

It was reported that, the sputter coating procedures cause temperature rising that alters bristle morphology.[22] Thus we used stereomicroscope instead of scanning electron microscopy.

This study does have certain limitations. Firstly, it was not a clinical study. Secondly, despite the abundance of products in the market, we only evaluated four different orthodontic toothbrushes. Besides this, while Jung et al. recommended to evaluate bristle configuration from five points for each sample, the specific designs of some products made this unfeasible in our study.[23] Therefore, we selected two tufts for each sample.

CONCLUSION

Among the evaluated toothbrush brands, Tepe emerged as the most acceptable, while Glimo and Pearldent exhibited non-acceptable bristle tip morphology. Tepe-branded orthodontic toothbrushes were identified as the safest option for preventing abrasive dentin wear and gingival recession.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

All authors contributed equally while this study preparing.

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