*Section: Research paper*

# Comparative evaluation of prophylactic and shear bond strength of orthodontic brackets with different toothbrush bristles –An in vitro study

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**ABSTRACT**

The objective of this study was to assess how brushing with soft, medium and hard bristle toothbrushes affected the shear bond strength of orthodontic brackets attached to removed human teeth. Following a mock brushing of the teeth, the bristle wear and bristle tip morphology were also assessed. 45 removed human molar and premolar teeth had orthodontic brackets attached on their smoothest surfaces. Test samples were allocated into three groups at random: Group 1, the control group, brushes their teeth with nothing; Group 2, the Oral B ; and Group 3, the Colgate 360. Samples were modified for a device that mimicked brushing teeth. A mechanical testing device was used to evaluate the binding strength between each bracket and each tooth. Furthermore evaluated were the bristle wear and bristle tip morphology indexes.The threshold for statistically significant differences was set at 0.05. There were no differences in the group's average bond strengths. Compared to the Oral B toothbrush, the Colgate brush demonstrated reduced bristle wear and superior bristle tip morphology. The binding strength of the orthodontic brackets was unaffected by the usage of either toothbrush, though. Consequently, any toothbrush can be used without risk by individuals receiving orthodontic treatment.

## Introduction

Plaque buildup is widely known to play a role in the etiology of caries and periodontal disease. Biofilm clearance is crucial to disease prevention and therapy. Personal teeth brushing and auxiliary techniques are the most cost-effective, practicable, and accessible approach of biofilm eradication [1]. Those undergoing orthodontic therapy, on the other hand, have a difficult time adopting oral hygiene techniques. Bands, brackets, and arches of the orthodontic device operate as barriers, preventing toothbrush brushes and supplementary cleaning from reaching the underlying tooth surface. This condition promotes biofilm production, which promotes gingivitis and caries formation[2,3].

Many developments have been advocated in the area of orthodontics throughout the previous 50 years. One significant difference was the substitution of direct bracket-bonding to the tooth enamel for the oral general bandage approach. This modification eased the fitting of permanent equipment and allowed for a shorter orthodontic treatment duration[4]. Nevertheless, the possibility of bracket separation is created, which can result in treatment delays and increased expenditures[5]. The bond strength of the bracket is also potentially affected by the friction generated during tooth-brushing[6,7]. The frictional force of toothbrushes on orthodontic brackets may alter the bristle morphology through wear. Worn toothbrushes reduce biofilm removal during brushing[8,9]. To avoid gingival tissue injury, round-tipped bristles are advised[10]. Some forms are related with abrasions at the cement-enamel interface and gingival recessions[11,12].These considerations are critical when deciding whether to replace an old toothbrush with a new one. Our team has extensive knowledge and research experience that has translate into high quality publications [13–22]

The purpose of this study was to see if brushing with a soft, medium, or hard bristled toothbrush changes the bond strength of orthodontic brackets as well as the wear of the bristles and bristle tips after two years of simulated brushing.

# MATERIALS AND METHODS

## Sample preparation and experimental conditions

Forty-five extracted human premolar and molar teeth were used in this study, which was approved by the SIMATS Ethical Committee. As selection criteria, the teeth had to be intact and free from restorations, caries, or root wear. The surfaces of each tooth were polished with rubber cups and non-fluoride prophylactic paste for 20 s, simulating a recent cleaning. Afterwards, orthodontic brackets were bonded to the flattest surface of each tooth. The material used to bond the brackets was a BIS-GMA resinous system (Transbond XT, 3M Unitek, Monrovia, California, USA) that was light-polymerized. A single researcher performed bonding following the manufacturer's instructions. After bonding, samples were individually stored in glass jars containing 5 ml of distilled water and maintained at 37°C. They were then stabilized in an auto-polymerizing acrylic resin, made using a metal matrix designed for this study, to obtain 45 test specimens.

The test specimens were randomly distributed into three groups:
Group 1, control group with no brushing;

Group 2, brushing with the Oral B Indicator 35 toothbrush (Oral B)
Group 3, brushing with the Colgate 360° toothbrush (Colgate-Palmolive).

Samples were adapted to a brushing machine, projected by the discipline of removable partial denture that simulated a two-year brushing period with a force of 200 N, frequency of 10 RPM, and 20,000 cycles of brushing movements.13

| Groups | Brushing | Bond strength | Wear of bristle tip |
|---|---|---|---|
| control | NO | YES | NO |
| Soft Bristle | YES | YES | YES |
| Medium bristle | YES | YES | YES |
| Hard bristle | YES | YES | YES |

## Analysis of bracket bond strength

The test specimens were modified to fresh auto-polymerizing acrylic resin blocks when the brushing phase was finished. A skilled, blinded researcher used a mechanical testing device (INSTRON) to assess the binding strength. The scale was set to 50 kg, the machine speed was set at 1.0 mm/min, and the recording speed was kept at 20 mm/min. 7 Each sample's required force to break the binding between the orthodontic bracket and wire was confirmed.

## Analysis of brush bristles

Following brushing simulations, the bristle wear and bristle tip morphology of 30 toothbrushes (15 Colgate 360° and 15 Oral B Indicator 35) were evaluated. As a pre-brushing reference, ten new toothbrushes—five Colgate 360° and five Oral B Indicator 35—were evaluated. Analyzing bristle wear was done using a photographic assessment approach.

## Statistical Analysis

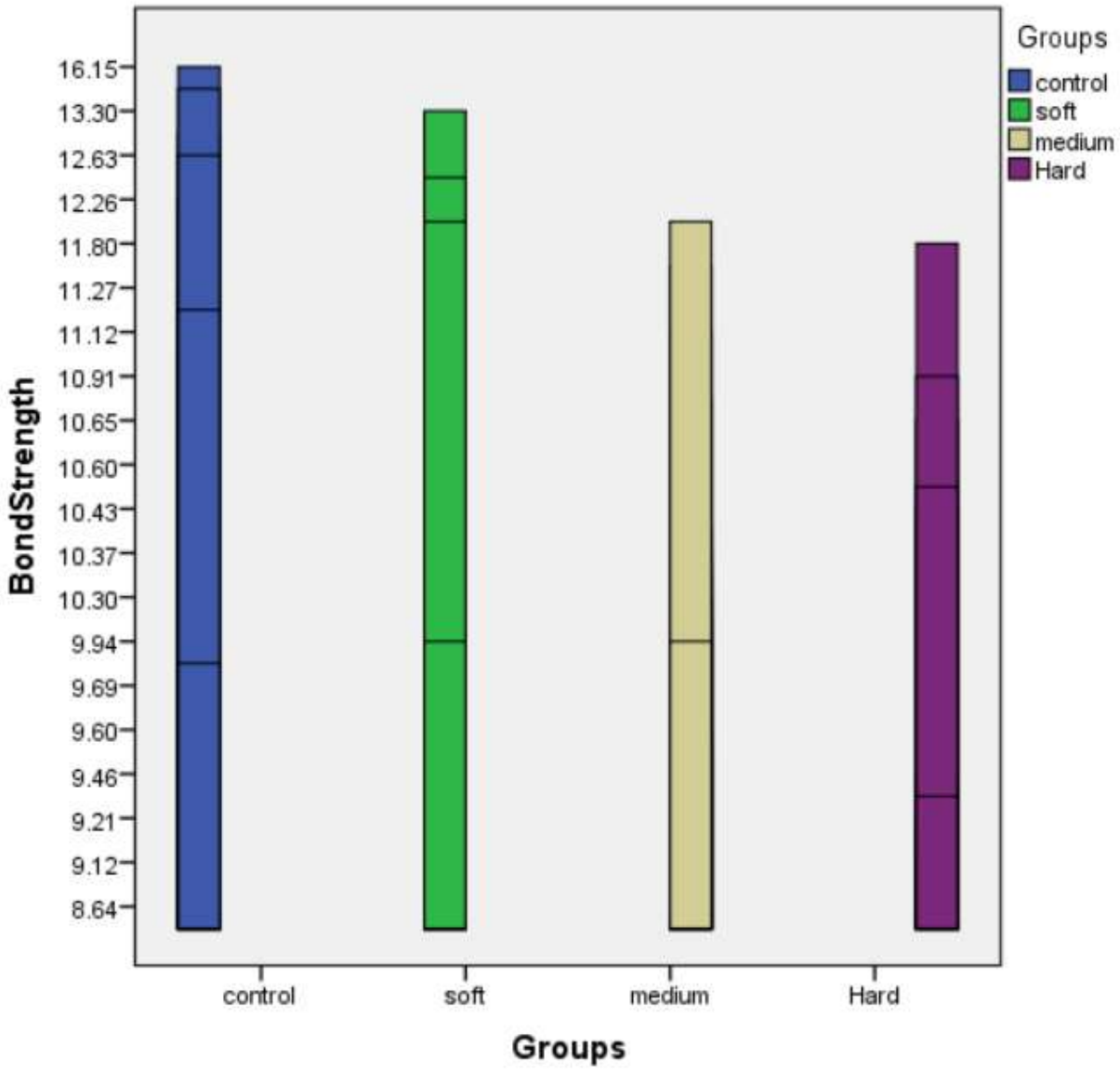
The statistical analyses were performed using IBM SPSS statistics software version 23. One way anova was used for the three groups comparison and post-hoc multiple comparison test was also used.

# Results

## Bracket bond strength

No significant difference was observed for the mean bond strength between Groups 1 (90.60 kgf/ cm²), 2 (90.89 kgf/cm²), and 3 (90.18 kgf/cm²). The bristle wear index (WI) was increased for both toothbrushes (Groups 2 and 3) after completion of the 15,000 brushing cycles.

Figure 1: Represents the graph of bond strength between the groups



## Bristle wear and assessment of bristle tips

Before brushing, the Colgate 360° toothbrush exhibited a more acceptable bristle tip morphology than the Oral B Indicator 35 toothbrush, however after brushing, the Colgate toothbrush displayed a more acceptable bristle tip morphology. For both toothbrushes in Groups 2 and 3, the bristle tip morphology before brushing was preferable to that after brushing. Brushing made the central (Figures 3) bristle tips of the Oral B Indicator 35 toothbrush worse. Brushing the Colgate 360° toothbrush made the side bristles worse but not the core bristles (Figures 4).

Figure 2: Graphic Represents the bristle wear between the three bristles

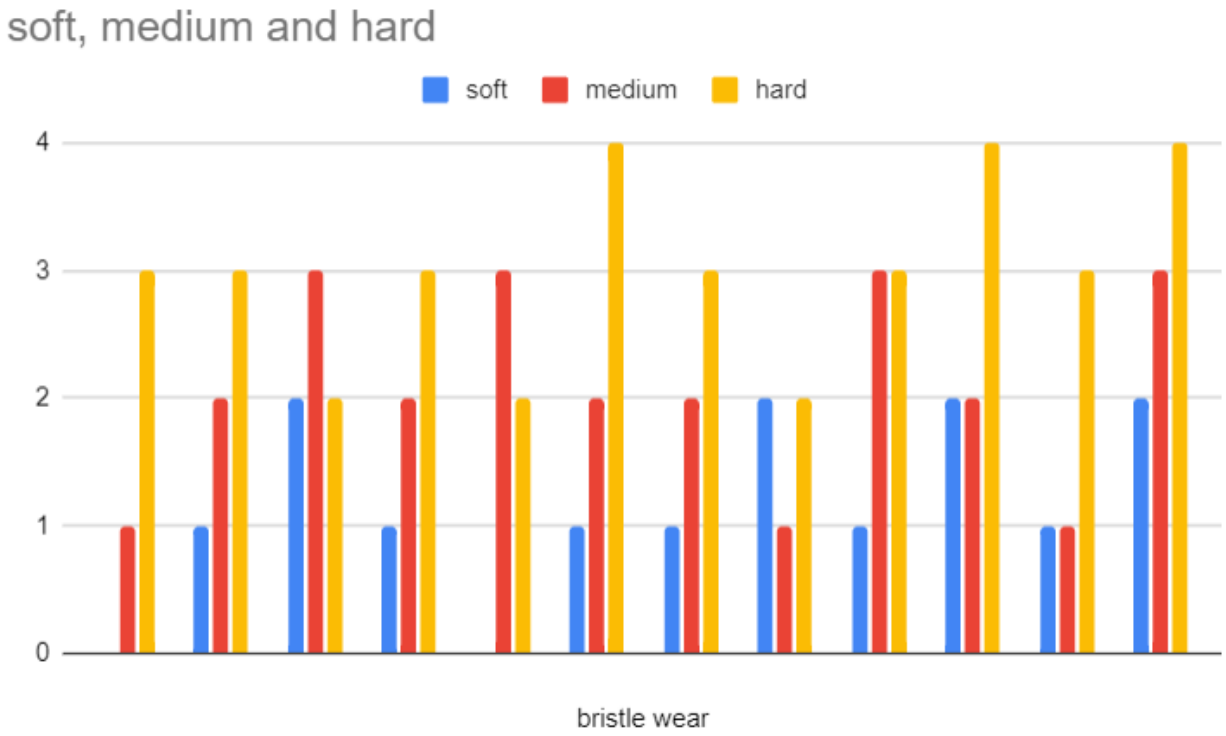


Figure 3: Static representation of the bristle wear between the Groups

BristleWear

| Groups | Mean | N | Std. Deviation |
|---|---|---|---|
| control | .0000 | 12 | .00000 |
| soft | 1.1667 | 12 | .71774 |
| medium | 2.0833 | 12 | .79296 |
| Hard | 3.0000 | 12 | .73855 |
| Total | 1.5625 | 48 | 1.28670 |

Dependent Variable: BristleWear

Tukey HSD

| (I) Groups | (J) Groups | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| control | soft | -1.16667* | .26531 | .000 |
| | medium | -2.08333* | .26531 | .000 |
| | Hard | -3.00000* | .26531 | .000 |
| soft | control | 1.16667* | .26531 | .000 |
| | medium | -.91667* | .26531 | .007 |
| | Hard | -1.83333* | .26531 | .000 |
| medium | control | 2.08333* | .26531 | .000 |
| | soft | .91667* | .26531 | .007 |
| | Hard | -.91667* | .26531 | .007 |
| Hard | control | 3.00000* | .26531 | .000 |
| | soft | 1.83333* | .26531 | .000 |
| | medium | .91667* | .26531 | .007 |

*. The mean difference is significant at the 0.05 level.

Figure 3: Static representation of the bond strength between the Groups

BondStrength

| | N | Mean | Std. Deviation |
|---|---|---|---|
| control | 12 | 11.8750 | 2.08977 |
| soft | 12 | 11.0633 | 1.03967 |
| medium | 12 | 10.4800 | .70410 |
| Hard | 12 | 9.8483 | .98030 |
| Total | 48 | 10.8167 | 1.47847 |

Dependent Variable: BondStrength

Tukey HSD

| (I) Groups | (J) Groups | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| control | soft | .81167 | .53638 | .438 |
| | medium | 1.39500 | .53638 | .059 |
| | Hard | 2.02667* | .53638 | .003 |
| soft | control | -.81167 | .53638 | .438 |
| | medium | .58333 | .53638 | .699 |
| | Hard | 1.21500 | .53638 | .122 |
| medium | control | -1.39500 | .53638 | .059 |
| | soft | -.58333 | .53638 | .699 |
| | Hard | .63167 | .53638 | .644 |
| Hard | control | -2.02667* | .53638 | .003 |
| | soft | -1.21500 | .53638 | .122 |
| | medium | -.63167 | .53638 | .644 |

## Discussion

The Colgate 360° toothbrush is designed to promote optimum hygiene regardless of how you brush. This toothbrush has a tongue cleaner to remove tongue coating, rubber cups for prophylaxis, and different-sized bristles to help remove biofilm in the interproximal zone[23] . (15) These features have been put out to explain why it is more effective than traditional toothbrushes at lowering plaque indices and gingival irritation[24,25] (16,17) These advantages would support the recommendation of this toothbrush to individuals seeking orthodontic treatment.

Yet significant frictional pressures must be used to remove plaque and pigments, which might weaken the binding and cause bracket separation. In contrast to the Oral B Indicator 35, we discovered that the Colgate 360° toothbrush had no effect on how well orthodontic brackets adhered to teeth. The binding strength of metal orthodontic brackets was evaluated by Hansen et al.[7] (1999) by simulating two years of brushing with ordinary electric (Interplak) and sonic toothbrushes (Sonicare). The bond strengths of the control (125.4 kgf/cm2) and sonic toothbrush (79.7 kgf/cm2) groups were significantly different, according to these authors, while the electric toothbrush group (107.5 kgf/cm2) did not differ from either the control or sonic toothbrush group. It was therefore unclear whether the variation in bracket bonding was primarily brought on by mechanical forces or by the impact of the sonic waves emitted by the toothbrushes.

After brushing the test specimens in the current investigation, considerable bristle wear was confirmed. The mechanical barrier of the orthodontic bracket makes brushing more difficult and causes it to wear out faster. Based on in vitro[26] and in vivo [8] studies indicating that worn toothbrushes remove less plaque in comparison to fresh brushes, it is advised that the toothbrush be changed if any indication of bristle wear is discovered, or every 2-3 months. Yet, several studies found no statistically significant differences in the elimination of biofilm from new and used toothbrushes[5,27–29]. According to these research, other aspects of oral hygiene, such as brushing duration, force, and patient motivation, are just as significant as bristle integrity[28]. To preserve oral and gingival tissues, the bristles' quality of the rounded ends is crucial. Dental abrasion and gingival recession occurrences are linked to bristles with a round tip[10,11,30]. 10,11,23 Research have revealed that many toothbrushes on the market lack standardized bristle tips[31,32]. When compared to Colgate 360° before brushing in the current trial, the Oral B Indicator 35 had more acceptable bristle tip morphology.

## LIMITATION

Due to various restrictions, the findings of this study should be evaluated with care. As in our study, toothbrushes are not often used for 24 months. The amount of cutting on both brushes was made worse by this circumstance. Another restriction is the 200 N standardisation of the brushing force. The intensity of brushing used by orthodontic patients varies greatly (range: 94–400 N28, mean: 250– 300 N29). Thus, our findings are an average estimate and do not always reflect patients who

## Conclusion

According to the technique used in this investigation, the Colgate 360° and Oral B Indicator 35 toothbrushes did not weaken the binding between the brackets. After brushing, the Oral B Indicator 35 and Colgate 360° toothbrushes showed obvious signs of bristle wear. To determine if this wear affects the mechanical plaque control, additional research with orthodontic patients is required. The bristle tip morphology of the Colgate 360° toothbrush was superior to that of the Oral B Indicator 35 after brushing. This happened as a result of the Colgate 360° side bristles shorter and having various diameters

[1] Haffajee AD, Cugini MA, Dibart S, Smith C, Kent RL Jr, Socransky SS. The effect of SRP on the

clinical and microbiological parameters of periodontal diseases. J Clin Periodontol 1997;24:324–34. https://doi.org/10.1111/j.1600-051x.1997.tb00765.x.

[2] Boyd RL, Baumrind S. Periodontal considerations in the use of bonds or bands on molars in adolescents and adults. Angle Orthod 1992;62:117–26. https://doi.org/10.1043/0003-3219(1992)062<0117:PCITUO>2.0.CO;2.

[3] Rafe Z, Vardimon A, Ashkenazi M. Comparative study of 3 types of toothbrushes in patients with fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 2006;130:92–5. https://doi.org/10.1016/j.ajodo.2006.01.018.

[4] Bishara SE, Ajlouni R, Laffoon JF, Warren JJ. Effect of a fluoride-releasing self-etch acidic primer on the shear bond strength of orthodontic brackets. Angle Orthod 2002;72:199–202. https://doi.org/10.1043/0003-3219(2002)072<0199:EOAFRS>2.0.CO;2.

[5] van Palenstein Helderman WH, Kyaing MM, Aung MT, Soe W, Rosema NAM, van der Weijden GA, et al. Plaque removal by young children using old and new toothbrushes. J Dent Res 2006;85:1138–42. https://doi.org/10.1177/154405910608501214.

[6] Bishara SE, Ostby AW, Laffoon JF, Warren JJ. The effect of modifying the self-etchant bonding protocol on the shear bond strength of orthodontic brackets. Angle Orthod 2007;77:504–8. https://doi.org/10.2319/0003-3219(2007)077[0505:TEOMTS]2.0.CO;2.

[7] Hansen PA, Killoy W, Masterson K. Effect of brushing with sonic and counterrotational toothbrushes on the bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 1999;115:55–60. https://doi.org/10.1016/s0889-5406(99)70316-1.

[8] Glaze PM, Wade AB. Toothbrush age and wear as it relates to plaque control. J Clin Periodontol 1986;13:52–6. https://doi.org/10.1111/j.1600-051x.1986.tb01414.x.

[9] Warren PR, Jacobs D, Low M-A, Chater BV, King DW. A clinical investigation into the effect of toothbrush wear on efficacy. J Clin Dent 2002;13:119–24.

[10] Silverstone LM, Featherstone MJ. Examination of the end rounding pattern of toothbrush bristles using scanning electron microscopy: a comparison of eight toothbrush types. Gerodontics 1988;4:45–62.

[11] Radentz WH, Barnes GP, Cutright DE. A survey of factors possibly associated with cervical abrasion of tooth surfaces. J Periodontol 1976;47:148–54. https://doi.org/10.1902/jop.1976.47.3.148.

[12] Claydon NC. Current concepts in toothbrushing and interdental cleaning. Periodontol 2000 2008;48:10–22. https://doi.org/10.1111/j.1600-0757.2008.00273.x.

[13] Malli Sureshbabu N, Selvarasu K, V JK, Nandakumar M, Selvam D. Concentrated Growth Factors as an Ingenious Biomaterial in Regeneration of Bony Defects after Periapical Surgery: A Report of Two Cases. Case Rep Dent 2019;2019:7046203. https://doi.org/10.1155/2019/7046203.

[14] Ahad M, Gheena S. Awareness, attitude and knowledge about evidence based dentistry among the dental practitioner in Chennai city. J Adv Pharm Technol Res 2016;9:1863. https://doi.org/10.5958/0974-360x.2016.00380.2.

[15] PradeepKumar AR, Shemesh H, Jothilatha S, Vijayabharathi R, Jayalakshmi S, Kishen A. Diagnosis of Vertical Root Fractures in Restored Endodontically Treated Teeth: A Time-dependent Retrospective Cohort Study. J Endod 2016;42:1175–80. https://doi.org/10.1016/j.joen.2016.04.012.

[16] Jangid K, Alexander AJ, Jayakumar ND, Varghese S, Ramani P. Ankyloglossia with cleft lip: A rare case report. J Indian Soc Periodontol 2015;19:690–3. https://doi.org/10.4103/0972-124X.162207.

[17] Kumar A, Sherlin HJ, Ramani P, Natesan A, Premkumar P. Expression of CD 68, CD 45 and human leukocyte antigen-DR in central and peripheral giant cell granuloma, giant cell tumor of long bones,

and tuberculous granuloma: An immunohistochemical study. Indian J Dent Res 2015;26:295–303. https://doi.org/10.4103/0970-9290.162872.

[18] Manohar J, Abilasha R. A Study on the Knowledge of Causes and Prevalance of Pigmentation of Gingiva among Dental Students. Indian Journal of Public Health Research & Development 2019;10:95. https://doi.org/10.5958/0976-5506.2019.01859.x.

[19] Sekar D, Mani P, Biruntha M, Sivagurunathan P, Karthigeyan M. Dissecting the functional role of microRNA 21 in osteosarcoma. Cancer Gene Ther 2019;26:179–82. https://doi.org/10.1038/s41417-019-0092-z.

[20] Girija SA, Jayaseelan VP, Arumugam P. Prevalence of VIM- and GIM-producing Acinetobacter baumannii from patients with severe urinary tract infection. Acta Microbiol Immunol Hung 2018;65:539–50. https://doi.org/10.1556/030.65.2018.038.

[21] Maheswari TNU, Venugopal A, Sureshbabu NM, Ramani P. Salivary micro RNA as a potential biomarker in oral potentially malignant disorders: A systematic review. Ci Ji Yi Xue Za Zhi 2018;30:55–60. https://doi.org/10.4103/tcmj.tcmj_114_17.

[22] Subashri A, Maheshwari TNU. Knowledge and attitude of oral hygiene practice among dental students. J Adv Pharm Technol Res 2016;9:1840. https://doi.org/10.5958/0974-360x.2016.00375.9.

[23] Hohlbein DJ, Williams MI, Mintel TE. Driving toothbrush innovation through a cross-functional development team. Compend Contin Educ Dent 2004;25:7–11.

[24] Nathoo S, Chaknis P, Petrone M, DeVizio W, Volpe AR. A clinical comparison of the gingivitis reduction and plaque-removal efficacy of a new manual toothbrush. Compend Contin Educ Dent 2004;25:37–45.

[25] Mankodi S, Wachs GN, Petrone DM, Chaknis P, Petrone M, DeVizio W, et al. Comparison of the clinical efficacy of a new manual toothbrush on gingivitis reduction and plaque removal. Compend Contin Educ Dent 2004;25:28–36.

[26] Kreifeldt JG, Hill PH, Calisti LJ. A systematic study of the plaque removal efficiency of worn toothbrushes. J Dent Res 1980;59:2047–55. https://doi.org/10.1177/00220345800590120401.

[27] Hogan LME, Daly CG, Curtis BH. Comparison of new and 3-month-old brush heads in the removal of plaque using a powered toothbrush. J Clin Periodontol 2007;34:130–6. https://doi.org/10.1111/j.1600-051X.2006.01022.x.

[28] Sforza NM, Rimondini L, di Menna F, Camorali C. Plaque removal by worn toothbrush. J Clin Periodontol 2000;27:212–6. https://doi.org/10.1034/j.1600-051x.2000.027003212.x.

[29] Tan E, Daly C. Comparison of new and 3-month-old toothbrushes in plaque removal. J Clin Periodontol 2002;29:645–50. https://doi.org/10.1034/j.1600-051x.2002.290709.x.

[30] Dyer D, MacDonald E, Newcombe RG, Scratcher C, Ley F, Addy M. Abrasion and stain removal by different manual toothbrushes and brush actions: studies in vitro. J Clin Periodontol 2001;28:121–7. https://doi.org/10.1034/j.1600-051x.2001.028002121.x.

[31] Checchi L, Minguzzi S, Franchi M, Forteleoni G. Toothbrush filaments end-rounding: stereomicroscope analysis. J Clin Periodontol 2001;28:360–4. https://doi.org/10.1034/j.1600-051x.2001.028004360.x.

[32] Jung M, Soydan N, Rubbert F, Wetzel W-E. Quality of bristle end-rounding on replaceable heads of powered toothbrushes. J Clin Periodontol 2005;32:604–9. https://doi.org/10.1111/j.1600-051X.2005.00719.x.