Innovations

A novel smart connected oscillating rotating toothbrush versus a smart connected sonic toothbrush for reduction of plaque and gingivitis: A systematic review

Disha Gogoi[1], Sindhu R[2], Dinesh Dhamodhar[3] , Sathiyapriya S[2] ,Prabu D[4], Rajmohan M[3] Bharathwaj V V[2]

[1]Under Graduate Student (Bachelor of Dental Surgery), Department of Public Health Dentistry , SRM Dental College and Hospital, Ramapuram, Chennai, India
[2]Master of Dental Surgery , Senior lecturer , Department of Public Health Dentistry , SRM Dental College and Hospital, Ramapuram, Chennai, India
[3]Master of Dental Surgery , Reader , Department of Public Health Dentistry , SRM Dental College and Hospital, Ramapuram, Chennai, India
[4]Master of Dental Surgery , Professor and Head , Department of Public Health Dentistry , SRM Dental College and Hospital, Ramapuram, Chennai, India.

Corresponding Author: **Disha Gogoi**

Abstract

Background:*- Toothbrushes have been used for many decades to effectively remove plaques and prevent gingivitis. Advanced toothbrushes like smart connected oscillating rotating toothbrush and sonic toothbrush were later introduced in the market for better outcomes to improve oral health.* ***Aim****:- To study the effectiveness of removal of plaque and gingivitis by using a smart connected oscillating rotating toothbrush versus a smart connected sonic toothbrush.* ***Methods****:- A literature search was done by using PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), Science Direct, Wiley using MeSh terms- oscillating rotating toothbrush, sonic toothbrush, plaque, gingivitis and smart connected. According to PRISMA guidelines, the mesh terms were altered in each search engine.* ***Results****:--The smart connected oscillating rotating toothbrush is compared with a smart connected sonic toothbrush, and the oscillating rotating toothbrush has shown significantly better results in removing plaques and gingivitis.* ***Conclusion****:- The smart connected oscillating rotating toothbrush has better efficacy in removing plaques and gingivitis than the smart connected sonic toothbrush.*

Keywords*: 1.0scillating rotating toothbrush, 2.sonic toothbrush, 3. plaques, 4.Gingivitis, 5.smart connected.*

Introduction

Mechanical plaque control is necessary on a daily basis to prevent dental caries, gingivitis as well as periodontal disease. For proper oral hygiene ideal design of a toothbrush is essential. A toothbrush must provide comfort, achieve proper plaque removal and no trauma to the soft tissue surrounding the oral cavity [1,2]. Gum bleeding while brushing is one of the indicator of gingivitis. Gingivitis is a preventable disease and can be reversed if

proper plaque control measures are taken. Here rather than a manual toothbrush, an electric toothbrush has better effectiveness to reverse gingivitis and elimination of plaque [3].

There are many toothbrushes available on the market, and one of them is a smart sonic toothbrush which can sweep at a frequency of 31000 brush strokes per minute. The brush head of this smart sonic toothbrush has 43% more bristles compared to a manual toothbrush [4]. The handle of the sonic toothbrush is longitudinal and angles downward at the top end. Other ergonomic features are an adequate grip zone which promotes secured grasp and have easy access to the on and off button [5].

Another next generation toothbrush that was launched in the year 2020 is a novel smart oscillating toothbrush which has a linear magnetic drive, resulting in oscillation, rotation and micro vibration. It works by transforming the motor energy into the bristle tips. The brush head of an oscillating toothbrush rotates from the centre point but not in a full circle, and some also have pulsating or in and out movement. These smart toothbrushes are extra helpful because they can sense the force applied while brushing plus indicate any extra force applied on the teeth, which can be the cause of abrasion [6,7]. There is an FSR [Force Sensing Resistor] sensor underneath the bristle so that the force from the bristle can be transferred to it. LEDs are also attached in these smart toothbrushes [8].

These smart/intelligent toothbrushes provide real time feedback to the users and the data acquired are transmitted to a smartphone or any other electronic device's various applications that helps in monitoring the brushing time and technique [9]. With smart toothbrushes on the market, dentists can also easily monitor the progress of oral health in adults as well as children [10].

Objective: To study the reduction efficiency of plaque and gingivitis between a novel smart connected oscillating rotating toothbrush and a smart connected sonic toothbrush.

Materials and methods

Study design: Systematic review of a randomized controlled trial

Eligibility criteria:

Inclusion criteria

- All the Randomized control trials updated till recently.
- Studies where oscillating rotating toothbrush and sonic toothbrush is mentioned as one of the interventions for plaque and gingivitis reduction.
- Full text articles available in search engines mentioned in the search strategy were included.

Exclusion criteria

- Non randomized studies
- Articles where oscillating or sonic toothbrush is used in comparative studies with manual toothbrush

Search strategy:

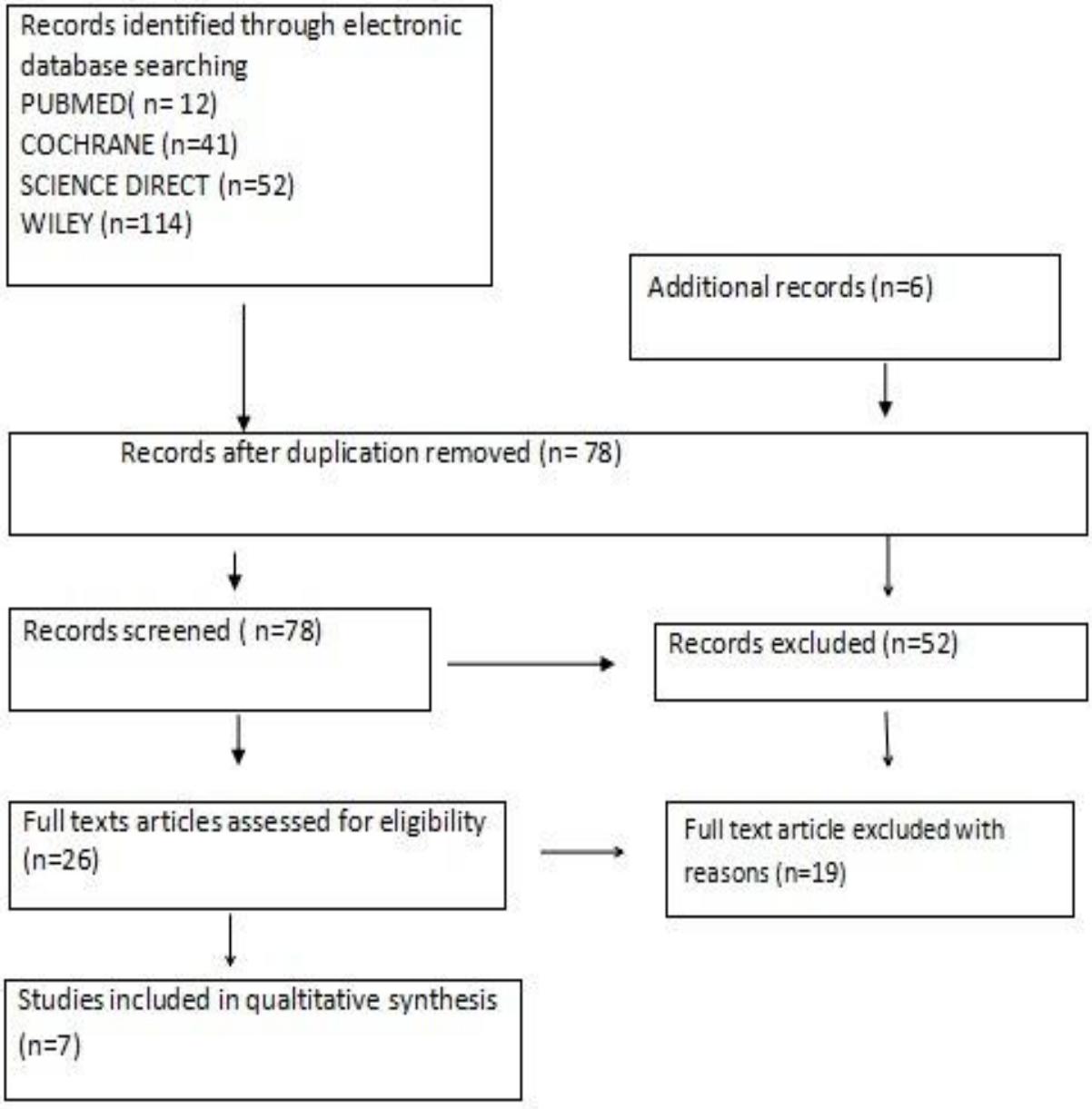
Published literature on assessing the removal of plaque and gingivitis by a smart connected oscillating rotating toothbrush versus a smart connected sonic toothbrush which includes original articles and research papers in databases such as Pubmed, Cochrane, Science Direct and Wiley, were taken into study for review. A literature

search to collect the data was performed using MeSH terms like oscillating toothbrush, sonic toothbrush, plaque, gingivitis and smart connected.

Search engine:

PubMed
Cochrane Central Register of Controlled Trials (Central)
Science Direct
Wiley

Figure no.1:-Flow diagram showing the number of studies screened, assessed for eligibility, excluded and included in the systematic review.



Results : A total of 221 records from various search engines were collected and about 7 articles were included for the review. There were about 143 duplicate articles which were removed, among which the article without full text was also removed, leading to 26 articles. Out of 26, 7 were selected for the final study.

Table 1 shows the characteristics of the interventions in the included studies. In all the 7 articles, there is a comparative study between oscillating rotating and sonic toothbrush. But the study differed individually regarding the sample size, age of the population, and duration of the intervention. 1 among the 7 trials did not mention patient characteristics. The subjects who participated had baseline mild to moderate gingivitis.

Table no. 1 characteristics of the interventions in the included studies

Authors name	**Year**	**Sample Size**	**Patient Characteristics**	**Duration**	**Number (case/control)**
Goyal CR et al. [11]	2009	175	Patients are in between 18 and 70 years of age and in good general health,who at least brush twice-daily.Subjects were entered by their whole mouth gingivitis score, which is between 1.75 and 2.3, as measured by the modified Gingival Index (MGI)	12 weeks	group1 (oscillating rotating toothbrush=87 subjects) Group 2 (sonic toothbrush= 88)
Klukowska. M et al. [12]	2012	130	Subjects taken are at least 18 years of age having good general health status. Evidence of gingivitis (at least in 10 sites scoring 1' or '2' via the GBI, baseline modified GI score between 1.75 and 2.3) and a baseline plaque score of 0.50 using the RMNPI are enrolled in the studies. Some of the subjects were excluded from participation, like a patients suffering from severe periodontal disease or active periodontitis, grossly carious teeth, pregnancy and lactation. Study participants were instructed to stop oral hygiene practice 12 hours prior to the baseline visit and not to eat, chew gums, drink, and use of tobacco 4 hours in advance.	8 weeks	group1 (oscillating rotating toothbrush=65 subjects) Group 2 (sonic toothbrush= 65)

Klukowska. M et al. [13]	2014	130	Subjects suffering from mild to moderate gingivitis at baseline were	6 weeks	group1 (oscillating rotating
			randomly given an O-R brush and a sonic brush. They were advised to use the brush twice daily.		toothbrush=65 subjects) Group 2 (sonic toothbrush= 65 subjects)
Ccahuana -Vasquez RA et al. [14]	2015	148	Subjects having mild-to moderate plaque and gingivitis were evaluated for gingival margin, whole baseline mouth, gingivitis, and gingival bleeding. In addition, they were advised to brush twice daily for two minutes with the assigned toothbrush while using a standard fluoride dentifrice for eight weeks.	8 week	group1 (oscillating rotating toothbrush=75 subjects) Group 2 (sonic toothbrush= 73 subjects)
Ccahuana -Vasquez RA et al. [15]	2018	148	Subjects having a mild-to-moderate plaque and gingivitis. Baseline gingivitis and oral examination is also done.	8 weeks	group1(oscillating rotating toothbrush=74 subjects) Group 2 (sonic toothbrush= 74 subjects)
Lv J, Guo B et al. [16]	2018	120	No significant patient characteristics are mentioned.	6 months	Group A(oscillating rotating toothbrush=40 subjects) Group B (high frequency sonic toothbrush=40 subjects) Group C= Other 40 are for traditional sonic toothbrush
Goyal CR et al. [17]	2021	110	Subjects included in this study were adults in good general health with 16 natural scorable teeth who typically uses a manual toothbrush. Baseline whole mouthMGI score of at least1.75 and not exceeding 2.5, and at least 20 but not > 90 bleeding sites at baseline, baseline pre brushing whole mouth RMPNI score greater than 0.5 are qualified to be the subjects for this study. Exclusion criteria are grossly carious crown, use of antibiotics and chlorhexidine mouthwash within the previous 2 weeks, severe periodontal disease, need for dental surgery within the last 2 months, seizure disorder, pregnancy, orthodontic appliances, RPD or pacemaker.	6 months	group1 (oscillating rotating toothbrush=55 subjects) Group 2 (sonic toothbrush= 55 subjects)

Table 2 shows the outcome data of plaque and gingival scores included in the studies. There was a progressive decrease in plaque and gingival scores in O-R toothbrush group than in the sonic toothbrush group from the baseline till the end of the survey in 7 of the studies with a significant p-value.

Table no.2:Outcome data assorted in included studies

Authors name	**Year**	**Effect measure**	**Results**
Goyal CR et al. [11]	2009	RMNPI = Rustogi Modification of the Navy Plaque Index, MGI = Modified Gingival Index, GBI = Gingival Bleeding Index.	Both the toothbrushes had been determined to be balanced for baseline RMNPI plaque (p = zero.300) and gingivitis as measured via MGI (p = 0.361) and GBI (p = 0.505). The tooth brushes were also balanced for both gender (p = 0.276), wherein normal sixty nine% were female, and 31% were male. The smoking status were also balanced between treatment groups, with 11% smokers and 89% non-smokers. It was also balanced for age (p = 0.883), with a mean of forty one years. The relative mean benefits favouring rotation-oscillation brush of 29.4% for GBI and 8.2% for MGI at 12 weeks (p<_0.001) There is also low RMNPI plaque by 33.3% compared to the sonic toothbrush (p < 0.001) at Week 12.
Klukowska.M et al. [12]	2012	MGI = Modified Gingival Index, GBI = Gingival Bleeding Index, RMNPI = Rustogi Modified Navy Plaque Index.whole mouth and interproximal RMNPI, SE = standard error, CI = confidence interval	A 30% statistically superior (P< 0.001) mean gingivitis reduction came into result for the multidirectional power brush in comparison to the sonic brush.The reduction in gingival bleeding relative to prior treatment was 28.6% more (0.014 adjusted mean between group difference). Themultidirectional power brush produced a 44.2% significant reduction (P= 0.003) in mean whole mouth RMPNI with a difference of 0.023.It also built a 76.9% significantly greater reduction in interproximal plaque (P< 0.001), whereas the between-brush reduction difference was found to be 0.103.

Klukowska.M et al. [13]	2014	Gingivitis and plaque were assessed at Baseline and Week 6 using the Modified Gingival Index (MGI), GingivalBleeding Index (GBI), and RustogiModified Navy Plaque Index (RMNPI). Data were analyzed using an Analysis of Covariance (ANCOVA)	32.6% = gingivitis, 35.4% = gingival bleeding, 32% for number of bleeding sites, 22% = whole mouth plaque, 24.2% = gingival margin plaque and 33.3% for approximal plaque ($p \leq 0.001$)were measured for the oscillating rotating toothbrush over the sonic brush exceptgingival margin plaque where p =0.018.
Ccahuana-Vasquez RA et al. [14]	2015	Modified Gingival Index, Gingival Bleeding Index, and the Rustogi Modified Navy Plaque Index.	Whole mouth=27.7% ,gingival margin=46.8% and approximal plaque = 29.3% compared with the sonic brush, while the reduction in gingivitis is 34.6%, gingival bleeding=36.4%, and the number of bleeding sites were 36.1% greater for the O-R brush than for the sonic brush ($p < 0.001$ for all six measures).
Ccahuana-Vasquez RA et al. [15]	2018	Modified Gingival Index; MGI), gingival bleeding (Gingival Bleeding Index; GBI), and plaque (Rustogi Modified Navy Plaque Index). Qualified	MGI=34.8%, GBI=48.4% and 42.6% in no. of bleeding sites have reduced after the use of O-R brush within eight weeks ($p < 0.001$ for each). Significantly greater whole mouth (26.2%) and proximal (38.5%) plaque reductions were also seen in the result.
Lv J, Guo B et al. [16]	2018	Modified Gingival Index (MGI) and Gingival Bleeding Index (GBI) Rustogi Modified Navy Plaque Index (RMNPI) at Baseline, Month 3, and Month 6. Statistical analysis between A vs B and A vs C were evaluated. Data were analyzed using an ANCOVA	Reductions of MGI and GBI scores were not significantly different between oscillating and high frequency sonic (group B)in the 3rd and the 6^{th} month. While oscillating brush had a 20.1% reduction in total RMNPI and 29.0% greater reduction in interproximal RMNPI at Month 6 ($P< 0.05$) is compared to high frequency sonic oothbrush. Compared to traditional sonic brush (group = C)oscillating brush showed 14.0% and 14.5% greater reductions in MGI and GBI respectively, and 26.0% greater reduction in interproximal RMNPI versus baseline at Month 6 ($P< 0.05$).

Goyal CR et al. [17]	2021	Subjects were divided according to tobacco use (present or absent), no. of bleeding sites (≤28 vs. ≥28) and scores for MGI((≤2.1 vs. ≥ 2.1) and RMNPI (≤ 0.62 vs. ≥0.62). Whole mouth MGI (mean plaque indices) and GBI (gingival bleeding index) are also calculated. Data were analyzed using an ANCOVA.	Gingivitis status had shown improvement by 96.4% in OR toothbrush and 81.8% in sonic toothbrush; P= 0.029. The O-R toothbrush gave a greater reduction in adjusted mean GBI score, adjusted mean MGI score and number of bleeding sites. At week 24, MGI score was 32.6%, GBI score23.7% and 26.1% for the number of bleeding sites, P< 0.001). After a single use on day 1, plaque removal was found to be more for the O-R brush compared to the sonic brush (P< 0.001); by week 24, the O-R brush showed greater reductions in whole mouth plaque, gingival margin plaque and approximal region plaque (24.6%,61.9% and 25.8% respectively)

Table 3 shows the bias assessment of the included studies, and most of the domains had an unclear risk of bias.

Table no.3 Bias assessment as included in the studies

Author Name, year	**Random sequence generation**	**Allocation concealment**	**Blinding of outcome**	**Incomplete Outcome Data**	**Blinding of participants and personnel**	**Selective reporting**	**Judgemental bias**
Goyal CR et al.,2009	+	+	?	-	+	-	+
Klukowska.M et al.,2012	+	+	-	-	+	-	+
Klukowska.M et al.,2014	+	+	+	?	+	-	+
Ccahuana Vasquez RA et al.,2015	+	+	?	+	+	-	+
Ccahuana Vasquez RA et al.,2018	+	+	?	+	+	-	+
Lv J, Guo B et al.,2018	+	+	-	?	+	-	?
Goyal CR et al.,2021	+	?	+	-	+	+	+

+= low risk of bias; - = high risk of bias; ?= unclear risk of bias

Discussion

For mechanical plaque control, we have been using normal toothbrushes and many advanced kinds of toothbrushes like smart connected sonic toothbrushes and smart connected oscillating rotating toothbrushes. All these advanced instruments have made it easier to check oral health. There are significant differences in plaque removal and reduction in gingivitis by using each of these different kinds of toothbrushes.

This systematic review showed a significant reduction in plaque and gingivitis from its baseline. All seven out of seven articles showed that the oscillating rotating toothbrush has more effectively reduced plaque, gingivitis and bleeding sites relative to the sonic toothbrush.

Goyal CR et al. reported that at week 12th, there was a significant reduction in the values of plaques, gingivitis as well as in the number of bleeding sites after using an oscillating rotating toothbrush compared to the sonic toothbrush. Rotation-oscillation brush users had significantly lower MGI gingivitis scores over the sonic toothbrush users. The benefits that are obtained from the oscillating rotating toothbrush are long term [11].

Klukowska.M et al. reported that in this 8-week trial, both the toothbrushes provided statistically significant reductions in gingivitis and plaque versus baseline, the new multidirectional power brush uniformly yielded greater reductions compared to the sonic toothbrush for whole mouth plaque, and subjects brushing with the multidirectional power brush has seen greater mean RMNPI plaque reduction at week 8. It also benefitted the interproximal (approximal) RMNPI regions [12] .

Klukowska.M et al. reported that this 6 weeks randomized comparative study showed that an oscillating-rotating toothbrush with an angled CrissCross bristles was significantly better than an advanced sonic power toothbrush at reducing gingival inflammation and bleeding, reducing whole mouth plaque, plaque along the gumline as well as removing interproximal plaques too. Subjects using the oscillating rotating brush rated it higher for overall user experience and also regarding cleaning, gentleness and the brush head [13].

Ccahuana-Vasquez RA et al. reported that The O-R brush was statistically more effective in reducing plaque and gingivitis than the sonic brush. Moreover, they are better at reducing the Whole mouth, gingival margin, and approximal plaque. The reductions in gingivitis, gingival bleeding, and number of bleeding sites were also significantly greater in the O-R brush [14].

Ccahuana-Vasquez RA et al. reported that The oscillating rotating brush provided greater reductions than the sonic brush for all gingivitis measures (MGI, GBI, and number of bleeding sites) after eight weeks of use. Significantly greater whole mouth and proximal plaque reductions were also demonstrated at Week 8 for the oscillating rotating brush than the sonic brush [15].

Lv J, Guo B et al . reported that the new high frequency sonic power toothbrush was not significantly different from the oscillating rotating power toothbrush in gingivitis reduction. They are still much better at removing plaques. This new high frequency sonic power toothbrush was more effective than the traditional sonic toothbrush in reducing gingivitis and plaque after long term use [16].

Goyal CR et al.reported that the O-R toothbrush had reduced the whole mouth lingual plaque from day 1 through week 24. It is more significant in removing gingivitis around the lingual area as well as lowering MGI, GBI, number of bleeding sites too. With the current study design, since the sonic toothbrush couldn't access any app usage like O –R toothbrush, hence to make the evaluation balanced, there was no app control in this study [17].

There is conclusive evidence that the smart connected oscillating rotating toothbrush has better efficacy in removing plaque and reducing gingivitis than the smart connected sonic toothbrush.

Conclusion

The novel smart connected oscillating rotating toothbrush has shown better gingivitis and plaque control results than the smart connected sonic toothbrush. It has also decreased the number of bleeding sites without adversely affecting the teeth..

References

1. *Borker, S. S., Lawande, S. A., & Samuel, J. (2022). Recent advancements in toothbrush systems for improved mechanical plaque control 8(1): 176-180.*
2. *Aparna, K. S., Puranik, M. P., & Sowmya, K. R. (2018). Powered toothbrush-A review. Int J Health Sci Res, 8(5), 299-306.*
3. *Thurnay, S., Adam, R., & Meyners, M. (2022). A Global, In-Market Evaluation of Toothbrushing Behaviour and Self-assessed Gingival Bleeding with Use of App Data from an Interactive Electric Toothbrush. Oral Health Prev Dent, 20(1), 1-10.*
4. *Marcia Delaurenti, R. D. H., Ward, M. M., Souza, D. S., Jenkins, P. W., Milleman, K. R., & Milleman, M. J. L. (2017). The effect of use of a sonic power toothbrush and a manual toothbrush control on plaque and gingivitis. Journal of Clinical Dentistry®, 1.*
5. *Hunter, G., Burns, L., Bone, B., Mintel, T., & Jimenez, E. (2012). Ergonomic audit of a specially engineered sonic powered toothbrush with unique sensing and control technologies, the Sonicare Flexcare, and the Oral-B Smart Series 5000. The Journal of Clinical Dentistry, 23, A26-30.*
6. *Adam, R. (2020). Introducing the Oral-B iO electric toothbrush: next generation oscillating-rotating technology. International dental journal, 70, S1-S6.*
7. *Walters, P. A., Cugini, M., Biesbrock, A. R., & Warren, P. R. (2007). A novel oscillating-rotating power toothbrush with SmartGuide: designed for enhanced performance and compliance. J Contemp Dent Pract, 8(4), 1-9.*
8. *Akhtaruzzaman, M. (2019). Prototype of a force-sensitive smart toothbrush. In Proc. EICT, 4th Int. Conf.*
9. *Marcon, M., Sarti, A., & Tubaro, S. (2016, October). Smart toothbrushes: inertial measurement sensors fusion with visual tracking. In European Conference on Computer Vision (pp. 480-494). Springer, Cham.*
10. *Kusmana, A., & Setiadi, Y. (2021). Integrated Dental Health Monitoring using Smart Tooth Brush and Application Vol 4 , No. 4, 73-80.*
11. *Goyal, C. R., Qaqish, J., He, T., Grender, J., Walters, P., & Biesbrock, A. R. (2009). A randomized 12-week study to compare the gingivitis and plaque reduction benefits of a rotation-oscillation power toothbrush and a sonic power toothbrush. Journal of Clinical Dentistry, 20(3), 93.*
12. *Klukowska, M., Grender, J. M., Goyal, C. R., Qaqish, J., & Biesbrock, A. R. (2012). 8-week evaluation of anti-plaque and anti-gingivitis benefits of a unique multidirectional power toothbrush versus a sonic control toothbrush. American journal of dentistry, 25(Spec No A), 27A-32A.*
13. *Klukowska, M., Grender, J. M., Conde, E., Goyal, C. R., & Qaqish, J. (2014). A six-week clinical evaluation of the plaque and gingivitis efficacy of an oscillating-rotating power toothbrush with a novel brush head utilizing angled CrissCross bristles versus a sonic toothbrush. The Journal of clinical dentistry, 25(2), 6-12.*
14. *Ccahuana-Vasquez, R. A., Conde, E., Grender, J. M., Cunningham, P., Qaqish, J., & Goyal, C. R. (2015). An Eight-Week Clinical Evaluation of an Oscillating-Rotating Power Toothbrush with a Brush Head Utilizing Angled Bristles Compared with a Sonic Toothbrush in the Reduction of Gingivitis and Plaque. The Journal of clinical dentistry, 26(3), 80-85.*
15. *Ccahuana-Vasquez, R. A., Conde, E. L., Cunningham, P., Grender, J. M., Goyal, C. R., & Qaqish, J. (2018). An 8-Week Clinical Comparison of an Oscillating-Rotating Electric Rechargeable Toothbrush and a Sonic Toothbrush in the Reduction of Gingivitis and Plaque. The Journal of Clinical Dentistry, 29(1), 27-32.*

16. *Lv, J., Guo, B., & Ling, J. (2018). A 6-month clinical evaluation of a high frequency sonic toothbrush in comparison with an oscillating-rotating power toothbrush and a traditional sonic toothbrush in reducing gingivitis and plaque. American Journal of Dentistry, 31(4), 171-176.*

17. *Goyal, C. R., Adam, R., Timm, H., Grender, J., & Qaqish, J. (2021). A 6-month randomized controlled trial evaluating a novel smart-connected oscillating-rotating toothbrush versus a smart-connected sonic toothbrush for the reduction of plaque and gingivitis. Am J Dent, 34(1), 54-60*