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Original Article

Diode Laser versus Conventional Surgical Circumferential Supracrestal Fiberotomy in Preventing Relapse of Orthodontically Derotated Teeth: A Randomised Control Trial

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Main Points
- Circumferential supracrestal fiberotomy significantly reduces the relapse tendency of orthodontically derogated anterior teeth.
- Circumferential supracrestal fiberotomy with a diode laser has results similar to the conventional surgical CSF method in reducing relapse potential.

ABSTRACT

Objective: To evaluate the effectiveness of a diode laser (810 nm) for circumferential supracrestal fiberotomy compared with conventional surgical circumferential supracrestal fiberotomy in preventing rotational relapse in orthodontically treated cases.

Methods: Seventy-six patients (age range from 18-25 years) with mandibular crowding ranging between 5-8 mm and rotation >10˚ (from the individualized arch form) treated non-extraction with a straight wire appliance (McLaughlin, Bennet, Trevisi; 0.022 inch) prescription were selected for the study. The patients were randomly allocated into 3 groups of 22 patients each: Group 1 (Control group-No circumferential supracrestal fiberotomy), Group 2 (Conventional circumferential supracrestal fiberotomy), and Group 3 (diode laser circumferential supracrestal fiberotomy). After leveling and alignment up to "0.019x0.025" stainless steel wire, the arch wire was removed for a period of 1 month. Impressions were made and the poured casts were scanned. The 3D models (.STL files) were evaluated for changes in the irregularity index and rotational relapse.

Results: One-way ANOVA and post-hoc Tukey's test were used for data analysis. Group 1 (Control group) showed greater relapse in both irregularity index and rotation angulations in comparison with Groups 2 and 3, which was statistically significant ($p<0.001$). There was no statistically significant difference in irregularity index and rotational relapse between Group 2 and Group 3 ($p=0.35$ for irregularity index, and $p=0.41$ for rotational relapse).

Conclusion: The control group showed significantly more relapse than both circumferential supracrestal fiberotomy groups. Both conventional and diode laser circumferential supracrestal fiberotomy decreased the relapse tendency.

Keywords: Diode laser, relapse, rotation, incisor

INTRODUCTION

Derotation of malaligned teeth is seldom considered a problem in modern orthodontic therapy. However, the maintenance of this derotation after the removal of orthodontic appliances remains a concern.[1] Orthodontic relapse is caused by the reorganization of the periodontal transseptal fibers and the gingival fibres.[1-3] Additionally, it is observed that the more severe the initial rotation, the greater the tendency for relapse.[4]

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Various methods have been utilized to minimize rotational relapse, such as early correction, overrotation, and long-term retention, but supracrestal fibrotomy is considered most efficacious.[5] This procedure, where the gingival fibers are severed with a surgical blade, was introduced by Edwards[6], and Crum and Andreasen.[7] Lasers have been used in the medical field since the 1970s and in dentistry since the 1980s. Since then, several developments have occurred in the field of lasers. The Food and Drug Administration approved the utilization of erbium lasers on hard tissue in 1997 and the diode laser on soft tissue in 1998. Since then, lasers have been used in many areas of orthodontic practice, such as orthodontic debonding, etching procedures, biostimulation, bone regeneration, and soft tissue surgical procedures.[8]

High - intensity lasers have become popular in orthodontics for the purpose of soft tissue surgical procedures. They provide a bloodless and atraumatic alternative to conventional surgical procedures. The laser allows for lesser postoperative pain as it inhibits pain receptors, lowers the risk of infection, and promotes healing.[9] Kim et al.[10] and Jahanbin et al.[5] noted a decrease in rotational relapse after using laser-assisted circumferential supracrestal fibrotomy.

Circumferential supracrestal fiberotomy utilizing a diode laser limits rotational relapse as the light energy from the diode laser (between 810-830 nm) is absorbed by soft tissue but poorly absorbed by hard tissue.[11] Although studies have been conducted on the efficacy of lasers in reducing relapse, not many human studies have been found where the efficacy of diode lasers, in particular, was tested.[12,13] The present study evaluated the effectiveness of 810 nm diode laser circumferential supracrestal fiberotomy versus conventional surgical circumferential supracrestal fiberotomy in the prevention of rotational relapse of mandibular anterior teeth.

Hypothesis being tested (N_o) were:

1) There exists no rotational relapse in cases treated with circumferential supracrestal fiberotomy and where no circumferential supracrestal fiberotomy was performed.

2) There exists no difference in the rotational relapse with conventional and diode laser circumferential supracrestal fiberotomy.

METHODS

Patients who reported in the department for treatment between January 2019 and July 2020 were included in the study. A priori sample size estimation was performed, where power was assumed to be at 90% and the confidence interval was maintained at 95%. Standard deviation and mean difference, as reported by a previous study was 1.5 and 1.5, respectively, and were used to calculate the sample size for the present study using SPSS Software version 28.[13] In this manner, sample size was calculated to be 66 patients. However, it was decided to keep a larger sample size in order to avoid the loss of the required sample in a situation where patients are unable to go through the complete study procedure.

After receiving approval from the Institutional Ethics Committee of Manav Rachna Dental College (ref no. MRDC/IEC/2019/16) for the study, 76 patients undergoing routine orthodontic treatment in the age range of 18-25 years were selected. Informed consent was obtained from all patients for their participation in the study. Patient consent was obtained to participate in the study. Six patients declined to participate in the study at this stage.

Randomization

The remaining 70 patients were randomly divided into 3 groups using the online Stat Trek software.

1. Group 1 (Control group- No circumferential supracrestal fiberotomy) =23 patients.

2. Group 2 (Conventional surgical circumferential supracrestal fiberotomy) =23 patients.

3. Group 3 (Diode laser circumferential supracrestal fiberotomy) =24 patients.

These patients had pretreatment mandibular anterior crowding of 5-8 mm from canine to canine, and mean rotation >10˚ as measured from the individualized arch form (Figure 1). Patients were assessed for clinical attachment loss, tooth mobility, probing depth, and alveolar bone loss with the help of standardized intraoral radiographs. Patients with clinical attachment loss, alveolar bone loss, or any systemic disease were excluded from the study.

Patients with gingival inflammation were referred to the department of periodontics for scaling and polishing, were advised chlorhexidine mouthwash and oral hygiene instructions. The patients were recalled to the department after one week for assessment for gingivitis before starting treatment. Scaling and

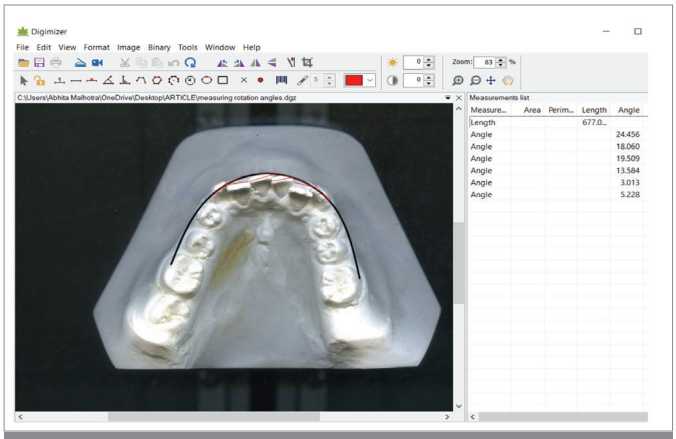

Figure 1. The degree of rotation of the anterior teeth was measured on the pretreatment cast, using the Digimiser software. A line was marked from the mesial-most point to the distal-most point for each of the 6 anterior teeth, and the angle of rotation was measured from this line to the tangent of the individualized arch form. Teeth with a mean rotation greater than 10˚ was included in the study sample

polishing were performed at 2-month intervals throughout the study period to ensure healthy gingival tissues.

Four patients were lost to follow-up. One patient from the control group, one patient from the conventional surgical group, one patient from the diode laser group discontinued treatment, and another refused to undergo the circumferential supracrestal fiberotomy procedure. These patients were removed from our study sample (Figure 2). The arches were leveled up to 0.019x0.025" stainless steel wire and kept in place for at least 3 months for the arch wire to express itself completely. The wire was subsequently removed, and circumferential supracrestal fiberotomy was performed using the conventional surgical method in Group 2 and diode laser in Group 3.

Study models were taken at three different time intervals: - T_0- Before treatment, T_1- After leveling and alignment, when the patient had been on 0.019x0.025" stainless steel wire for 3 months, T_2- One month after the removal of arch wire.

1. Measuring the irregularity in the lower anterior region: Little's irregularity index[14] was measured using the online software Meshmixer 3.5 (Autodesk, Inc.) The STL images of the casts, which were scanned utilizing the iTero 3D scanner, were transferred to the Meshmixer software, and the measurements were made with the help of the software (Figure 3).

The irregularity was assessed at T_0, T_1, and T_2.

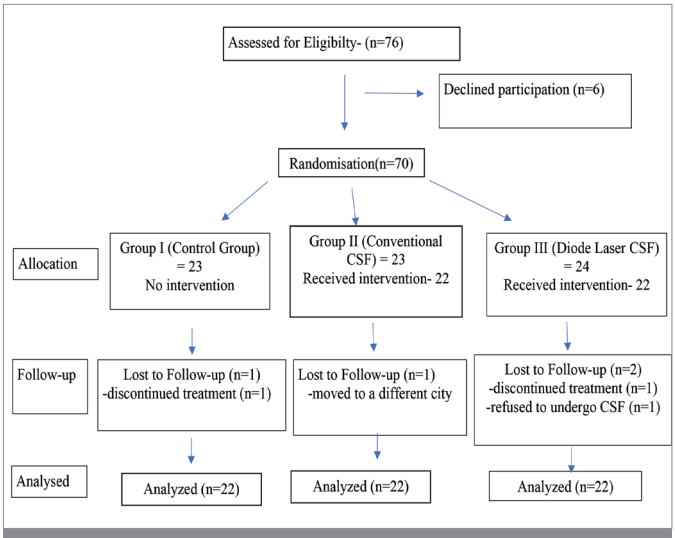

Figure 2. CONSORT flow chart of patients in each group during trial

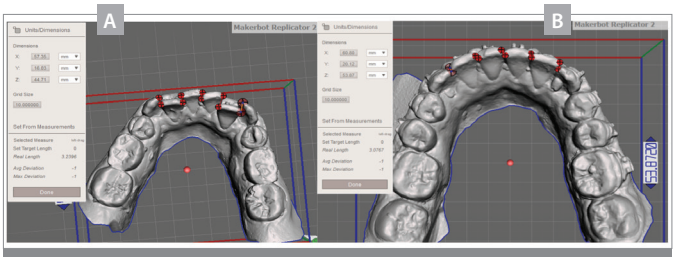

Figure 3. A) Little's irregularity index measured on the digital cast utilising Meshmixer software. B) Little's irregularity index on digital cast after removing archwire for 1 month

2. Measuring rotations:

a) Pretreatment (T_0):

The study model was scanned using an Epson Perfection V700 Photo Dual Analyser Lens System Scanner. The image received was then transferred to Paint 3D software (Microsoft, Version 6.2105.4017) and the individualized arch form was constructed. This image was then transferred to Digimizer Image Analysis software (Version 5.7.5; 2005-2021 MedCalc Software Ltd, Belgium) that allows precise manual measurements on an image. The teeth with a mean rotation >10°, were included in the sample (Figure 1).

b) Pre- and Post-Intervention (T_1 and T_2): The scanned images of casts were transferred to the Digimizer Image Analysis software. The midsagittal plane was constructed, and the six angles formed for each of the six anterior teeth were measured to the midsagittal plane (Figure 4).

Intervention

1) Conventional Surgical: Circumferential supracrestal fiberotomy was performed under infiltration anesthesia with 2% Lignocaine with 1:80000 Adrenaline (Lignocaine, Indoco Warren Lignox). Using a No. 12 surgical blade, intergingival, transgingival, transseptal, and semicircular fibers were transected (Figure 5).

2) Diode Laser: Gallium-aluminum-arsenide (Ga-Al-As) diode laser (AMD Picasso Diode Laser, 7405 Westfield Blvd., Indianapolis) with an 810-nm wavelength was used to do the CSF procedure.[11] A 15% Lignocaine surface anesthetic (Lidayn Surface Anaesthetic Spray, Global Dent Aids Pvt Ltd, Noida, Uttar Pradesh) was used and then the laser tip was inserted through the gingival sulcus, and the incision was extended around the tooth circumference keeping the laser at a setting of 1.2 W in repetitive pulsed mode (Figure 6).

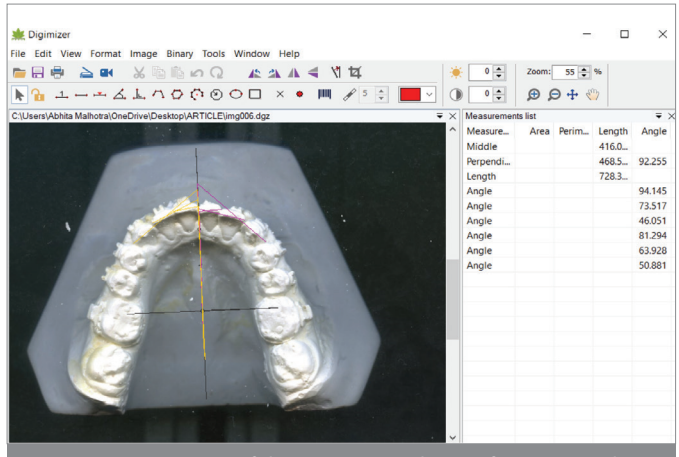

Figure 4. Measurement of the rotation angulation of anterior teeth was conducted using the Digimizer Image Analysis software. The scanned images of casts after alignment (T1), and after relapse (T2), were transferred to the software. The midsagittal plane was constructed by creating a line perpendicular to the line joining the mesial pit of the first molars on either side. The six angles formed for each of the six anterior teeth were determined by a line joining the mesial and distal contact points of each of the each tooth to the mid-sagittal plane. The inferior and inner angles were measured, and mean of all angles was calculated

Statistical Analysis

The data were analyzed with SPSS software (Version 28, Chicago, Illinois, USA). The amount of relapse seen in the irregularity index and rotation angulations (T_2-T_1) in the three groups has been tabulated (Table 1). The normality of the data was assessed and then groups were compared utilizing the ANOVA statistics test (Table 2). Intergroup comparison of relapses in crowding and rotation was also done using the post hoc Tukey's test (Table 2). A p value ≤0.05 was considered statistically significant.

All measurements of irregularity and rotational angulations were repeated after two weeks by the same observer. The interclass correlation coefficient (ICC) value was 0.9 with a 95% confidence interval for both rotational relapse values and for Little's irregularity index measurements.

Figure 5. Conventional CSF procedure

Figure 6. Laser aided CSF procedure

Table 1. Amount of relapse seen after CSF, as assessed by Little's irregularity index, and rotation, in each group

Patient No.	Group 1		Group 2		Group 3	
	LII (mm) (T_2-T_1)	R-Mean (Degree) (T_2-T_1)	LII (mm) (T_2-T_1)	R-Mean (Degree) (T_2-T_1)	LII (mm) (T_2-T_1)	R-Mean (Degree) (T_2-T_1)
1	4.8	8.3	3.7	4.2	1.8	3.2
2	6	9.5	2.8	4.5	2.5	2.3
3	1.1	5.7	2.2	4.4	1.5	2.5
4	3.6	6	2.4	6.3	2.9	4
5	2.9	6.2	0.9	3.7	3.4	6.3
6	4.1	13	2.2	3.8	3	4.3
7	7.6	7.5	2.8	2.7	1.6	5.7
8	4.9	8.2	2.4	5.7	3.3	4
9	7.4	7.3	3.9	5.5	3.9	6.2
10	6.2	9.2	2.2	6	1.5	5
11	4.3	7.4	2.8	3.7	2.3	3.3
12	3.7	6.8	3.2	4.2	1.5	2.5
13	5.7	9.5	2	6.5	1.3	3.8
14	5.8	8.7	1.4	5.3	2.3	4.2
15	5.7	7.9	2.6	4.7	1.4	3.6
16	4.6	6.5	3.4	3.4	1.2	2.4
17	5.3	8.3	1.6	3.4	0.7	3.1
18	7.6	5.5	3.1	2.8	1.3	3.5
19	4.7	6.9	2.3	3.1	2.5	2.7
20	3.7	5.8	1.5	5.7	1.6	4.3
21	5.0	8.7	3.6	2.4	2.6	3.5
22	4.4	5.3	2.7	3.3	1.2	2.8

Group 1- Control group, Group 2-Conventional CSF, Group 3- Laser-CSF
LII: Change in Little irregularity index (T_2-T_1) observed after relapse from the alignment, by the particular treatment modality (mm)
R-Mean- Change in rotation angulations (T_2-T_1) observed after relapse from the alignment, by the particular treatment modality (mm)

Table 2. Intergroup comparison (post-hoc Tukey's test) of change in irregularity Index and rotation after relapse (T_2-T_1)

Intergroup comparison		Little's irregularity index		Rotation	
		Mean difference	p value	Mean difference	p value[a]
Group 1	Group 1	2.4273	<0.001*	2.5773	<0.001*
	Group 2	2.9000	<0.001*	3.1273	<0.001*
Group 2	Group 1	-2.4273	<0.001*	-2.5773	<0.001*
	Group 3	0.4727	0.345	0.5500	0.308
Group 3	Group 1	-2.9000	<0.001*	-3.1273	<0.001*
	Group 2	-0.4727	0.345	-0.5500	0.308

*Statistical significance: p<0.05.

RESULTS

The intergroup statistical comparison for pretreatment values (T_0) for both Irregularity Index (p=0.08) and rotation (p=0.44), was found to be insignificant, suggesting that all the groups were comparable at the pretreatment stage, with no difference between the groups.

ANOVA test for relapse (T_2-T_1) revealed a statistically significant difference between the groups when both Little's Irregularity Index and Rotation values were compared (Table 2). After utilizing the post-hoc Tukey's test, it was observed that Group 1 (Control group- No circumferential supracrestal fiberotomy; irregularity index=4.96±1.54 mm, rotation=6.91±1.29˚) showed changes that were statistically significant (p<0.001) compared to both experimental groups i.e., Group 2 (Conventional circumferential supracrestal fiberotomy group; irregularity index=2.53±0.78 mm, rotation=5.16±3.78˚), and Group 3 (Diode Laser circumferential supracrestal fiberotomy group; irregularity index=2.06±0.86 mm, rotation=3.78±1.17˚). Thus the first null hypothesis, stating that there is no difference in the relapse tendency between cases treated with circumferential supracrestal fiberotomy and the control group, where no supracrestal fiberotomy was performed, is rejected. The post-hoc Tukey's test, however, did not reveal any significant difference between the experimental groups, Group 2 and Group 3, for both the irregularity index and rotational relapse (p>0.05). Therefore, the second null hypothesis is accepted, stating that there exists no difference in the rotational relapse tendency when conventional surgical supracrestal fiberotomy is performed and when diode laser fiberotomy is performed.

DISCUSSION

Gingival fiber elasticity, cheek, lip, and tongue pressure, and jaw growth are among of the major reasons for orthodontic relapse.[15] When observed under the scanning and transmission electron microscope, the stretched gingival fibers appear torn, disorganized, and laterally spaced.[16] An increased number of elastic fibers are also observed near these torn collagen fibers. It has been suggested that relapse occurs more due to the elastic fibers than the collagen fibres.[16,17] The relapse tendency decreases after the supraalveolar gingival fibers are severed.[18]

The evidence of progressive instability in a treated case following orthodontic retention was first noted by the relapse of mandibular incisor crowding. Post-retention malalignment is less prevalent in the maxillary than in the mandibular anterior segment.[19] Therefore, the area of observation was chosen to be the mandibular anterior region in our study to assess relapse after the correction of crowding.

The greatest amount of relapse is observed within 18 to 24 hours of the removal of fixed appliances.[20] In cases where extractions have been performed, 50% of relapse occurs within one week of closing the extraction space.[19,21] Therefore, the period immediately after removal of fixed appliances is crucial in preventing relapse, and measures must be taken to prevent relapse in the initial stages after appliance removal. Our study assessed relapse for a time period of 1 month after removal of the arch wire.

The results of our study indicated a greater relapse tendency in the control group where supracrestal fiberotomy was not performed, as opposed to when it was utilized. This suggests that supracrestal fiberotomy significantly aided in the prevention of rotational relapse of incisors. The control group in our study showed relapse (irregularity index=4.96±1.54 mm, and for rotation=6.91±1.29˚) during the 1-month observation period, which was statistically significant compared to the results achieved with either method of circumferential supracrestal fiberotomy (conventional and laser method) (p<0.001). Therefore, supracrestal fiberotomy significantly reduced the relapse. Several other studies have noted similar results.[13,22,23] Miresmæili et al.[13] reported significant relapse in the control group (11.28±2.93˚) compared to the fibrotomy groups (laser group 4.89±2.08˚, CSF group 5.09±1.59˚) (p<0.001). Al-Jasser et al.[22] observed a mean rotational relapse of 1.44º (14% of initial rotation) after circumferential supracrestal fiberotomy, which was statistically insignificant. Taner et al.[23] noted a significant increase in the irregularity index in the control group compared to the supracrestal fiberotomy group (p<0.01). Ahrens et al.[18] also observed greater relapse in the control group (5.75˚) than in the fibrotomy group (0.42˚) with statistical significance (p<0.01).

We attempted to comparatively assess the relapse tendency between two methods of circumferential supracrestal fiberotomy, i.e., the conventional surgical method, as suggested by Edwards[6],

versus diode laser supracrestal fiberotomy. No statistical significance was found (p>0.05) between the conventional (irregularity index=2.53±0.78, rotation=5.16±3.78˚) and diode laser circumferential supracrestal fiberotomy (irregularity index=2.06±0.86, rotation=3.78±1.17˚). This held true for both the irregularity index (p=0.35) and rotation angulations (p=0.41). Similar results were observed by Miresmæili et al.[13]. They noted that circumferential supracrestal fiberotomy procedures decreased rotational relapse and there was no statistical difference between the laser group (4.89±2.08˚) and the conventional circumferential supracrestal fiberotomy group (5.09±1.59˚). This suggested that the decrease in relapse tendency of mandibular anterior teeth, achieved using either method of fibrotomy, was comparable.

Since there is insufficient literature reporting the efficacy of diode laser fiberotomy and comparing its effects with conventional surgical fiberotomy, our study was designed to bridge this prevalent gap. However, the sample size in this study is small, and it is necessary for future studies with a larger sample size and longer duration of relapse assessment to be conducted.

Several contributing factors to long-term relapse, such as the growth of the jaws,[24] third molars,[25] intercanine width changes,[26] and labial inclination of the incisors must be considered.[27] Circumferential supracrestal fiberotomy decreases the relapse tendency in the short term. Since early relapse and crowding can increase the severity of long-term relapse, it must not be ignored. Therefore, this study highlights the importance of circumferential supracrestal fiberotomy (whether surgical or laser) in alleviating the post-treatment rotational relapse.

Study Limitations

To accurately measure the amount of relapse occurring after alignment, the archwire must be removed for at least 6 months. However, this would raise serious ethical concerns not only in terms of allowing the relapse to occur but also for extending the treatment duration. Therefore, a future study could be designed where the relapse tendency is assessed for a longer duration after appliance removal. Furthermore, it is imperative that future studies are conducted with a larger sample size to report the results with greater accuracy.

CONCLUSION

The prevention of relapse of orthodontically derotated teeth is of great importance for successful treatment. Different methods have been utilized to decrease the relapse tendency of orthodontically derotated teeth, such as early correction, overcorrection of the rotation of teeth, and long-term retention. Circumferential supracrestal fiberotomy (whether done conventionally or with Diode Laser) is now routinely used and has proven to be a potent tool for successful treatment. Our study emphasizes the importance of circumferential supracrestal fiberotomy in decreasing the relapse tendency of derotated mandibular anterior teeth. It also asserts that, although soft tissue lasers are popular in orthodontics, they are not a superior procedure in preventing rotational relapse than the conventional surgical circumferential supracrestal fiberotomy.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Institutional Ethics Committee of Manav Rachna Dental College (ref no. MRDC/IEC/2019/16).

Informed Consent: Informed consent was obtained from all patients for their participation in the study. Patient consent was obtained to participate in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - S.K., A.M., P.B., N.A., A.K.S.; Design - S.K., A.M., P.B., N.A., A.K.S.; Supervision - S.K., A.M., P.B., N.A., A.K.S.; Fundings - S.K., A.M., P.B.; Materials - S.K., A.M., P.B., A.K.S.; Data Collection and/or Processing - S.K., A.M.; Analysis and/or Interpretation - S.K., A.M., P.B., N.A., A.K.S.; Literature Review - S.K., A.M.; Writing - S.K., A.M., P.B., N.A., A.K.S.; Critical Review - A.M., P.B., N.A., A.K.S.

Declaration of Interests: All authors declare that they have no conflict of interest.

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