A RANDOMISED CONTROLLED TRIAL ON CLINICAL EFFICACY OF SODIUM PERBORATE MIXED WITH DISTILLED WATER AND 30% HYDROGEN PEROXIDE IN THE LIGHTENING OF NON-VITAL DISCOLOURED ANTERIOR TEETH

A.D. Odofin[1], J. Taiwo[2], I.A. Solanke[3], O. Ibiyemi[2], A.O Afolabi[4]

1. Government Dental Centre, Oyo State Hospital Management Board, Dugbe, Ibadan, Nigeria..
2. Department of Periodontology and Community Dentistry, University of Ibadan, Nigeria.
3. Department of Restorative Dentistry, University of Ibadan, Nigeria.
4. Department of Dental Services, Federal Medical Centre, Owo, Ondo State, Nigeria.

Correspondence:
Dr. O. Ibiyemi
Department of Periodontology
and Community Dentistry,
Faculty of Dentistry,
University of Ibadan,
Nigeria.
Email: shola_ibiyemi@yahoo.com

ABSTRACT

Objective: To compare the effectiveness of sodium perborate mixed with distilled water and sodium perborate mixed with 30% hydrogen peroxide as non–vital bleaching agent of anterior discolored teeth.

Materials and methods: A randomized controlled trial was undertaken among 61 patients who presented with 70 discolored anterior teeth at the Conservative and Family Dentistry Clinics of the University College Hospital, Ibadan, Nigeria. The 70 teeth were randomly allocated into two groups of treatments. In Group A, the test group, the coronal part of endodontically treated teeth was further treated with sodium perborate mixed with distilled water while group B, the control group, the coronal part of endodontically treated teeth were also further treated with sodium perborate mixed with 30% hydrogen peroxide. Information on study participants biodata and satisfaction with treatment were obtained. Tooth shade assessment was done using shade guide units of the vitapan shade guide at baseline and during recall visits on days 7, 14, and 21. Frequencies, means and standard deviations were generated. Chi-squared test was used to determine the association between two categorical variables at p<0.05.

Results: In the control group the mean ± SD tooth shade was 12.5 ±3.2, 8.7 ± 3.8, 4.9 ± 2.8 and 3.1 ± 2.2 at baseline, Day 7, Day 14 and Day 21 respectively. In the test group, the corresponding values are 12.8 ± 3.2, 9.6 ± 3.9, 5.6 ± 3.0 and 4.0 ± 2.9. The mean ± SD tooth shade scores of control and test group was 12.5 ± 3.2 and 12.8 ± 3.2 respectively (p = 0.15). Twenty-two (62.9%) and 19(54.3%) of the study participants in the control and test groups respectively reported that they were extremely satisfied (p=0.60).

Conclusion: The effectiveness of sodium perborate mixed with distilled water and sodium perborate mixed with 30% hydrogen peroxide in lightening the coronal part of endodontically treated non-vital discolored anterior teeth were similar. Both bleaching agents demonstrated similar patient satisfaction.

INTRODUCTION

Tooth discolouration is the alteration in the color of a tooth which can either be extrinsic or intrinsic based on the aetiology and location of the stain.[1-4]

Extrinsic stains are stains from food and beverages such as coffee, tea, and wine deposited on the surfaces of teeth, therefore are not incorporated within the tooth substance.[5] In intrinsic discolouration, the stains are incorporated within the tooth substance in a localized and generalized manner, based on etiology.[5] The common causes of generalized intrinsic discolouration include amelogenesis imperfecta, dentinogenesis imperfecta, and tetracycline stain,[3] while the most common cause of localized intrinsic discolouration is intra-pulpal hemorrhage secondary to trauma to teeth resulting in pulp necrosis and eventual loss of vitality.[6]

Anterior tooth discoloration is one of the most commonest reasons for dental consultation since concern about appearance is increasing among people worldwide.[5] Several treatment options are available for intrinsic discolouration which include microabrasion, bleaching, veneers, and jacket crowns.[4,7] Veneers and jacket crowns are invasive and expensive treatment options while tooth bleaching is more cost

effective.[8-10] In most developing countries especially in Africa, the less expensive and more conservative bleaching is a reasonable and common choice of treatment.[6]

Bleaching as a treatment option for non-vital tooth with intrinsic discoloration can be an in-office technique, a walking bleach technique, or a combination of both.[11] These techniques can be intracoronal, extracoronal or a combination of both and studies have shown that they all give satisfactory results.[8,12] Intracoronal bleaching involves the use of agents which are packed into the pulp chamber and then activated by heat or just sealed within the chamber for a number of days resulting in the release of oxidizing radicals that bring about the bleaching effect.[4]

Agents that are commonly used include hydrogen peroxide, carbamide peroxide, and sodium perborate.[6] Sodium perborate in its usual powder form decomposes when damp to release nascent oxygen as the oxidizing radical.[9] It is used by mixing with hydrogen peroxide or distilled water.[7]

The use of sodium perborate and hydrogen peroxide as a bleaching agent has been reported to be associated with side effects such as alteration of the micro hardness of the tooth structure and cervical root resorption.[9,13] This is well observed when the etiology of loss of tooth vitality is trauma.[13] The combined effect of alteration in the structure of the tooth by sodium perborate and hydrogen peroxide requires the use of less destructive regimen like sodium perborate mixed with distilled water which has not been used as a tooth bleaching agent. However, there is a need for a study that will compare the effectiveness of sodium perborate mixed with distilled water and sodium perborate mixed with hydrogen peroxide as non-vital anterior tooth bleaching agent, which this present study sought to do.

MATERIALS AND METHODS

The study was a randomized controlled trial, study participants were prospectively and consecutively recruited from patients attending both the Conservative Dentistry and Family Dentistry Clinics of the University College Hospital, Ibadan, Nigeria between September 2017 and May 2019. Ethical clearance for the study was obtained from the University of Ibadan/ University College Hospital, Ibadan Ethical Review Board with assigned number UI/EC/17/0084.

Seventy discolored teeth of 61 patients were randomized into two groups of 35 teeth per group by simple balloting in which the participants were requested to pick a wrapped paper labelled 'A' or 'B' from a ballot box. Participants who picked 'A' were recruited into the test group (Sodium perborate mixed with distilled water) while those who picked 'B' were recruited into the test group (Sodium perborate mixed with 30% hydrogen peroxide). For study participants who had more than one anterior discoloured teeth, they were asked to pick the wrapped paper labelled 'A' or 'B' for each discoloured teeth since each tooth is a unit of randomisation. Teeth included in the study were teeth with satisfactory obturation of canal and history of intrapupal hemorrhage or pulpal necrosis but free from dental caries and periodontal disease. Those excluded from the study were participants who had previous non vital bleaching as it will not give a true picture of the discolored shade, teeth with calcified or obliterated canals, discoloration from restorative materials and participants who were smokers as smoking will impair the progress of the treatment.

Before the study participants were recruited, an independent examiner was trained and calibrated on how to determine the shades of a tooth using the Vitapan classical shade guide® (Zahn Fabrick, Bad Sackingen, Germany) under natural light by a specialist in restorative dentistry. The calibration was done by both the examiner and specialist measuring tooth shades of 10 teeth twice after a time interval of 1 hour 3 weeks before the commencement of the study and the intra and inter examiner variability was determined using Kappa statistics. The baseline shade of each tooth to be treated as well as that of the contralateral tooth was determined by the independent examiner who was blinded to study groups allocation. The examiner undertook the shade assessment under natural light using the Vitapan shade guide. The Vitapan shade tabs were arranged in a value order as prescribed by the manufacturer from the lightest to the darkest shade; with assigned ranking numbers 1(B1) to 16 (C4) to allow for statistical computations. All the participants had scaling and polishing to remove extrinsic stains and isolation of the discolored tooth was done with rubber dam. Access cavity was reestablished with a round bur after which the gutta percha filling was reduced with gates glidden burr to 2mm below the cemento-enamel junction of the tooth to accommodate the glass ionomer cement lining. This depth was determined using a periodontal probe. The bleaching agent was then mixed and packed with the spoon excavator into the pulp cavity and condensed well against the labial wall. Access was temporized with zinc phosphate cement, occlusion was checked and adjusted where necessary. The recall visit was on days 7, 14, and 21. At each recall visit, the shade of the teeth was recorded using the Vitapan shade guide after which access was reestablished and the bleaching agent cleaned out. A fresh mix of bleaching agents was then

packed into the pulp cavity before temporizing access with zinc phosphate. The bleaching agents used were sodium perborate (SP) (Sultan products®, USA) mixed with either distilled water or 30% hydrogen peroxide gel for the experimental and control groups, respectively. The changes observed at each visit were documented as Shade guide units (Sgu) movement from the baseline shade as it progressed to a lighter shade.

A self-administered questionnaire was used to obtain information on study participants' bio-data and their perceptions to achieving optimal tooth shade and satisfaction of the tooth shade.

The data collected from the participants were recorded in the subjects' data collection forms. Data were entered and analyzed using SPSS (Statistical Package for Social Sciences) version 23. Summary statistics such as frequencies, proportions, means, and standard deviations were used to present the data on participants' tooth colour shades, tooth shade scores, self-perception to achieving optimal tooth shade and satisfaction of the tooth shade. Chi-square was used to compare qualitative variables between achieving optimal shade and type of bleaching agent as well as between level of satisfaction of tooth shade and type of bleaching agent, while the student t-test was used to compare the mean tooth shade scores of study participants at baseline, day 7, 14 and 21. The test of significance was set at $p<0.05$.

RESULTS
A total of 61 participants with 70 anterior discolored teeth started and completed the study. The ages of the participants ranged between 18 and 60 years with a mean ±SD age of 34.3±9.0 years. The majority 30 (49.2%) of participants were within the 31 – 45 years age group. More males 34(55.7%) than females 27(44.3%) participated in the study. The majority 53(86.9%) of the participants had tertiary education, 6(9.9%) had secondary education and 1(1.6%) participant had primary and no formal education respectively. Seventeen (27.9%) of the participants were professionals. The intra-examiner variability of measuring the tooth shades for the examiner and specialist were 92% and 95% respectively. The inter-examiner variability was 94%.

Table 1 shows that 34(97.1%) teeth, 19(54.3%) teeth, 4(11.4%) teeth, and 1(2.9%) tooth of the study participants in the control group had darker shade (A3-C4) at baseline, Day 7, Day 14, and Day 21, respectively. The corresponding values for teeth with lighter shade (B1-D3) in these participants were 1(2.9%), 16(45.7%), 31(88.6%) and 34(97.1%) teeth. Table 1 also shows that 5(14.3%) teeth, 1(2.9%) tooth, 0(0%) tooth and 0(0%) tooth of the study participants in the control group had darkest tooth shade (C4). The corresponding values for teeth of the control study participants with lightest tooth shade (B1) was 0(%) tooth, 1(2.9%) tooth, 4(11.4%) teeth and 8(22.8%) teeth.

Table 2 shows that 34(97.1%) teeth, 23(65.7%) teeth, 4(11.4%) teeth and 2(5.7%) teeth of the study participants in the test group had darker shade (A3-C4) at baseline, Day 7, Day 14 and Day 21 respectively. The corresponding values for teeth with lighter shade (B1-D3) in these participants are 1(2.9%) tooth, 12(34.3%) teeth, 31(88.6%) teeth and 33(94.3%) teeth. Table 2 also shows that 11(31.4%) teeth, 2(5.7%) teeth,

Table 1: Distribution of tooth color shades of teeth of participants in the control group (Sodium Perborate with 30% Hydrogen Peroxide) at various time intervals.

*Vita tooth Shade	Vita tooth shade Score	Baseline No. (%)	Day 7 No. (%)	Day 14 No. (%)	Day 21 No. (%)
B1	1	-	1(2.9)	4(11.4)	8(22.8)
A1	2	-	-	6(17.1)	15(42.8)
B2	3	1(2.9)	2(5.7)	2(5.7)	1(2.9)
D2	4	-	1(2.9)	3(8.6)	1(2.9)
A2	5	-	7(20.0)	10(28.5)	3(8.5)
C1	6	-	-	2(5.7)	5(14.3)
C2	7	-	2(5.7)	3(8.6)	1(2.9)
D3	8	-	3(8.5)	1(2.9)	-
A3	9	7(20.0)	9(25.8)	3(8.6)	1(2.9)
D4	10	4(11.4)	1(2.9)	-	-
B3	11	3(8.6)	2(5.7)	-	-
B4	13	2(5.7)	-	-	-
C3	14	2(5.7)	3(8.5)	1(2.9)	-
A4	15	11(31.4)	3(8.5)	-	-
C4	16	5(14.3)	1(2.9)	-	-

Note: Vita tooth shades in descending order of lightness

Table 2: Distribution of tooth color shades of teeth of participants in the test group (Sodium Perborate Plus Distilled Water) at various time intervals.

Vita tooth Shade	Vita tooth shade scores	Baseline No. (%)	Day 7 No. (%)	Day 14 No. (%)	Day 21 No. (%)
B1	1	-		-	3(8.5)
A1	2	-	1(2.9)	7(20.0)	14(40.0)
B2	3	-	-	1(2.9)	1(2.9)
D2	4	-	-	4(11.4)	3(8.5)
A2	5	1(2.9)	6(17.1)	7(20.0)	1(2.9)
C1	6	-		-	10(28.5)
C2	7	-	-	10(28.5)	-
D3	8	-	5(14.2)	2(5.7)	1(2.9)
A3	9	6(17.1)	7(20.0)	1(2.9)	-
D4	10	5(14.3)	3(8.5)	2(5.7)	1(2.9)
B3	11	3(8.6)	1(2.9)	-	-
B4	13	1(2.9)	-	-	-
C3	14	-	9(25.8)	-	1(2.9)
A4	15	8(22.8)	1(2.9)	-	-
C4	16	11(31.4)	2(5.7)	1(2.9)	-

Note: Vita tooth shades in descending order of lightness

1(2.9%) tooth and 0(0%) tooth of the study participants in the test group had darkest tooth shade (C4). The corresponding values for teeth of participants in the test group with lightest tooth shade (B1) was 0(0%) tooth, 0(0%) tooth, 0(0%) tooth and 3(8.5%) teeth.

Table 3 shows that the mean ± SD tooth shade scores of participants in the test group were 12.8±3.2 while those in the control group was 12.5±3.2, however the difference was not statistically significant (p = 0.75). Table 3 also shows that the mean ± SD tooth shade scores of participants in the test group were 9.6 ± 3.9,

Table 3: Mean ± SD tooth shade scores of participants' teeth in control and test groups at various time intervals.

Time intervals	Type of bleaching agents		t	p value
	Control (Sodium perborate + 30% hydrogen peroxide) Mean ± SD	Test (Sodium perborate + distilled water) Mean ± SD		
Baseline	12.5±3.2	12.8±3.2	-0.3	0.75
Day 7	8.7±3.8	9.6±3.9	-0.9	0.33
Day 14	4.9±2.8	5.6±3.0	-1.0	0.32
Day 21	3.1±2.2	4.0±2.9	-1.5	0.14

Note: SD= standard deviation, t = student t test.

Vitapan classical shade guide® (Zahn Fabrick, Bad Sackingen, Germany)

5.6 ± 3.0 and 4.0 ±2.9 for Day 7, 14 and 21 respectively while the corresponding values for these time intervals among participants in the control group were 8.7 ± 3.8, 4.9 ± 2.8 and 3.1 ± 2.2 respectively (p > 0.05).

Table 4 shows that study participants with 13(37.1%) and 14(40.0%) of control and test teeth respectively reported that the bleaching after 3 weeks achieved optimal shade change (p = 0.81). After 3 weeks of bleaching the non-vital teeth, overall 2(2.9%) study participants who were in the test group were

sodium perborate in 30% hydrogen peroxide which will make the former a safer choice.

In this study, the mean tooth shade score at baseline was 12.5 for teeth of participants in the sodium perborate mixed with 30% hydrogen peroxide group and 12.8 for participants in the sodium perborate mixed with distilled water group. In the first bleaching session on Day 7, the corresponding mean values were 8.7 and 9.6 respectively. These findings were at variance with previous reports[6,15,16] where sodium perborate

Table 4: Comparison of self-perception of achieving optimal shade among participants in the control and test groups.

Achieving optimal shade	Type of bleaching agents		χ^2	p value
	Control (Sodium perborate + 30% hydrogen peroxide) No. (%)	Test (Sodium perborate + distilled water) No. (%)		
Yes	13 (37.1)	14 (40.0)	0.06	0.81
No	22 (62.9)	21 (60.0)		

dissatisfied with their tooth shade. A higher proportion of the participants in the control group 22(62.9%) compared to the test group (54.3%), were extremely satisfied with their tooth shade at 21 days (p = 0.60) (Table 5).

DISCUSSION

Table 5: Comparison of participants level of satisfaction with final tooth shade in control and test groups.

Level of satisfaction	Type of bleaching agents		χ^2	p value
	Control (Sodium perborate + 30% hydrogen peroxide) No. (%)	Test (Sodium perborate + distilled water) No. (%)		
Extremely satisfied	22 (62.9)	19 (54.3)	1.66	0.60
Very satisfied	13 (37.1)	14 (40.0)		
Dissatisfied	0(0)	2 (5.7)		

*Note: * Fisher's exact test*

Walking bleach technique is an established treatment option for non-vital discolored anterior teeth.[6] It is a common choice of bleaching discolored teeth especially in developing countries as it is a less expensive and more conservative treatment option.[6] The common bleaching agent used for this technique is hydrogen peroxide with or without sodium perborate. However, side effects like cervical resorption have been associated with the use of hydrogen peroxide in bleaching discolored anterior teeth,[8,9,13] while some researchers[11,14] have reported that sodium perborate is not contributory to the side effect seen in non-vital bleaching. Nevertheless, sodium perborate cannot be used alone as it has to be wet to be active.[7,10] Therefore, this study was done to find out if the combination of sodium perborate and distilled water is as effective as

mixed with distilled water had a slower onset of action, thereby did not achieve significant tooth lightening. At the review of the second bleaching session on Day 14, the mean tooth shade score was 4.9 and 5.6 for teeth of participants in sodium perborate mixed with 30% peroxide and sodium perborate mixed with distilled water groups respectively. This showed that the latter was more effective than the former which is consistent with earlier reports[15,16] which showed that sodium perborate mixed with water exhibited improved bleaching effect from the second bleaching session. This is contrary to the findings of Umunnah et al.[6] and Lim et al.[15] who reported that the former was more effective than the latter. A previous report revealed that there was no difference between the bleaching actions of the two after two bleaching

actions. At Day 21, the end of the third bleaching session, further improved bleaching effect was observed. This is in agreement with finding of a previous study[17] that maximal efficiency of sodium perborate can be achieved after the third bleaching session and contrary to previous opinions that indicated that maximum intracoronal bleaching effect is achieved after two bleaching sessions with insignificant changes thereafter.[14] In this present study, the mean tooth shade score at this third session was 3.1 and 4.0 for teeth of participants in sodium perborate mixed with 30% peroxide and sodium perborate mixed with distilled water groups respectively. Just like the end of second session bleaching the latter exhibited improved bleaching than the former.

After the non-vital bleaching, the mean tooth shade in teeth of participants in sodium perborate mixed with 30% peroxide and sodium perborate mixed with distilled water groups decreased progressively to 3.1 and 4.0 at Day 21 respectively indicating that the change in tooth color became more pronounced as the days increased. These findings are in agreement with findings from previous studies.[14,16] In this present study, the color change became more prominent at Days 14 and 21 in agreement with findings from previous studies[14,16] in which desirable result was seen after two and three weeks of non-vital bleaching. The clinical implications are that it takes 14 days to achieve significant change in color and 21 days to achieve optimal change in treatment of discolored non-vital teeth.

The mean tooth shade score was slightly lower among teeth treated with sodium perborate with 30% hydrogen peroxide than teeth treated with sodium perborate in distilled water at the various time intervals. However, these slight differences were not statistically significant as reported in a previous study on invitro comparison of different bleaching agents in the discolored teeth.[14] Their findings revealed that the combination of sodium perborate and hydrogen peroxide has a synergistic effect that gives an initial accelerated action to the bleaching process, but sodium perborate mixed with distilled water achieves similar results in due course.[1,14] In this study, there was no statistically significant difference in the level of satisfaction of final tooth shade between study participants in both groups. After the bleaching process, 94.3% of study participants who used sodium perborate and distilled water were satisfied with the appearance of their teeth. This is slightly higher than 87.8% reported as patients' satisfaction after intra coronal non vital bleaching with sodium perborate by Gupta *et al.*, 2014[18] and this observation is encouraging and makes the use of sodium perborate with distilled

water meaningful. The practitioner can safely use this option as an effective alternative for non-vital bleaching of discolored teeth.

CONCLUSION
The effectiveness of sodium perborate mixed with distilled water was similar to that of sodium perborate mixed with 30% hydrogen peroxide in the lightening of the coronal part of endodontically treated non-vital discoloured anterior teeth. Both bleaching agents demonstrated similar patient satisfaction. This implies that sodium perborate mixed with distilled water is an alternative less expensive and more conservative treatment option for non-vital discoloured anterior teeth.

REFERENCES
1. **Plotino G,** Buono L, Grande NM, Pameijer CH, Somma F. Non-vital bleaching: a review of the literature and clinical procedures. J Endodontics. 2008;34,394-406.
2. **Murthy CS,** Sudhanva ME, Raghavendra R, Vishwas B. Combined approach for tooth whitening: A case report. Int Journal of Clinical Dent Sci. 2, 2011;69-71.
3. **Umar I,** Kamalak H. Bleaching discoloured devital teeth with using of new agents. IOSR Journal of Dental and Medical Science (IOSR-JDMS). 2014; 13,79-82.
4. **Izidoro ACS,** Martins GC, Higashin C, *et al.* Combined technique for bleaching non-vital teeth with 6 months clinical follow up. International Journal of Oral Dental Health. 2015;1,1-4.
5. **Sruthy P,** Rajesh H, Vinitha AB, Anupama SR. Extrinsic stains and management: a new insight. J Acad. Indus. Res. 2013;1,435-442.
6. **Umuanah AU,** Sede MA., Ibhawo LO. Clinical efficacy of 35% carbamide peroxide and sodium perborate in intracoronal bleaching of discoloured non-vital teeth. JMBR: A Peer review Journal of Biomedical Sciences. 2013;12,96-104.
7. **Akpata ES.** Operative Dentistry, 2nd edition, Quintessence publishing: 2005; 173-195.
8. **Valera** MC, Camargo CHR, Carvalho CAT, Oliveira LD, Camargo SEA, Rodrigues CM, 2009. Effectiveness of carbamide peroxide and sodium perborate in non-vital discoloured teeth. J Appl Oral Sci.2009;17,254-261.
9. **Harshitha C.** Effects of tooth whitening agents in non-vital teeth. J, Pharm, Sci & Res. 2014;6,124-126.
10. **Ganesh R,** Aruna S, Joyson M, Manikandan D. Comparison of the bleaching efficacy of three different agents used for intracoronal beaching of discoloured primary teeth: an in vitro study. J of

Indian Society of Pedodontics and Preventive Dentistry. 2013;1,17-21.

11. **Fearon J.** Tooth whitening: concepts and controversies. J of the Irish Dent Assoc. 2007;53, 24-38.

12. **Leith R,** Moore A, O'Connell AC. An effective bleaching technique for non-vital discoloured teeth in children and adolescents. J Irish Dent Assoc. 2009;55,184-189.

13. **Bahuguna N.** Cervical root resorption and non-vital bleaching. Endodontology. 2013;25,106-111.

14. **Ho S,** Goerig AC. An in vitro comparison of different bleaching agents in the discoloured tooth. J Endodon. 1989;15,106–111.

15. **Gupta SK**, Saxena P. Evaluation of patient satisfaction after non-vital bleaching in traumatised discoloured intact anterior teeth. Dent Traumatol. 2014;30,396-399.

16. **Warren MA**, Wong M, Ingram TA. 3rd. In vitro comparison of bleaching agents on the crowns and roots of discolored teeth. J Endodon. 1990; 16,463–467.