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Research Article

Comparison of Periodontal Status of Adult Individuals Using Charcoal and Regular Nylon Toothbrushes in a Nigerian Health Facility

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Abstract

The high prevalence of periodontal disease in adolescents, adults, and older individuals makes it a public health concern. Although studies have been reported on the efficacy of charcoal-infused versus Nylon toothbrushes on periodontal health, there appears to be a lack of documented reports. This study compared individuals' periodontal health using a charcoal-infused and a regular nylon bristle toothbrush. This randomized clinical crossover study recruited all consecutive participants who presented to the Department of Periodontics at a tertiary facility for scaling, between May 2022 to April 2023. Each participant made use of each toothbrush; Charcoal-infused and Nylon toothbrush. Participants were instructed to brush with either toothbrush and the same fluoride toothpaste, morning and evening after meals, for three minutes and with the modified Bass technique. They were recalled after three weeks for assessment and the PI, GI, and CPITN were recorded at baseline and after three weeks of use of toothbrushes. After six months of washout (using whatever individual was used to), the toothbrush was exchanged, and the same procedure and assessments were done. Data collected were Biodata (age, sex, marital status, occupation, education, and ethnic group) and records of PI, GI, and CPITN values. A level of significance was set at $p<0.05$. All analysis was done with SPSS software version 26, (IBM, Armonk, New York, US). A total of twenty - two adults with a mean age of 32.82 ±12.19 years were recruited in this study. There was an improvement in periodontal status as all the participants had healthy gingivae at the end of the study. There was a significant reduction of the mean CPITN values for charcoal ($p=0.0001$) and Nylon ($p= 0.001$) over three weeks. However, there was no statistically significant difference in PI, GI, and CPITN ($p =0.757$, $p =0.806$, $p =0.391$, and $p =0.1$) respectively. The charcoal-infused toothbrush was not better than the Nylon bristle toothbrush in maintaining the periodontal status of participants in this study over three weeks. However, the periodontal status of participants was positively impacted.

Keywords

Charcoal/Nylon, Toothbrush, Periodontal Status

1. Introduction

Periodontal health is related to oral health and general well-being [1]. Periodontitis is the most common chronic inflammatory disease seen in humans, with considerable impacts on individuals and society [2]. People with untreated

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periodontitis which is an oral disease, result in preventable pain, infection, and reduced quality of life, as well as missed school and productivity losses. Poor oral health may be associated with heart disease, stroke, diabetes, pneumonia, and other respiratory diseases. Good oral health is also necessary for healthy aging, playing a crucial role in nutrition, employment, self-esteem, and continued social interaction. It is therefore important to preserve periodontal and oral health status. Supragingival plaque removal is considered to be of utmost importance in the decline of the prevalence of caries, gingivitis, and periodontitis [3].

Periodontal health and oral health status can be maintained with proper plaque removal measures since the primary aetiologic factor of periodontal diseases is bacterial plaque [4, 5]. Plaque removal measures include the use of manual toothbrushes and dentifrices, tooth floss, interdental brushes, and mouth rinses. The efficacy of mechanical plaque control with a manual toothbrush depends on user dexterity, technique, force, duration, and frequency during brushing [5].

The choice of an individual's toothbrush design is determined by his oral health needs. The toothbrush design is dependent upon toothbrush head size, shank angulation, bristle material, and arrangement. The brushing plane of toothbrushes is determined by the bristle length and angulation [5]. The nylon bristle toothbrush is commonly used with varying bristle diameter, length, taper, and arrangement within tuft slots in the head of the toothbrush [5].

The bending, splaying, and flaring of worn bristles possibly affect their plaque removal efficacy requiring the replacement of toothbrushes [6].

The blending of charcoal into nylon bristles can reduce halitosis, reduce plaque, and also kill bacteria [7]. Bristles of charcoal toothbrushes are black and are prepared by blending *binchotan* charcoal into nylon bristles [8]. When Charcoal is exposed to high temperatures often in combination with gases such as oxygen during manufacturing, it becomes activated. Charcoal when activated has a high absorptive capacity [7]. When a form of carbon is treated it essentially becomes activated charcoal. The treatment involves the removal of water and other volatile constituents from carbon-based materials, such as bamboo, wood, or coconut husk and shell [8], to make the surface of its particles porous. The pores act like magnets for other particles like dirt and oil which it absorbs, allowing all of the unwelcome substances to be swept away when the charcoal is washed off [8].

In theory, charcoal binds to everything in its path like stains, tartar, bacteria, viruses, and even the tonsils [7]. Extrinsic stains slowly accumulate on the outermost part of the tooth structure, the enamel. These gradually developing stains are due to certain substances in caffeine, wine, smoking, and some stain-producing foods [8]. Extrinsic stains are the secondary causative factor for periodontal disease [8]. The more the stain, the more plaque, the more the disease, and the poorer the oral hygiene status.

Activated charcoal helps to push up the pH level of the oral cavity primarily because it can bind with acidic components in plaque and results in their accelerated removal from the oral cavity. Nylon bristles toothbrush is the most commercially available toothbrush manufactured [9]. Nylon bristles were copies of natural bristles in length and thickness initially [9]. They were stiffer than natural bristles of similar diameters, and did not have the hollow stem of natural bristles, and thus did not absorb water [9]. However, compared to natural bristles, nylon filaments have additional advantages; they can be in various uniform diameters and shapes; and end-rounded to be gentle on gingival tissues during brushing [9]. However, the charcoal blended into nylon bristles toothbrush gives an added advantage of binding to the acidic components of plaque and improving plaque removal. Therefore, it will be necessary to compare the effectiveness of charcoal and nylon toothbrushes in maintaining periodontal and oral health status. Thus, activated charcoal helps to remove plaque and results in relieving halitosis [7].

Tooth brushing is the most widely used method for plaque control, and a wide variety of toothbrushes are commercially available. Studies comparing the efficacy of available toothbrushes are scarce [10]. In a study among dental practitioners, there was also low awareness and knowledge of charcoal-based products [8]. The use of a charcoal toothbrush was recommended in a study, as it demonstrated better plaque removal efficacy as compared to plain nylon bristle [11]. Thus, it is necessary to have an efficient plaque removal measure for maintaining both periodontal and oral health status, especially in our setting.

Traditionally our forefathers used charcoal which aided in good dental plaque control; however, studies have not been done to test their effectiveness, efficacy, and efficiency in our setting. A major point raised by a previous study was that charcoal-infused bristle toothbrushes had better plaque control efficacy than regular nylon toothbrushes among dental students [11]. Thus in areas such as ours, it will be necessary to know the plaque control effectiveness by comparing the Charcoal-infused bristles toothbrush versus the regular Nylon toothbrush; to provide alternative oral hygiene methods to persons who may be aware of charcoal used for oral hygiene practice however unsure of its effect and safety. Also, a paucity of studies has been reported in Nigeria to demonstrate the efficacy of charcoal-infused toothbrushes compared to nylon bristle toothbrushes in maintaining periodontal health status. The aim therefore is to compare the periodontal health of persons using charcoal-infused toothbrushes with those using regular nylon bristles.

2. Materials and Methods

Following ethical approval (ADM/E/A/VOL, VII/14831070), a randomized clinical crossover study was conducted between May 2021 to May 2022 among adult participants who presented to the Periodontics clinic, of a Nigerian Tertiary health facility. Individuals who met the inclusion

criteria, presented for dental treatment, and gave their consent, were recruited into the study. They used both the regular nylon toothbrushes and the new charcoal-infused bristle toothbrushes.

Inclusion criteria included Adults 18 years and above and without co-morbidities. (Hypertension, Diabetes). Subjects without habits and conditions that cause reduced saliva. Subjects not wearing orthodontic or prosthetic appliances. Subjects without crowding. Subjects who were not on antimicrobials or analgesics. Subjects who did not report tobacco use in any form. Subjects without mouth breathing and occlusal parafunction.

This clinical study was registered with the Pan African Clinical Trial Registry (www.pactr.org) database, with an identification number; PACTR202305892616028.

A sample size of 22 was calculated with the Siyasinghe and Sooriyarachichi formula [40],

$$(n = \frac{(Z\alpha_{/2}+Z_{ß})^2 {\sigma_m}^2}{2(\mu_1-\mu_2)^2})$$

The data collected were age, gender, occupation, level of education, and marital status. Other data collected were recorded on the proforma provided; on the assessment of Plaque, Oral Hygiene status, gingival status, and Community Periodontal Index for Treatment Needs.

Oral Examination was done with a Dental mirror and an Explorer.

A Pre-test was also conducted. This involved 4 participants (18% of the sample size) that were not part of the study; before the commencement of the study. Two of the participants used charcoal toothbrushes and the other two used regular nylon toothbrushes to assess their adherence to the oral hygiene instructions with the same frequency, timing, and technique following the use of the toothbrush.

Participants were selected using a systematic sampling technique, by choosing the second person with a sampling interval (Population/ sample size=30/15) of two, after random sampling of the first sample fulfilling the selection criteria as they present. A clinical examination was performed on the dental chair. Assessments were done for the Plaque, Oral hygiene, and Periodontal status with the use of the Turesky-modified Quigley Hein plaque index, Simplified Oral hygiene index, gingival index, and the community periodontal index of treatment needs (CPITN) Index. Oral hygiene instructions; were given on the frequency, sequence, and timing of tooth brushing. The standard brushing instructions involve the use of either a Charcoal-infused or regular Nylon toothbrush with a Modified Bass brushing technique for three minutes twice a day after meals (morning and evening), and brushing each quadrant six times. They also used fluoride-containing toothpaste provided for them. Participants were also discouraged from using other mechanical or chemical plaque control methods. They had oral prophylaxis. Two participants were assessed in a day, thrice a week. A ballot form of random sampling: using sealed envelopes was given to participants to determine what toothbrush to use first.

2.1. Introductory and First Appointment

Initial oral prophylaxis was done to take the plaque score to zero. There was a recall of one day without brushing to allow the build of plaque for the baseline, and a record of the assessments for PI, OHI-S, CPITN, and GI. Eleven participants had one charcoal-infused bristle toothbrush each, while the other eleven were given one nylon bristle toothbrush each, for use in three weeks.

2.2. Second Appointment

Participants' plaque index, Simplified Oral hygiene index, Gingival index, and the community periodontal index of treatment needs (CPITN) Index, were assessed and the records were documented. The first toothbrush was retrieved, and the oral hygiene instruction re-emphasized. Participants were encouraged to use their previous plaque control method and return after six months.

2.3. Crossover and Third Appointment

There was a washout period of six months, and participants came for a third appointment.

A second oral prophylaxis to standardize the patient (take the plaque score to zero) was carried out. There was a recall of one day without brushing to allow the build of plaque for the baseline of the second phase of intervention and a record of the assessments of PI, OHI-S, CPITN, and GI was taken. The toothbrushes (Charcoal-infused, regular Nylon) were given for another three weeks, such that those who used charcoal in the first phase got the nylon toothbrush. Oral hygiene instructions were re-emphasized.

2.4. Fourth Appointment

The assessment was done using the Plaque index, GI, OHI-S, and CPITN after three weeks, and measurements were recorded.

Study participants were assessed for baseline parameters, plaque levels, oral hygiene, and periodontal status before and after three weeks of using the different experimental toothbrushes.

Both descriptive and inferential statistics were performed. In descriptive statistics, the categorical data were presented as frequency and percentages while the continuous data were summarized as range, means and standard deviation. In the inferential statistics, of group differences in variables, such as an independent t-test, paired t-test, and ANOVA (Analysis of Variance test) was employed. The level of significance was set at $p<0.05$. All data was analyzed using SPSS software version 26 (IBM, Armonk, New York, US).

3. Results

A total of 22 participants were recruited for this crossover study. There were more females (13, 59.1%) than males (9, 40.9%) in the study. The mean age of the study participants was 32.82 ±12.19 years. There was a statistically significant difference in the age distribution between the two toothbrush sequence categories (p=0.006). There was also a statistically significant difference in marital status (p=0.010) and occupational level (p = 0.009). However, these significant differences will not affect the study outcomes as this was a crossover study, where all participants received both interventions and served as their controls.

There was a considerable reduction in the level of gingivitis, as all the participants had healthy gingivae at the end of the study. There was a significant reduction of the mean CPITN values for charcoal (p=0.0001) and Nylon (p= 0.001) over three weeks. Both toothbrushes impacted the periodontal status in improving oral health. However, there was no statistically significant difference in GI, and CPITN (p =0.391, and p =0.1 respectively) in comparison to either toothbrush after the three weeks of use.

4. Discussion

Periodontal diseases are prevalent in developed and developing countries and affect about 20-50% of the global population [39]. This high prevalence of periodontal diseases, in adolescents, adults, and older individuals makes it a public health concern [38]. Several studies on the Prevalence of periodontal diseases in Nigeria have been on the increase with a varied rate from 15% to about 90% [41, 44-49]. Periodontal diseases have been known to have a considerable impact on our society [2], and if left untreated cause reduced quality of life, missed school attendance, and productivity losses. It is, therefore, necessary to preserve periodontal and oral health status using proper plaque removal measures [5], like nylon bristle or charcoal-infused toothbrushes. It has also been established that the primary aetiologic factor of periodontal disease is bacterial plaque [4, 5, 13-34]. Consequently, this study aims to compare the effectiveness of charcoal and nylon toothbrushes in maintaining oral health and periodontal states.

A total of twenty-two participants participated in this study with 100% participation. This study was conducted as a cross-over study so that the participants acted as their controls; their technique, duration, sequence, and frequency in brushing remained similar during both phases with the use of the toothbrushes [7]. The participants were blinded to the interventional toothbrushes (Charcoal-infused and regular Nylon) given to them using sealed envelopes at the different phases of the study to remove the Hawthorne effect (knowledge of an intervention influencing the outcome) experienced in a study with a single toothbrush use [49].

This study was carried out with each toothbrush, used over three weeks during each phase of the study [48], with assessments for PI, OHI-S, CPITN, and GI performed at baseline and three weeks from baseline for both phases of the intervention. The toothbrush was used for three weeks to utilize the utmost efficacy of the toothbrush as some toothbrushes experience wear by one month from commencement of use.

Oral hygiene instructions; were given to all participants to adhere to a similar technique (modified Bass), sequence (six times on each quadrant), duration (3 minutes), and frequency morning and evening every day) to subject both toothbrushes to similar patterns of use [12]. A pre-test comprising four volunteer participants, was carried out to assess their adherence to the oral hygiene instructions with the same frequency, timing, and technique; in the use of the toothbrush. The outcome was satisfactory, and further educated them; on their oral health promotion. Participants were monitored with phone calls to remind them of the instructions and their dates of appointments.

All participants were given oral prophylaxis at the baseline and after the washout period of six months to standardize them. Then participants were given a day recall to allow for the build of plaque without brushing at night, and assessments for the baseline were done. At the end of the three weeks for each phase of the study, assessments of the PI, OHI-S, CPITN, and GI were also done.

The modified Bass technique was chosen for this study as the bristle tips removed plaque from the cervical area of teeth along the free gingival margin and facilitated intra-sulcular brushing without causing abrasive trauma to the gingiva [49].

More females (59.1%) were found to be present in this study, and this was also similar (72%) in the study by Kini et al, who studied the plaque removal efficacy and bristle wear between charcoal-infused and nylon bristle toothbrushes [12]. This predominance of females could be attributed to the better oral health-seeking behavior that is among them [35, 50]. Although there was no significant difference among the genders in the toothbrush categories in this study, there was a significant difference among genders in PI, OHI-S, and brushing frequency in a study by Kolawole et al, in western Nigeria [47] and another study in India [36]. Similar to this study, there was no significant difference between charcoal based and non-charcoal-based toothbrushes in maintaining oral hygiene in other studies [37, 51-57].

5. Conclusion

The charcoal-infused toothbrush was not better than the Nylon bristle toothbrush in maintaining the periodontal status of participants in this study over three weeks. Moreover, the periodontal status of participants in this study was positively impacted by the use of both interventional tools.

Limitation

The sample size included in the study is small.

Apart from the various advantages of Charcoal cited in the study, there are also a few disadvantages/adverse effects of using Charcoal toothbrushes.

Abbreviations

PI	Plaque Index
GI	Gingival Index
CPITN	Community Periodontal Index of Treatment Needs
US	United States of America
OHI-S	Simplified Oral Hygiene Index
ANOVA	Analysis of Variance Test

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The research was self-funded.

Data Availability Statement

The data are available on request from the corresponding author.

Conflicts of Interest

The authors declare no conflict of interest related to the study.

Appendix

Table 1. *Socio-demographic Characteristics of the Study Participants.*

Variable	Sequence (N=22)		Total	Statistic	P value
	†N_1 - C_2 (n=11)	C_1 - N_2 (n=11)			
Sex					
Male	6 (54.5%)	3 (27.3%)	9 (40.9%)	Yates=0.752	0.386
Female	5 (45.5%)	8 (72.7%)	13 (59.1%)		
Total	11 (100%)	11 (100%)	22 (100%)		
Age Category (yrs.)					
≤20	0 (0%)	4 (36.4%)	4 (18.2%)	Fishers=11.242	0.006*
21-30	1 (9.1%)	5 (45.5%)	6 (27.3%)		
31-40	6 (54.5%)	1 (9.1%)	7 (31.8%)		
≥41	4 (36.4%)	1 (9.1%)	5 (22.7%)		
Total	11 (100%)	11 (100%)	22 (100%)		
Mean Age	40.82 ±9.32	24.82 ±9.17	32.82 ±12.19	T=4.057	0.001*
Marital status					
Single	2 (18.2%)	8 (72.7%)	10 (45.5%)	Yates=6.600	0.010*
Married	9 (81.8%)	3 (27.3%)	12 (54.5%)		
Total	11 (100%)	11 (100%)	22 (100%)		
Educational Level					
Primary	1 (9.1%)	0 (0%)	1 (4.5%)	Fishers=2.062	0.476
Secondary	1 (9.1%)	0 (0%)	1 (4.5%)		

Variable	Sequence (N=22)		Total	Statistic	P value
	†N_1 - C_2 (n=11)	C_1 - N_2 (n=11)			
Tertiary	9 (81.8%)	11 (100%)	20 (90.9%)		
Total	11 (100%)	11 (100%)	22 (100%)		
Ethnic group					
Edo	5 (45.5%)	7 (63.6%)	12 (54.5%)	Fishers=4.529	0.200
Esan	2 (18.2%)	4 (36.4%)	6 (27.3%)		
Igbo	1 (9.1%)	0 (0%)	1 (4.5%)		
Others	3 (27.3%)	0 (0%)	3 (13.6%)		
Total	11 (100%)	11 (100%)	22 (100%)		
ISCO Occupational Classification					
Level I	0 (0%)	6 (54.5%)	6 (27.3%)	Fishers=10.233	0.009
Level II	5 (45.5%)	1 (9.1%)	6 (27.3%)		
Level III	4 (36.4%)	4 (36.4%)	8 (36.4%)		
Level IV	2 (18.2%)	0 (0%)	2 (9.1%)		
Total	11 (100%)	11 (100%)	22 (100%)		

† N_1 - C_2= Nylon bristle (1st period) Charcoal-infused (2nd period) Group; C_1 - N_2= Charcoal-infused (1st period) then Nylon bristle (2nd period) Group. ISCO: International Standard Classification of Occupations [41].

Table 2. *Comparison of the GI P values in participants using Charcoal-infused toothbrushes and those using regular Nylon bristle toothbrushes.*

GI Scores	Nylon n (%)	Charcoal n (%)	Total n (%)	P value
24 hours				
0	4 (36.4)	4 (36.4)	8 (36.4)	0.023
1	5 (45.5)	7 (63.6)	12 (54.5)	
2	2 (18.1)	0 (0.0)	2 (9.1)	
3	0 (0.0)	0 (0.0)	0 (0.0)	
3 weeks				
0	9 (81.8)	7 (63.6)	16 (72.7)	0.015
1	2 (18.2)	4 (36.4)	6 (27.3)	
24 hours				
0	8 (72.7)	8 (72.7)	16 (72.7)	0.452
1	2 (18.2)	3 (27.3)	5 (22.8)	
2	1 (9.1)	0 (0.0)	1 (4.5)	
3 weeks				
0	11 (100.0)	11 (100.0)	22 (100.0)	-------
Total	11 (100.0)	11 (100.0)	22 (100.0)	

Table 3. *Analysis of variance table to test for Carryover (treatment sequence) and Period effects on GI.*

Source	Df	Type III SS	F value	P value
Sequence effect	1	0.117	1.099	0.301
Period	1	0.080	0.752	0.391
Error	39	4.140	-	-

Table 4. *Intergroup and Intragroup Comparisons for GI.*

GI Scores	Nylon n (%)	Charcoal n (%)	Total n (%)	P value
24 hours				
0	4 (36.4)	4 (36.4)	8 (36.4)	0.023
1	5 (45.5)	7 (63.6)	12 (54.5)	
2	2 (18.1)	0 (0.0)	2 (9.1)	
3	0 (0.0)	0 (0.0)	0 (0.0)	
3 weeks				
0	9 (81.8)	7 (63.6)	16 (72.7)	0.015
1	2 (18.2)	4 (36.4)	6 (27.3)	
24 hours				
0	8 (72.7)	8 (72.7)	16 (72.7)	0.452
1	2 (18.2)	3 (27.3)	5 (22.8)	
2	1 (9.1)	0 (0.0)	1 (4.5)	
3 weeks				
0	11 (100.0)	11 (100.0)	22 (100.0)	-------
Total	11 (100.0)	11 (100.0)	22 (100.0)	

Table 5. *CPITN P values in participants using Charcoal-infused toothbrushes and those using regular nylon bristle toothbrushes.*

CPITN Scores	Nylon n (%)	Charcoal n (%)	Total n (%)	P value
24 hours				
0	1 (9.2)	0 (0.0)	1 (4.5)	0.200
1	4 (36.1)	8 (72.7)	12 (54.5)	
2	5 (45.5)	3 (27.3)	8 (36.4)	
3	1 (9.2)	0 (0.0)	1 (4.5)	
3 weeks				
0	5 (45.4)	5 (45.4)	10 (45.5)	0.798
1	4 (36.4)	5 (45.4)	9 (40.9)	
2	2 (18.2)	1 (9.1)	3 (13.6)	
24 hours				
0	6 (72.7)	4 (36.4)	10 (45.5)	0.311

CPITN Scores	Nylon n (%)	Charcoal n (%)	Total n (%)	P value
1	1 (9.2)	0 (0.0)	1 (4.5)	
2	4 (36.1)	6 (54.5)	10 (45.5)	
3	0 (0.0)	1 (9.2)	1 (4.5)	
3 weeks				
0	10 (90.9)	7 (63.6)	17 (77.2)	0.162
1	1 (9.1)	2 (18.2)	3 (13.6)	
2	0 (0.0)	2 (18.2)	2 (9.2)	
Total	11 (100.0)	11 (100.0)	22 (100.0)	

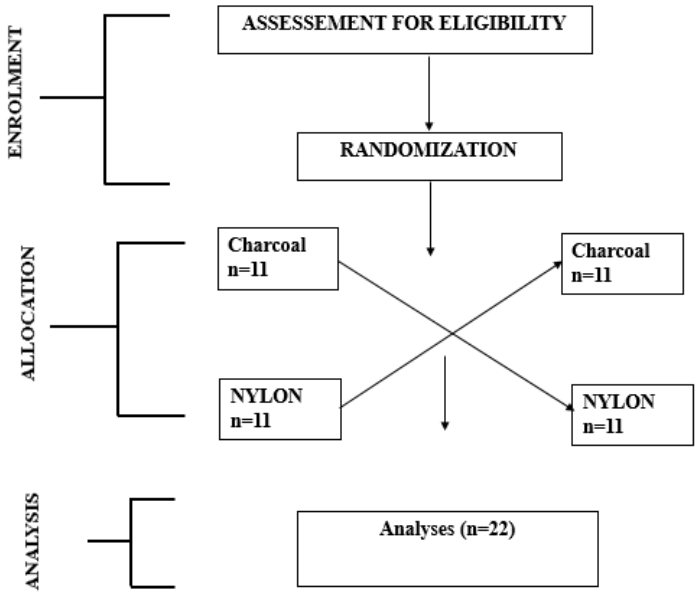

Figure 1. *Flowchart of Study participants- Enrolment, allocation, intervention, follow-up, and data analysis of a crossover trial, with each serving as its control. (Modified from the CONSORT (Consolidated Standards of Reporting Trials) 2010 Statement [42, 43].*

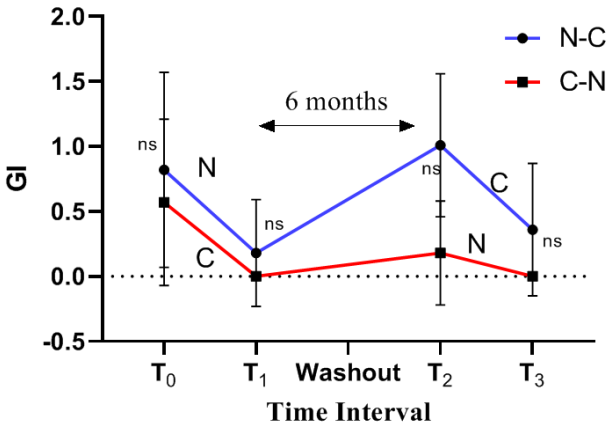

Figure 2. *The trend of GI in the Study groups.*

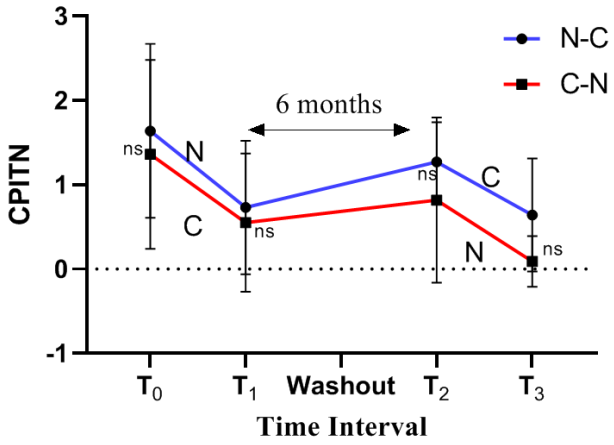

Figure 3. *The trend of CPITN in the study groups.*

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