

# Xerostomia in Dialysis Patients – Oral Care to Reduce Hyposalivation, Dental Biofilms and Gingivitis in Patients with Terminal Renal Insufficiency

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## Research Article

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# Abstract

## *Objectives*

Dialysis patients suffer from xerostomia based on hyposalivation even in stimulated saliva testing. It was, therefore, the aim (i) to evaluate an optimized oral hygiene system with an oral care gel on oral dryness, dental plaque control and number of gingivitis teeth, (ii) to document the efficacy in a randomized controlled trial with dental indices and (iii) to record the individual oral health-related quality of life.

## *Methods*

After ethical approval (EC-UWH 103/2019), 44 dialysis patients signed informed consent forms and were divided into two groups followed up for four weeks. Subjects in verum group A were taking the daily oral care gel OROFAN® based on biopolymers with mild antibacterial and saliva stimulating action. They were compared to control group B executing routine oral hygiene with conventional dentifrice and toothbrushes. The Oral Health Impact Profile was documented at baseline and at the end of the study.

## *Results*

Twenty-two subjects were allocated to group A and group B. At baseline, there were no significant differences concerning renal insufficiency (years on dialysis, complications), systemic diseases, or dental background (caries experience, periodontal diseases, plaque index, number of gingivitis teeth). All subjects exhibited hyposalivation (< 0.7-1.0 ml/min).

Control group B showed no significant differences from baseline to the end of the study in dry mouth parameters, in all dental plaque and inflammation indices, or in the Oral Health Impact Profile. In contrast, verum group A exhibited a highly significant ( $p < 0.001$ ) decrease in xerostomia frequency, number of gingivitis teeth and plaque index. The Oral Health Impact Profile improved considerably ( $p < 0.01$ ).

## *Significance of Results*

Terminally ill patients may gain better oral health and, consequently, improved quality of life by rather simple oral care, including long-lasting, eatable anti-inflammatory oral hygiene gel and dentist's devotion.

# Introduction

Xerostomia is the subjective sensation of dry mouth. The objective sign of a dry mouth is the hypofunction of the salivary glands with measurably decreased saliva production (Ying Joanna and Thomson 2015). Salivary flow plays a critical role in maintaining physiological balance in the oral cavity. Loss of saliva volume means loss of antibacterial properties, favoured plaque formation, acceleration of tooth demineralization and caries development. Microorganisms in the oral cavity are a component of eubiotic plaque, contribute to the prevention of infections and perform a protective function. If this

physiological biofilm with eubiotic conditions becomes unbalanced, a pathogenic plaque with dysbiotic conditions forms and increases the risk of caries and gingivitis development (Gängler et al. 2010).

The reduction in salivary flow means that the patient is at increased risk of developing caries, having problems wearing dentures, or developing infectious diseases (Neuhaus and Strömberg 2020). In addition, xerostomia, its resulting consequences and diseases can lead to a decrease in the quality of life and even to a decrease in the patient's psychological stability.

Xerostomia is relatively common in Europe and is found in more than 20 percent of the population, with women and the elderly being more frequently affected (Billings et al. 1996, Nederfors et al. 1997). In those over 65 years of age, it is reported to occur in approximately 30% (Ship et al. 2002).

A recent study in a population of 65-year-old Oslo residents showed that 8% of the population had unstimulated salivary flow below 0.1 ml/min, and 3% of the subjects studied had xerostomia and hyposalivation (related to unstimulated salivary flow). Xerostomia was significantly correlated with medication, rheumatic diseases, radiotherapy of head and neck tumors and type 2 diabetes (Diep et al. 2021).

It is a common accompanying symptom in patients with chronic kidney disease or end-stage renal failure requiring dialysis. Changes in the amount and composition of saliva lead to hyposalivation or xerostomia (Jover Cerveró et al. 2008, Vendramimi et al. 2011, Kaushik et al. 2013, Swapna et al. 2013). Xerostomia in renal patients is favored by other chronic diseases, such as diabetes mellitus or hypertension, and taking necessary medications.

The aim of this study was to examine whether subjectively perceived xerostomia is associated with reduced saliva production in patients with renal failure requiring dialysis and whether oral health can be favorably influenced by means of intensified oral care. In particular, it should be examined whether this is more successful with a special edible oral care gel and a nursing toothbrush than with the measures previously used by the patients.

## Methods

The study was performed in 44 patients (18 women and 26 men) between 30 and 85 years (mean age 57.5 years) under ambulatory dialysis therapy (43 patients hemodialysis, 1 patient peritoneal dialysis) as a randomized controlled trial. Ethical approval was obtained from the Ethical Committee of the University of Witten/Herdecke (No. 103/2019). All subjects had the subjective feeling of dry mouth, and they gave written consent after clinical and procedural information by the study dentist (LE).

The subjects were randomly divided into two groups. The Verum Group used a new oral care gel OROFAN® containing xylitol, ChitoClear, Aloe vera, hydroxyethyl cellulose and O-cymen-5-ol. (Dr. Hinz Group, Herne, Germany) and the OROFAN®- nursing toothbrush, designed and clinically tested for handicapped patients (Lohaus, 2020). The patients in the control group continued their usual oral

hygiene at home with conventional dentifrice and manual toothbrushes (16 patients) or powered toothbrushes (6 patients). The study period was 28 days.

At the start of the study, after obtaining information, education and informed consent, a baseline examination was performed; after two weeks, an intermediate examination was performed; and after four weeks, the final examination was performed. At the same time, all subjects in both groups were trained in the correct performance of twice-daily oral hygiene. Subjects in the verum group were instructed on how to use the gel and the nursing toothbrush.

At the baseline examination, a general survey of personal data, underlying diseases, secondary diseases, other diseases and drug medications, performance of dialysis and oral hygiene was carried out. At the intermediate examination, subjects were questioned regarding their subjective oral hygiene and dry mouth feeling. In case of problems and difficulties concerning toothbrushing, plaque control and gingivitis bleeding, the individual oral care was optimized by reinstruction. The final anamnestic questionnaires were taken after four weeks.

At baseline, the stimulated total salivary flow rate was measured for evidence of hyposalivation. Oral findings were recorded at the baseline examination. The assessment of plaque accumulation on the dorsum of the tongue was performed at three severity levels. Dental plaque was assessed using the Silness and Loe plaque index SLI (Silness and Loe 1964) in five codes, and gingivitis and periodontitis experience was assessed using the GPMT index (Gaengler 1984), counting the number of teeth exhibiting gingivitis and periodontitis after six-point probing around all single teeth. Caries prevalence was assessed using the DMF/S index (Klein and Palmer 1938). Denture hygiene for the maxilla and mandible was documented with the Denture Hygiene Index (DHI) according to Wefers (1999) and indicated as a percentage of the coating (plaque)-free areas.

To investigate subjective perceptions and record individual oral health-related quality of life, the Oral Health Impact Profile (OHIP-G14; John et al., 2002) was asked at baseline and at the end of the study. This validated version of the German version is a partly self-administered questionnaire that focuses on seven items (functional limitation, pain, psychological discomfort, physical disability, psychological disability, social disability and handicap). The 14 questions in the hands of subjects were commented on and finally self-documented in 5 codes (0 – never, 1 – hardly ever, 2 – occasionally, 3 – fairly often, 4 – very often). The total code number ranges, therefore, from 0 to 56.

At the intermediate examination, a special control belief questionnaire was completed to assess the patient's own attitude toward oral hygiene. At the final examination, the subjective success of oral hygiene measures was also assessed by means of a questionnaire.

Statistical analysis was performed with the statistical program system IBM SPSS Professional Statistics Premium, release 26, 64-bit version, using the Kolmogorov-Smirnov test, the t-test, the Wilcoxon-Mann-Whitney U test, the Wilcoxon signed-rank test, Pearson's chi-square test, and the McNemar test. The significance level was set at  $p < 0.05$ ,  $p < 0.01$ , and  $p < 0.001$ .

## Results

There were 22 subjects in both groups, and no differences were found between the two groups in terms of years on dialysis, number of complications under dialysis, medications (continuous therapy, medications for dialysis or taken on-demand), as well as the need for care and number of diagnoses. The most common disease in both groups was hypertension, 95.5% and 86.4%, respectively. There was no difference in the number of diabetes mellitus subjects (HbA1c 6.9% and 6.8%, respectively), and nicotine consumption was similar in both groups, with the majority of subjects describing themselves as nonsmokers. No significant differences could be documented with regard to the number of teeth per patient, the last visit to the dentist and/or a dental hygienist.

At baseline, a statistically significant difference between the two groups was seen only for the frequency of dry mouth ( $p < 0.05$ ), with a greater frequency in the verum group. Dry mouth during dialysis was present in 59.1% of subjects in the verum group and 50.0% in the control group.

The stimulated salivary flow rate was similar in both groups. Normal saliva production under stimulation ( $> 1.0$  ml/min) could not be documented in any patient. A significantly decreased salivary flow rate below 0.7 ml/min was detected in 86.4% of patients in the control group and in 81.8% of patients in the verum group. A salivary flow rate of 0.7-1.0 ml per minute was additionally found in 3 patients in the control group and in 4 patients in the verum group.

Significant differences in dental diagnostic parameters were not found between the groups at baseline. Tongue plaque was present in 63.6% of the control group and 59.0% of the verum group. The mean modified plaque index (SLI), GPM/T (gingivitis teeth, periodontitis teeth, missing teeth, total index) and denture hygiene index (DHI) were similar, as was oral health-related quality of life (OHIP-14) (Table 1).

Table 1

Oral hygiene and Oral Health Impact Profile parameters and statistical differentiation at baseline and final examination in the control and verum groups of dialysis patients

Parameter	Control group			Verum group		
	Baseline (x +/- SD)	Final (x +/- SD)	p <	Baseline (x +/- SD)	Final (x +/- SD)	p <
Dry mouth frequency 0–4	2,14+/-0,99	2,24+/-0,94	n.s.	2,82+/-0,80	1,76+/-0,70	0.001
Dry mouth during dialysis y/n	11	12	n.s.	13	5	0.01
Plaque-Index SLI codes 0–3	1.35+/-0,67	1.16+/-0.62	n.s.	1.44+/-0.55	0.99+/-0.47	0.001
Tongue coating codes 0–2	1.73+/-0.63	1.5+/-0.60	0,1	1,73+/-0.07	1.14+/-0.36	0.01
Gingivitis teeth (n)	6.12+/-3.98	6.41+/-4.46	n.s.	7.56+/-6.14	4.76+/-4.70	0.001
Periodontitis teeth shallow (n)	9.00+/-4.63	9.88+/-3.85	n.s.	9.00 +/-4.30	8.35 +/-4.39	0.05
Denture Hygiene Index maxillary Plaquefree %	28.33+/-18.37	34.50+/-26.09	n.s.	33.89+/-22.45	61.14+/-29.48	0.05
Denture Hygiene Index mandibulary Plaquefree %	36.67+/-40.33	44.00+/-40.37	n.s.	32.71+/-27.78	51.14+/-18.14	0.05
OHIP -G14 7 Items, 5 codes, total 0– 56	6.25+/-6.36	5.67+/-5.7	n.s.	6.62+/-5.74	4.75+/-5.02	0.01

Dry mouth during dialysis was present in 59.1% of patients in the verum group initially, 42.9% at the intermediate examination, and only 19.0% at the end of the study. Additionally, 66.7% of those who complained of dry mouth during dialysis at the baseline examination did not report dry mouth at the final examination. In contrast, the dry mouth symptoms did not change in the control group (50.0% of subjects at baseline examination, 52.4% at the end of study).

At the intermediate examination, the verum group showed a decrease in the frequency of dry mouth ( $p < 0.001$ ), dental plaque index SLI ( $p < 0.001$ ), and number of gingivitis teeth from GPM/T index ( $p < 0.001$ ). The maxillary denture hygiene index DHI ( $p < 0.05$ ) and the mandibular denture hygiene index DHI ( $p < 0.05$ ) documented increased percentages of plaque-free denture areas. The mean value of the dental plaque index SLI improved from 1.44 to 1.16, the number of gingivitis teeth decreased from 7.56 to 5.82, the maxillary denture hygiene index DHI increased from 33.89–56.00%, and the mandibular DHI from 32.71–49.71% of plaque-free areas (Table 1)

The trend of improving oral health continued in the verum group at the final examination, and some pronounced differences could be assessed: the frequency of dry mouth and dry mouth during dialysis improved both significantly, as did the decreasing plaque index SLI (Fig. 1) and the decreasing number of gingivitis teeth and periodontitis teeth ( $p < 0.05$ ) (Fig. 2).

Individual oral health-related quality of life assessed by the OHIP-14 started with a rather low dental impact on quality of life in both groups with mean code 6.25 in the control group and 6.62 in the verum group. At the final examination, a statistical improvement with a mean code of 4.75 in the verum group was documented. Taking all patients together, the OHIP-14 code ranged from 0 to 23 at baseline and from 0 to 18 at the end of the study. Comparing the mean OHIP-14 code 0–9 of all patients (no impact, very little impact of oral health on quality of life) with mean code 10–28 (occasionally to fairly often), the slight improvement was significantly different between the two groups. This finding is supported by 4 patients in the verum group at baseline versus 7 patients at the end of study, having never experienced any dental/oral impact on quality of life during the last month (OHIP-14 code 0).

In contrast to the low OHIP-14 impact, the questionnaires concerning the subjective value of oral hygiene in the verum group documented positive perceptions. Subjects rated the taste of the edible oral care gel as good and expressed satisfaction with the new oral hygiene recommendation. The moisturizing effect on the lips and oral mucosa was rated particularly suitable, as was the refreshing taste of lemon to palliate the dry mouth feeling. The special nursing toothbrush was rated as congenial for proper oral hygiene and particularly for cleaning even complex dentures.

When comparing the results of the baseline and the end of the study, there were no significant differences in the parameters measured in the control group (Table 1).

## Discussion

Dialysis patients are often found to have less saliva and alterations of the composition, often resulting in hyposalivation or xerostomia (Jover Cerveró, 2008; Kaushik et al., 2013). Under dialysis, not only systemic infections but also oral diseases such as caries, gingivitis and periodontitis are favored (Ariyamuthu et al. 2013). At the onset of dialysis, dental and periodontal status is comparable to systemically healthy individuals but worsens with increasing duration of dialysis (Bayraktar et al., 2007). Periodontal diseases and poor oral hygiene status are found more frequently than in healthy controls (Bhatsange & Patil, 2012). In hemodialysis patients, saliva production is decreased with and without salivary stimulation (Kaushik et al., 2013). A recent meta-analysis showed that chronic kidney disease patients presented a lower salivary flow rate, and it was also verified that hemodialysis can increase the salivary flow rate of these patients. It is concluded that there is a need for customized clinical planning of dental care (Rodrigues et al., 2022).

All patients we studied reported xerostomia, and sialometry did not measure normal saliva secretion in a single patient. Out of 139 patients initially interviewed, 53 patients (38.1%) reported that they suffered from dry mouth, which is very consistent with data from the literature (Cunha et al., 2007). Of these, 44 patients gave informed consent to participate in this study.

The overall dental health of dialysis patients is rather poor and requires greater attention. Common findings include gingivitis and increased dental plaque accumulation (Klassen & Krasko 2002).

Sufficient dentures of the maxilla were present in 39.5% and of the mandible in 23.8% of the patients in both examined groups. All of them exhibited poor denture hygiene.

Mouth dryness favors the occurrence of other problems in the oral cavity. In both peritoneal dialysis and hemodialysis, an increased dental plaque index is found (Bayraktar et al., 2008; Altamimi et al., 2018), which worsens with the duration of dialysis (Atassi, 2002). Under hemodialysis, increased tongue coating is observed in addition to dry mouth, often associated with taste changes (Kho et al., 1999).

A high frequency of periodontitis teeth with a high severity of periodontitis has been documented in hemodialysis patients (Altamimi et al., 2018). Patients with chronic periodontitis during hemodialysis showed a generally higher mortality than those without this concomitant disease, although this was not confirmed in multivariate statistical analysis, possibly due to insufficient patient numbers (de Souza et al., 2014; Palmer et al., 2015; Almeida et al. 2017).

In any case, we observed a regression of inflammatory changes only in the verum group, which may be due to the long-lasting coating effect of the oral hygiene gel on mucosal irritation and gingival inflammation. The number of teeth exhibiting gingivitis and shallow periodontitis dropped from 7.56 to 4.76 (gingivitis) and from 9.00 to 8.35 (P1 shallow pocketing) because of the improved plaque control by the subjects and the mechanism of action (MOA) of the gel lasting for hours at tooth surfaces and at oropharyngeal mucosal surfaces as a protective bio-layer.

In long-term haemodialysis of 6.7 +/- 5.6 years, gingival and periodontal inflammatory reactions correlate with quality of life, both from physical and psychological aspects. Oral health-related quality of life, assessed with the Short Form 36-Item Health Survey, could be improved by targeted intervention with periodontal treatment (Veisa et al., 2017).

Hemodialysis seems to discourage patients from visiting their dentist, resulting in a high need for treatment (Xie et al., 2014). The majority of patients only visit their dentist when they have complaints, and not all dentists are aware of the oral health-related needs of dialysis patients (Ziebolz et al., 2012).

Patients with chronic renal failure on dialysis and with the symptom of dry mouth often also present with other oral diseases. Therefore, a detailed medical and dental history is required. The measurement of the saliva flow rate is useful, and corrective measures of hyposalivation may prevent oral diseases (Plemons et al., 2014).

Strategies for treating xerostomia are aimed at alleviating symptoms and their consequences. They include stimulant pharmaceuticals and saliva replacement therapy with oral moistening agents (Daladom et al., 2016; Yu et al., 2016). Rinses with licorice water (Yu et al., 2016) or Aloe vera (Bin Mohsin et al., 2017) were also reported to be beneficial in hemodialysis patients.

The patients in the present study showed a very beneficial effect of the oral care gel application, as the dry mouth that initially existed in more than half of the patients during dialysis was significantly reduced after four weeks. The study showed that consistent dental care and oral hygiene with suitable products led to a highly significant reduction in xerostomia, plaque accumulation and the number of gingivitis teeth. Not only objective parameters such as dental plaque index SLI, number of gingivitis teeth and shallow pocketing according to the index GPM/T, denture hygiene index DHI or tongue coating but also subjective perceptions such as frequency of dry mouth, dry mouth on dialysis or oral health-related quality of life (OHIP-14) were significantly improved. Thus, even in chronic and terminally ill patients, dental care and oropharyngeal gel improve oral health-related quality of life.

Xerostomia is a common problem in end-stage renal disease. It has also been demonstrated in the present study that this subjective feeling of dry mouth is often associated with hyposalivation in dialysis patients. Factors that are important for the development but cannot be influenced are gender, possibly age and type of dialysis. Medication - dry mouth is a major side effect of many medications - can also only be adjusted within a narrow range. The performance of dialysis is associated with considerable psychological problems for the patient and requires an adjustment of the entire lifestyle, including a restriction of the amount of drinking. The problems associated with xerostomia are usually not considered significant by the dialysis team and are also not considered a priority by the patient. Therefore, the willingness to consistently perform and optimize oral hygiene is also not too high. Daily oral care should also be better monitored by the dialysis team, with a specially organized collaboration between the dialysis facility and dental institutions producing favorable results (Yoshioka et al. 2015).

The rather low impact of oral health on quality of life according to the OHP-14 data with 7 items and 14 questions is mainly due to the psychological status of patients under hemodialysis. They are under the permanent supervision of nephrologists, and consequently, their health behavior is dominated by chronic kidney disease. However, a professional oral hygiene programme contributes to a slight increase in OHIP-14-related quality of life. Even more importantly, the motivation of taking more self-care using a long-lasting, saliva-stimulating and fluoride-containing oral hygiene gel under the umbrella of dental professionals' devotion contributes to psychological comfort and to the prevention of gingival and mucosal inflammation and dental caries progression.

The intention of this study was to improve the oral hygiene status of all patients. However, the instruction and training of oral hygiene alone resulted in a limited improvement of the dental and psychological parameters. With alternative oral care products such as a gel with long mucosal adhesion and, therefore, prolonged bioavailability and a special nursing toothbrush, it was demonstrated for the first time that a significant influence on xerostomia, plaque accumulation and the number of gingivitis teeth can be achieved within a short period of time in a vulnerable group of long-term patients requiring intensive care, without the need for additional measures. The results of this study probably also apply to other vulnerable patient groups with oropharyngeal inflammatory reactions.

## **Conclusions**

The complex dental examination, including all relevant clinical parameters and the xerostomia status at baseline, confirms poor oral health in dialysis patients.

The primary goal of dental and medical care is to palliate the xerostomia in-between and during dialysis. The patients try to drink as little as possible; therefore, an oral edible gel may reduce the dry mouth feeling with a maximum of 15 ml liquid per 24 hours.

Dental plaque control after motivation, training and re-training of adequate oral hygiene with a multifunctional nursing manual toothbrush and gingivitis/mucositis control by a long-lasting gel, based on biopolymers, contributes to improvement of oral health within a short period of four weeks and with rather limited personal and material resources.

The oral health impact profile, assessed by the OHIP-14 short questionnaire, documented a rather low impact because of the overwhelming medical, physiological and psychological impact of terminal renal insufficiency and dialysis. However, questionnaires on new experiences of oral hygiene with alternative consumer goods (toothbrushes) and cosmetics (oral edible gel) documented the contrary. The patients liked the contact by a dental professional and were satisfied with the toothbrushing training and additional home use of the gel whenever the xerostomia feeling was disturbing. Most important is the dentist's or dental hygienist's devotion, followed by the appreciation of patients.

## **Declarations**

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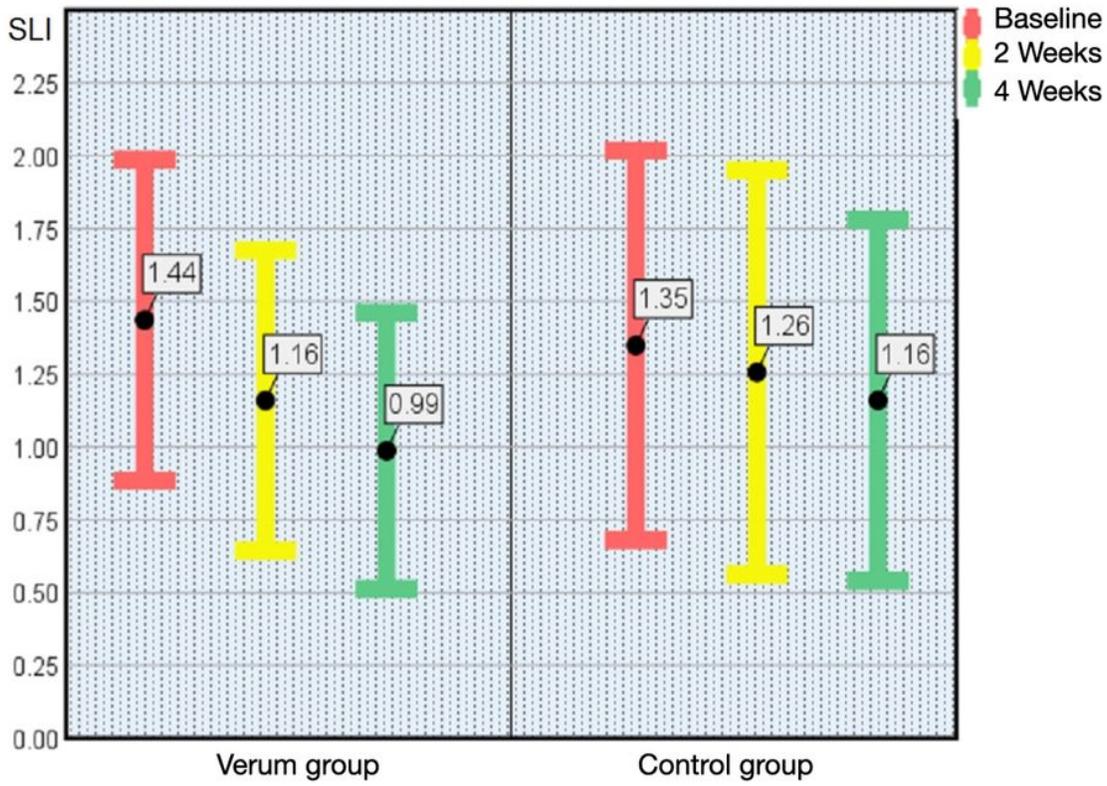
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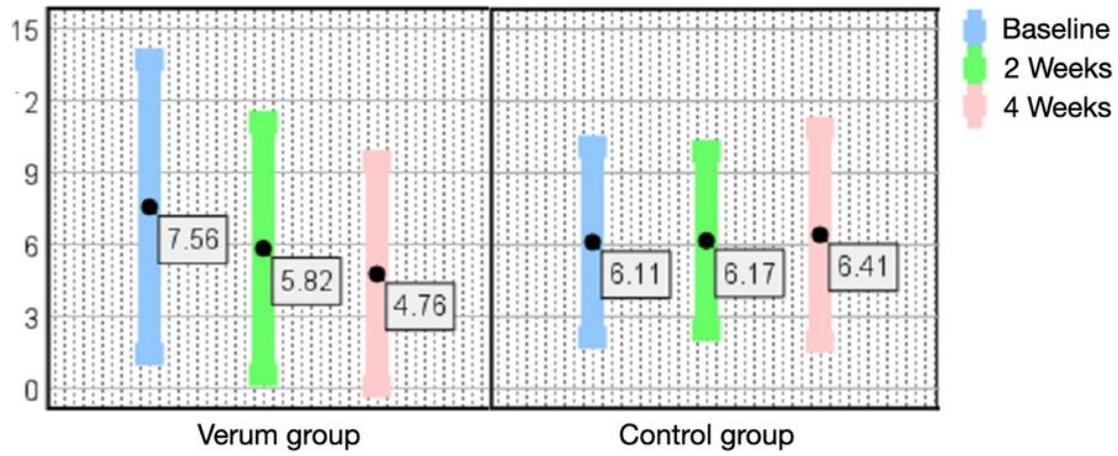
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## Figures



**Figure 1**

Plaque index according to Silness and Loe (SLI;  $x \pm SD$ ) from baseline to the end of the study (0 - 2 - 4 weeks) in the verum group and control group.



**Figure 2**

Number of teeth exhibiting gingivitis according to the GPM/T index ( $x \pm SD$ ) from baseline to the end of the study (0 - 2 - 4 weeks) in the verum group and control group.