

A randomised controlled trial to evaluate the effectiveness of personalised oral hygiene advice delivered via video technology

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ABSTRACT

Objectives: To determine whether video-technology oral hygiene advice (OHA) improved clinical plaque and bleeding on probing (BOP) scores in individuals diagnosed with gingivitis, compared to conventional OHA after 3-months.

Methods: This parallel, randomised 2-arm treatment, single-centre study, assessed Turesky Plaque Index (TPI) and BOP at baseline and 3-months in adult participants with mild-moderate gingivitis. Eligible participants with smartphones were randomised at baseline to intervention (tailored video OHA), or control (conventional OHA). Oral hygiene (OH) habits/attitudes were recorded with a questionnaire. All participants used a manual toothbrush with anti-gingivitis toothpaste twice daily.

Results: 57 participants completed the study. Both groups had improved gingival health (BOP) after 3-months, change from baseline being significantly greater in the intervention group (12.21% vs 6.80%, $p < 0.05$). TPI scores decreased more in the intervention than control group, but the difference did not reach significance (1.15 vs 0.92, $p = 0.079$). OH habits and attitudes were similar at baseline and few differences between the groups were observed after 3-months, however frequency of interdental brush use was significantly increased, while self-rated oral health was significantly decreased in the intervention as compared to control group at this timepoint ($p < 0.05$).

Conclusions: The combination of an individually tailored instructional video with appropriate toothbrushing using anti-gingivitis toothpaste and interdental brush, significantly improved participants' gingival health over 3-months compared to brushing with an anti-gingivitis toothpaste with conventional OHA as delivered in the general dental services. This study demonstrates the benefit of changing OH behaviour and delivering OHA using an individually tailored approach with contemporary methodology.

Clinical Significance: OHA is usually verbally delivered over short time periods. This study demonstrates video technology with individualised OHA improves OH adherence and empowers individuals, the recipient receiving personal visual cues with ability to replay advice and technique reiteration. This real-world technology could be better utilised in general dental practice.

1. Introduction

According to the General Dental Council in the UK, it is the responsibility of the dental care team to provide patients with comprehensive and accurate preventative education and instruction in a manner which encourages their self-care and motivation [1]. The

patient's existing method of brushing may need to be modified to clean all tooth surfaces systematically, maximise plaque removal and to brush the gum line carefully [2]. Poor oral hygiene is commonly reflected in the presence of accumulated dental plaque and plaque induced diseases such as periodontal diseases [3,4]. Gingivitis is reversible inflammation of the soft tissues surrounding the teeth in response to dental plaque, and

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prevention is achieved with twice daily self-performed oral hygiene [5]. However, if gingivitis is left untreated, periodontitis can develop in susceptible individuals [6]. Periodontitis is one of the most common oral diseases, affecting 62 % of the adult dentate population globally (2011–2020) [7]. Estimates from the recent Global Burden of Disease study indicated that in 2019 there were 1.1 billion cases of severe periodontitis worldwide, and that the prevalence rate had increased by 8.44 % between 1990 and 2019 [8]. Periodontitis leads to the destruction of the supporting and surrounding tooth structure which in turn can lead to tooth loss [9]. Periodontitis is now associated with a number of other systemic health conditions and has been shown to elevate the risk of diabetes, rheumatoid arthritis, and Alzheimer's disease [10,11].

Effective plaque removal at home is a skill that can only be accomplished when a patient understands the goal of good oral hygiene practices and has some knowledge of beneficial oral hygiene tools and aids [12]. Cleaning between teeth, ideally using an interdental brush (IDB), is recommended prior to toothbrushing as a habit-forming approach, which is considered to be good practice through adult life [13]. Most oral hygiene advice is given either verbally or in written form, however, while studies have shown that advice delivered this way increases patient knowledge, behaviour change has been indicated as key for improving oral health outcomes [14]. Cognitive behavioural techniques, such as the formation of goals, actions and written coping plans have been integrated with dental hygiene intervention [15] and have been found to be more effective than verbal oral hygiene instructions alone [16]. More recently, the use of technology for the provision of Oral hygiene advice (OHA), such as images from intra-oral scanners has been explored for its delivery [17], and a personalised approach has been advocated [18]. It is suggested that patient specific OHA could be more effective than generic standardised OHA, particularly in the control of periodontal diseases [18].

Whilst capturing images of a patient's own oral health can both be informative showing them where they have cleaned well and badly, and improve oral health outcomes [17,19], a demonstration of how to toothbrush effectively is also important, as is an understanding why plaque removal is important to reduce gingival bleeding and help prevent progression to periodontitis in those susceptible. In a short-term research project that evaluated a 2-minute video demonstrating the use of an electric toothbrush to improve oral hygiene, the results supported the video method as compared to use of the paper instruction leaflet provided with the toothbrush, particularly when designed as a "watch and follow" routine [20]. A similar study comparing the use of video versus written instructions for plaque removal by electric toothbrush concluded that plaque removal can be improved by using an instructional video [21]. As well as providing visual clarity of OHA, in contrast to an in-person demonstration on the clinic, a video can be replayed at home as many times as is needed.

In a study by Guin & Donaldson (1991) [22], it was suggested that instructional videos should be made by the clinicians responsible for treating the target group patients, to ensure precise information is incorporated. With advances in technology and the fact that most patients now have a smartphone with video capability, a video personalised to the patient's needs can now be recorded on their phone, compliant with General Data Protection regulation (GDPR), which they can access whenever required. This aim of this paper was to evaluate the efficacy of a complex intervention comprising OHA delivered with the aid of patient specific personalised instructional videos as compared to the standard OHA delivered in the general dental services for the improvement of plaque control and periodontal health. The null hypothesis being there would be no difference in patients' oral health between the two OHA methods after 3 months.

2. Materials and methods

2.1. Study design

This was a parallel, randomised (1:1 ratio), 2 treatment, single-blind (blinded to the dental assessor), single centre study in healthy adult participants. The study, undertaken by a UK dental school team at a UK dental hospital, was approved by the Health and Social Care Research Ethics Committee B and the Health Research Authority, and conducted according to good clinical practice and the Declaration of Helsinki. The study was registered on International Standard Randomised Controlled Trial Number (ISRCTN) registry of randomised clinical trials.¹

2.2. Recruitment and eligibility

Adult patients attending routine or assessment clinics at the study site were approached to take part in the study by their treating clinician and provided with study information, those interested in participating were invited to a screening appointment. Volunteers who attended screening and gave informed consent were assessed for eligibility and enrolled in the study by the study dentist. Eligible participants were adults aged 18 or over who were not currently receiving orthodontic treatment, who had a minimum of 18 scorable teeth with an average plaque score of ≥ 2.0 as assessed by Turesky Plaque Index (TPI) [23], and >10 % bleeding on probing (BOP) [24] across all sites and no periodontal pocketing of greater or equal to 4 mm. Participants also needed to agree and be able to use a manual toothbrush for the duration of the study, have a smartphone and be confident in re-playing recorded videos on this. Individuals on courses of anti-inflammatory, antimicrobial or anti-statin medications, or who had secondary modifying factors such as being immunocompromised, or smokers/users of nicotine e-cigarettes were excluded. Volunteers who had ≥ 50 % BOP across all sites were also excluded as were those who had undergone periodontal surgery within the previous 2 years. The sample size of at least $n = 28$ participants in each group ensured at least 80 % power (2-sided significance of 5 %) to detect mean differences between groups of at least 4.5 % in the mean change from baseline BOP.

2.3. Intervention phase

At baseline, all enrolled participants were assessed clinically by the study dentist who recorded TPI [23] and BOP [24]. Participants were then given a Patient Oral Health Questionnaire [17,25] (Table 1) that explored their current oral hygiene regime, aspects of their oral health, how motivated they were to achieve good oral health and any concerns they had about their oral health. Following completion of this questionnaire, participants were randomised by the un-blinded study co-ordinator to intervention or control group according to a pre-determined block randomisation schedule provided by the study statistician, and their randomisation number, assigned in ascending numerical order as they were deemed eligible for enrolment onto the study [19].

Participants in the intervention group were given OHA which was video-recorded using the participant's own smartphone mounted onto a tripod and positioned to capture the participant's mouth. The qualified oral health educator was video-recorded giving the participant OHA specific to their mouth, indicating which teeth/areas needed more attention and how best to clean these areas, and included tailored instruction for IDB cleaning using interproximal brushes. This video was available to intervention group participants on their smartphone after they left the clinic so they could refer back to it at any time. Participants in the control group received verbal OHA in accordance with the standard of care in the general dental services by the same qualified oral

¹ STudy registration number: ISRCTN 11752262.

Table 1

Questions asked in Patient Oral Health Questionnaire and Patient Attitudes to Oral Health Questionnaire. Questions that were adjusted for visit 1 or 2 are indicated.

Question	Visit
Patient Oral Health Questionnaire	
• What is your: (<i>date of birth, age, gender</i>)	1
• How many times per day do you regularly brush your teeth? (<i><1/day, 1/day, 2/day >2/day</i>)	Both
• When do you normally brush your teeth? (<i>morning, evening, day</i>)	Both
• Do you normally brush your teeth (<i>before breakfast, after breakfast, neither, both?</i>)	Both
• Which kind of toothbrush do you use the most often? (<i>Manual or power</i>)	1
• Are you right or left-handed?	Both
• Do you currently use a toothpaste? (<i>yes, no</i>):	Both
◦ if yes, which?	Both
• Do your gums bleed when you brush your teeth? (<i>yes, no</i>)	Both
• Do you think you have bad breath? (<i>yes, no</i>)	2
• Do you use any of the following additional teeth cleaning aids? (<i>Dental Floss, Flossettes, Single tufted brush, Interdental brushes, Air flosser, Water flosser, none</i>)	Both
◦ If yes, how often do you use them? (<i>daily, weekly, occasionally</i>)	2
• Are you currently concerned about your oral health? (<i>yes, no</i>)	2
◦ If yes, what are your concerns? (<i>Condition of teeth, Function of teeth, Appearance, Breath, Sensitivity, Other/not sure</i>)	2
• Has your diet changed since you started the study with us? (<i>yes, no, not sure</i>)	Both
• How would you rate your current oral health? (<i>excellent, very good, good, fair, poor, not sure</i>)	Both
• Are you motivated in maintaining oral health? (<i>very, fairly, neither/nor, not, not sure</i>)	1
• Has your motivation to maintain your oral health changed since you started the study with us? (<i>yes, no, not sure</i>)	2
• Did you use the video oral hygiene instructions? (<i>Yes, No, Not applicable</i>)	Both
• Were the video oral hygiene instructions provided in this study useful for you? (<i>very, fairly, neither/nor, not, not sure</i>)	1
• How often did you use the video oral hygiene instructions provided in this study (<i>Daily, Weekly, monthly, not sure</i>)	2
Patient Attitudes to Oral Health Questionnaire	
All answered on a scale of 1 (not at all) to 10 (extremely so):	
Do you think bleeding gums and gum disease is a serious health concern? If my bleeding gums are left untreated the likelihood that I will develop gum disease in the future is high	
Following my Oral Health plan over the next 12 weeks will improve the health of my mouth and reduce my risk of developing gum disease	
Following my Oral Health plan over the next 12 weeks has improved the health of my mouth and reduced my risk of developing gum disease	
I know I can follow my Oral Health plan over the next 12 weeks	
I have followed my Oral Health plan over the last 12 weeks	
Following my Oral Health plan will be difficult to do	
Following my Oral Health plan was difficult to do	
My gum disease concerns me I will do my best to follow my Oral Health plan over the next 12 weeks	
I will do my best to follow my Oral Health plan in the future	

health educator which included basic instruction for IDB cleaning using interproximal brushes [26]. Both treatment regimens included the provision of interproximal brushes for the participants to use as part of their oral health education and a manual toothbrush with anti-gingivitis toothpaste to use twice daily (Zendium®, Unilever PLC, Port Sunlight, Wirral, Merseyside CH62 4ZD. Participants in both groups were then asked to complete a second short questionnaire, Patient Attitudes to Oral Health [17] (Table 1).

Participants returned to the study site after 3 months. At this visit participants completed the Patient Oral Health Questionnaire again. On the second visit this also included questions for the intervention group asking whether the video instructions provided were useful to them. All participants also completed the Patient Attitudes to Oral Health questionnaire a second time and then were assessed for plaque accumulation and gingival health by the study dentist.

2.4. Dental assessments

Dental outcome measures were whole mouth percentage BOP and TPI, assessed at baseline and after 3-months by the dental assessor. BOP

was scored using a binary recording of either YES (bleeding observed) or NO (no bleeding observed) at 4 sites per tooth as described by Ainamo & Bay [24]. Plaque was scored clinically by the study dentist following plaque disclosure using a 6-point scale at 4 sites per tooth (buccal, labial, lingual and palatal) where 0 = no plaque, 1 = separate flecks or discontinuous band of plaque and the gingival margin, 2 = thin (up to 1 mm), continuous band of plaque at the gingival margin, 3 = band of plaque wider than 1 mm, but less than one-third of surface, 4 = plaque covering one-third or more, but less than two-thirds of surface and 5 = plaque covering two-thirds or more of surface [23].

2.5. Questionnaires

Self-reported oral health outcomes were assessed by questionnaire at baseline and after 3-months. The Patient Oral Health Questionnaire comprised 17 questions, 2 of which included images of toothbrushes and IDB cleaning aids. This is based in part on those used previously by this research team [17,25] but adapted for this study. An overview is shown in Table 1, including how questions were adjusted for each visit, together with the Patient Attitudes to Oral Health Questionnaire [17].

3. Statistical methods

The difference in the improvement (change from baseline) between groups in BOP and TPI at 3 months was analysed by Analysis of Covariance (ANCOVA) using the corresponding baseline value as covariate. The differences in change from baseline between groups for ordinal and continuous questionnaire variables (where the question was asked at both visits and the participant responded each time) were analysed by the same method. Due to the small sample size, questionnaire variables for which there were binary answers were analysed by ANCOVA and also in parallel by logistic regression and the MOVER (Method Of Variance Estimates Recovery) or square-and-add algorithm for differences [27,28] to confirm findings, outcomes were similar by all 3 methods. The ANCOVA p-values are reported here for these variables.

4. Results

Between 11th September 2019 and 14th December 2022, 77 participants were assessed for study eligibility, enrolled, and completed the study. Participant flow through the study is shown in the Consolidating Standards of Reporting Trials (CONSORT) flowchart (Fig. 1). There were 13 screen fails and 7 participants were lost to follow up, a total of 57 participants completed the study, 28 in the intervention and 29 in the control group, numbers that equalled (intervention) and slightly exceeded (control), the 28 required by the sample size calculation. Aside from those lost to follow up, there were no withdrawals from the study and no Adverse Events were reported.

Participants were 79 % White, 81 % female, and the median age (range) was 45 (20–72) with no significant differences in demographics between the control and intervention groups.

Colgate® was the most commonly used brand of toothpaste that participants reported using at baseline (50.8 %) followed by Oral B® (21.1 %). While the majority of participants only reported the brand of toothpaste they were using, 21 % reported specific types of toothpaste used within these brands, with the most reported being Colgate sensitive® (7.0 %). Other brands of toothpastes reported were Sensodyne® (5.2 %), Aquafresh® (3.5 %), Oral B Pro Expert® (3.5 %), Corsodyl® (3.5 %) and Crest® (1.8 %). 10.5 % of participants did not report which toothpaste they used and 3.5 % answered with multiple brands of toothpaste as they buy the product that is cheaper at the time of purchase.

The whole mouth mean percentage BOP (%BOP) and Turesky plaque scores at baseline and after 3-months are shown in Table 2, $n = 28$ (intervention) and $n = 29$ (control) participants, for both clinical scores. The mean percentage of sites with BOP and mean Turesky plaque score

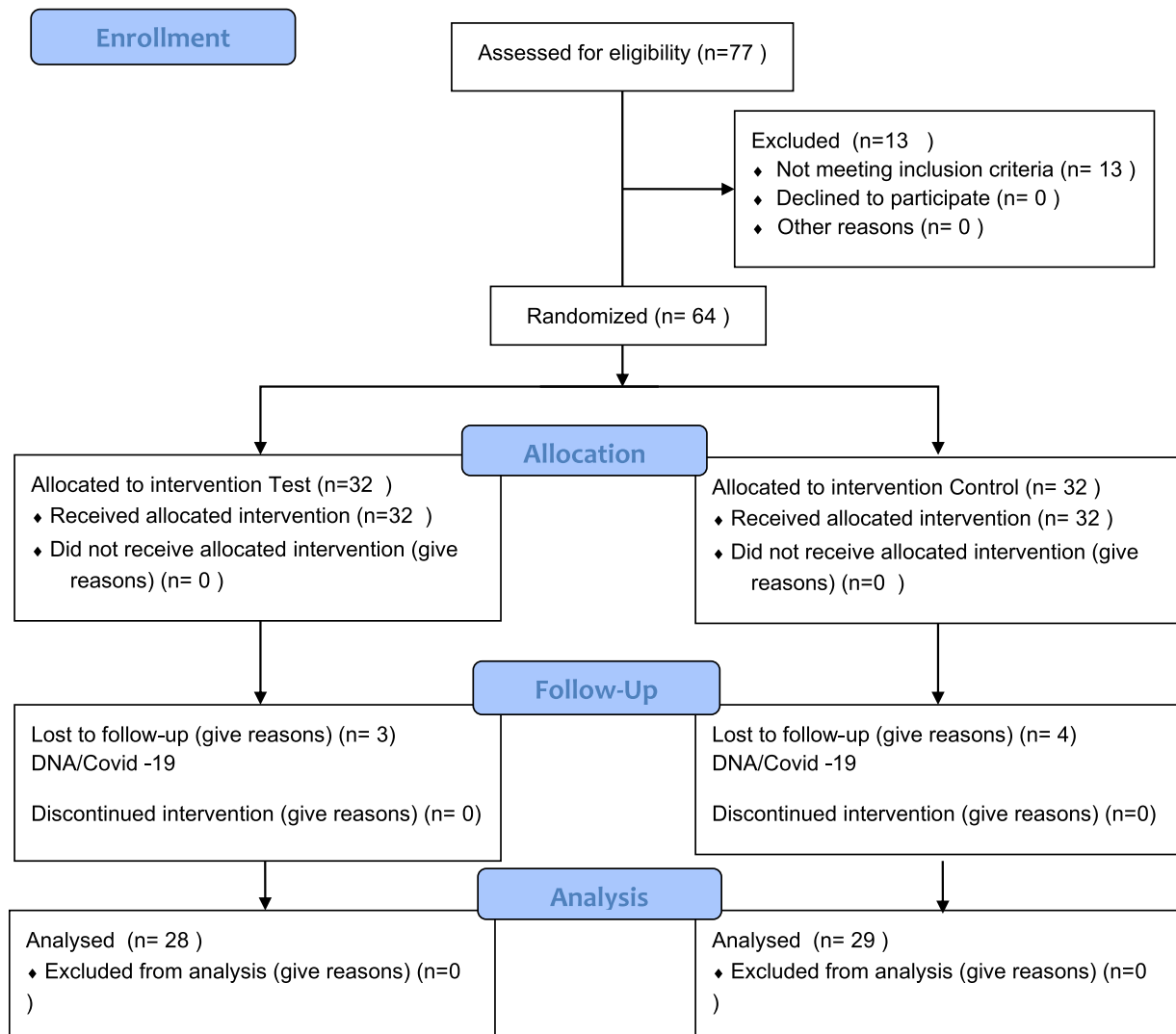


Fig. 1. Participant flow through the study. DNA/Covid - 19 = Did not attend (DNA) due to the Covid-19 pandemic.

Table 2
Whole-mouth%BOP and TPI at baseline, 3-months and the change from baseline.

	% BOP Mean (SD)		TPI Mean (SD)	
	baseline	3 months	baseline	3 months
Control (n = 29)	33.53 (9.48)	26.73 (12.20)	2.51 (0.42)	1.60 (0.65)
Intervention (n = 28)	34.78 (8.44)	22.58 (9.61)	2.48 (0.52)	1.34 (0.48)

BOP = Bleeding on probing, TPI = Turesky plaque index.

were similar in both groups at baseline.

The analysis of the differences in the change from baseline in%BOP and TPI between the control and intervention groups is shown in

Table 3
Between group comparison of improvements in%BOP and TPI at 3-months.

	Adjusted difference	95 % confidence limits		p-value
		Lower	Upper	
BOP	-5.28	-9.29	-1.27	0.011
TPI	-0.243	-0.515	+0.029	0.079

BOP = Bleeding on probing, TPI = Turesky plaque index.

Table 3. While there was an improvement in%BOP for both groups after 3 months, the Intervention group showed a statistically larger improvement ($p < 0.05$). Turesky scores also improved more in the Intervention group after 3 months, however, the difference did not reach significance ($p = 0.079$).

The change in gingival condition for each group is shown in **Table 4**, data presented is for $n = 28$ (intervention) and $n = 29$ (control) participants, for both clinical scores. Slightly more participants improved their gingival health in the intervention as compared to the control group.

Participants in both groups reported attitudes to oral health and their oral hygiene habits at baseline and at 3-months. The majority of the results are reported in **Tables 5 and 6**, however a few items appear only in the text). At baseline considering all participants, the majority

Table 4
Change in gingival health status.

	Localised to Generalised gingivitis n (%)	No change n (%)	Generalised to localised gingivitis n (%)	Localised gingivitis to health n (%)
Control (29)	1 (3.4 %)	19 (65.5 %)	7 (24.1 %)	2 (6.9 %)
Intervention (28)	0 (0 %)	16 (57.1 %)	11 (39.3 %)	1 (3.6 %)

Table 5
Participant reported oral health and oral hygiene habits.

		Control (%)			Intervention (%)			
		Baseline	3 months	CFB	Baseline	3 months	CFB	
Brushing frequency	Once a day	2 (6.9)	1 (3.4)	-3.4 %	1 (3.6)	1 (3.6)	-	
	Control <i>n</i> = 29	26 (89.7)	28 (96.6)	6.9 %	27 (96.4)	25 (89.3)	-7.1 %	
	Intervention <i>n</i> = 28	> twice a day	1 (3.4)	0 (0)	-3.4 %	0 (0)	2 (7.1)	7.1 %
Brushing Before or after breakfast	Brush Before	17 (58.6)	16 (55.2)	-3.4 %	12 (42.9)	13 (46.4)	3.4 %	
	Control <i>n</i> = 29	Brush After	10 (34.5)	10 (34.5)	-	14 (50.0)	12 (42.9)	-7.1 %
	Intervention <i>n</i> = 28	Neither*	0 (0)	0 (0)	-	1 (3.6)	1 (3.6)	-
	Both	2 (6.9)	3 (10.3)	3.4 %	1 (3.6)	2 (7.1)	3.4 %	
SR oral health problems	Bad Breath	6 (20.7)	5 (17.2)	-3.5 %	7 (25.0)	2 (7.1)	-17.9 %	
	Control <i>n</i> = 29	Gums Bleeding	12 (41.4)	4 (13.8)	-27.6 %	11 (39.3)	6 (21.4)	-17.2 %
	Intervention <i>n</i> = 28							
ID Cleaning Aids	Floss	10 (34.5)	15 (51.7)	17.2 %	14 (50.0)	19 (67.9)	17.9 %	
	Control <i>n</i> = 29	Flossettes	5 (17.2)	7 (24.1)	6.9 %	3 (10.7)	2 (7.1)	-3.6 %
	Intervention <i>n</i> = 28	STB	4 (13.8)	3 (10.3)	-3.5 %	4 (14.3)	4 (14.3)	-
	IDB	21 (72.4)	22 (75.9)	3.5 %	16 (57.1)	24 (85.7)	28.6 %	
	Air Flosser	1 (3.4)	2 (6.9)	3.5 %	1 (3.6)	2 (7.1)	3.5 %	
	Water Flosser	1 (3.4)	1 (3.4)	-	1 (3.6)	1 (3.6)	-	
	None	2 (6.9)	0 (0)	-6.9 %	3 (10.7)	1 (3.6)	-7.1 %	
Frequency of Using ID Aids	Daily	13 (44.8)	18 (62.1)	17.3 %	11 (39.3)	19 (67.9)	28.6 %	
	Control <i>n</i> = 29	Weekly	5 (17.2)	5 (17.2)	-	7 (25.0)	3 (10.7)	-14.3 %
	Intervention <i>n</i> = 28	Occasionally	8 (27.6)	1 (3.4)	-24.2 %	7 (25.0)	3 (10.7)	-14.3 %
	No response	3 (10.3)	5 (17.2)	6.9 %	3 (10.7)	3 (10.7)	-	
Oral Health Concerns	Any	17 (58.6)	13 (44.8)	-13.8 %	20 (71.4)	11 (39.3)	-32.1 %	
	Control <i>n</i> = 29	Condition	13 (44.8)	6 (20.7)	-24.1 %	14 (50.0)	7(25.0)	-25.0 %
	Intervention <i>n</i> = 28	Function	2 (6.9)	1 (3.4)	-3.5 %	0 (0)	0 (0)	-
	Appearance	12 (41.4)	7 (24.1)	-17.9 %	6 (21.4)	5 (17.9)	-3.6 %	
	Breath	2 (6.9)	4 (13.8)	6.9 %	6 (21.4)	3 (10.7)	-10.7 %	
	Sensitivity	14 (48.3)	7 (24.1)	-24.2 %	13 (46.4)	7 (25.0)	-21.4 %	
	Other/unsure	3 (10.3)	0 (0)	-	2 (7.1)	2 (7.1)	-10.3 %	
	None	8 (27.6)	8 (27.6)	0 (0)	5 (17.9)	9 (32.1)	14.2 %	
Rating their Oral Health	Excellent	1 (3.7)	1 (3.7)	-	0 (0)	0 (0)	-	
	Control <i>n</i> = 27	Very Good	3 (11.1)	11 (40.7)	29.6 %	4 (15.4)	5 (19.2)	3.8 %
	Intervention <i>n</i> = 26	Good	18 (66.7)	13 (48.1)	-18.6 %	13 (50.0)	14 (53.8)	3.8 %
	Fair	4 (14.8)	1 (3.7)	-11.1 %	9 (34.6)	7 (26.9)	-7.7 %	
	Poor	1 (3.7)	1 (3.7)	-	0 (0)	0 (0)	-	
Levels of Motivation	Very	23 (79.3)	24 (82.8)	3.5 %	18 (64.3)	20 (71.4)	7.1 %	
	Control <i>n</i> = 29	Fairly	5 (17.2)	4 (13.8)	-3.4 %	10 (35.7)	8 (28.6)	-7.1 %
	Intervention <i>n</i> = 28	Neither/Nor	1 (3.4)	1 (3.4)	-	0 (0)	0 (0)	-

CFB = Change from Baseline, SR = Self-reported, STB = single tufted brush, IDB = ID brush.

* doesn't eat breakfast.

Table 6
Patient attitudes to oral health at baseline and after 3 months.

Question ¹	Control		Intervention	
	Mean (SD)		Mean (SD)	
	Baseline	3-months	Baseline	3-months
Gum disease serious health concern ²	8.41 (1.78)	8.76 (1.96)	8.50 (1.82)	8.71 (1.54)
Likelihood of gum disease if BOP untreated ²	9.03 (1.15)	9.34 (1.20)	9.04 (1.20)	9.18 (1.22)
Following plan will/has improved gum health ²	8.28 (2.10)	7.66 (2.02)	8.82 (1.28)	7.61 (2.39)
I know I can/have followed the plan ²	8.72 (1.62)	9.03 (1.15)	9.71 (0.81)	9.07 (1.33)
It will be/was difficult to follow the plan ²	2.62 (2.53)	3.38 (3.00)	1.50 (1.29)	3.36 (2.64)
My gum disease concerns me ³	6.86 (3.05)	6.48 (3.45)	6.50 (3.02)	5.71 (3.22)
I will try to follow the plan for 3-months/in the future ³	9.54 (1.07)	9.28 (1.31)	9.86 (0.45)	9.64 (0.78)

¹ All questions scored on a scale from 0 (not at all) to 10 (extremely so).

² Control, *n* = 29; Intervention, *n* = 28.

³ Control, *n* = 28; Intervention, *n* = 28.

brushed twice daily (93.0 %) and the percentage that reported brushing before and after breakfast was similar (50.9 % and 42.1 %, respectively). Daily use of interdental aids was reported by 42.1 % of participants with ID brushes (66.7 %) and floss (42.1 %) the most common choices in both

groups. There were no significant differences in oral hygiene habits between the groups at baseline.

Oral health concerns at baseline were reported by 64.9 % of participants overall, with condition (47.4 % and sensitivity (47.4 %) being the most common areas of concern in both groups. The majority of participants (71.4 %) reported that they viewed their oral health at baseline at least as “good” but were very motivated to make improvements (71.9 %), with little difference between the groups.

After 3-months no differences between the groups were seen for most self-reported oral health and oral hygiene habits, however, the control group rated their oral health significantly better (adjusted difference 0.35 (95 % CI 0.022 to 0.678), *p* = 0.037) than the intervention group. In addition, while both groups showed an increase in the change from Baseline (CFB) when asked about the frequency in which they used their IDB at 3-months, there was a significantly greater increase (CFB) in the use of IDB in the intervention as compared to the control group (adjusted difference 0.175 (95 % CI 0.003 to 0.348), *p* = 0.047).

Although there was no between group difference in change in motivation over the study period, some participants supplied additional information in the free text box associated with the question. The most common (21.1 % comments) was that using IDBs more often resulted in increased motivation to adhere to their brushing routine as they had noticed an improvement in their own oral health since baseline. The second most common comment indicated they had a better understanding of how to use IDBs (8.8 %) since being on the study. A similar proportion of participants in both groups reported increased motivation at the end of the study with 16/29 (55.2 %) in the control and 15/27

(55.6 %) in the intervention group.

All but one of the participants in the intervention group used the video between study visits, 4 participants reported using it daily (15.4 %), 12 weekly (46.2 %) and 4 monthly (15.4 %) 6 were unsure (23.1 %) and 2 did not answer this question. The majority (66.7 %) of intervention group participants rated the video very useful, while 22.2 % found it fairly useful. Only a minority of 11.1 % reported they were equivocal of the video’s usefulness. Both groups were asked at 3-months if their diet had changed since baseline. Only 3 participants reported making changes to their diet, of the 26 responses in the control group one participant reported using less sugar and of the 28 responses in the intervention group, 2 participants reported they had decreased their sugary drink intake.

Patient attitudes to oral health at baseline and after 3 months are shown in Table 6. There was very minimal change between baseline and 3-months for either group for any of the questions in this questionnaire and no significant differences seen between groups for any of the items (Table 7).

5. Discussion

This study aimed to determine whether instructional personalised short videos, used as “tailored” patient oral hygiene education tools, improved participant’s oral health after 3-months compared to conventional OHA delivered in general dental services. The null hypothesis was rejected, instructional personalised short videos demonstrated significantly improved oral health outcomes compared to conventional OHA after 3 months.

Localised gingivitis, defined according to the classification of periodontal diseases and conditions [29], can occur as early as 7 days following suspension of oral hygiene, extending to generalised gingivitis after 23 days [3,30]. A healthy individual can regain oral health in 10 days when efficient and effective brushing is reinstated, plaque needing to be removed from all surfaces on a daily basis [31]. In the present study BOP scores improved from generalised (>30 %) to localised (10–30 %) gingivitis in both groups indicating that participants engaged in regular, effective plaque removal, sufficient to result in improved oral health. BOP reduction was significantly greater in the intervention group which likely reflects the significantly increased and effective use of IDBs by this group, supporting the efficacy of the personalised video OHA. Interestingly, improvements in self-reported bleeding on brushing (BoB) and overall oral health were greater in the control as compared to the intervention group. Gingivitis is usually painless, rarely bleeds spontaneously and most often involves only subtle clinical changes [32] and is grossly under-reported by patients [33]. It is likely that

participants in the control group underestimated their BoB, while those in the intervention group had a better awareness of BoB and its relevance to oral health reporting it more accurately, further supporting the efficacy of a personalised OHA video.

After 3-months, plaque levels had reduced more in the intervention than the control group, but the difference was not significant. This may be due to the Hawthorne effect where study participants alter their behaviour consciously or unconsciously as a result of being on a study [34]. Similar to the conclusions of Daly et al. [19], all study individuals may have brushed better in the days preceding their 3-month visit, from the receipt of their study visit reminder a few days before their appointment BOP being an outcome generated over days and weeks compared to a plaque score that can be influenced by the last brushing episode. As the Hawthorne effect is short-lived, BOP scores in non-intervention participants would be unlikely to be altered [34]. All participants also used an anti-gingivitis toothpaste Zendium® toothpaste, which has been shown to have good efficacy in reduction of BOP and plaque to a lesser extent due to its mode of action over a 3-month period [35], and likely contributed to the oral health gains seen in both groups. However, the greater reduction in plaque and BOP scores in the intervention group suggests the video OHA resulted in better plaque removal. This finding is similar to that from a study in which OHA was personalised by the use of images of the participants mouths in the intervention group, and both groups received an anti-gingivitis toothpaste containing 67% w/w (weight per weight) sodium bicarbonate; a positive effect on oral health was attributed to the toothpaste, but in the intervention group, a further benefit could be attributed to the personalised OHA [19].

Overall, the data suggests that the use of personalised short OHA videos is more effective than standard OHA for improving patient’s oral health. This is a significant finding as smartphone use is common and increasing [36], and OHA can be delivered by any member of the dental team who has the appropriate training; thus this is a method of enhanced OHA delivery that could be widely employed at no extra cost. Improvements in overall oral health are important for preventing gingivitis progression to periodontitis, associated tooth loss and risk of systemic disease [10,11,37,38], and also for reducing associated concerns over appearance, speech, mastication, taste, and socializing [39,40]. Halitosis has been shown to have a negative effect on quality of life resulting in social anxiety, another possible consequence of gingivitis [41], and reduced following oral hygiene education and Step 1 therapy of the BSP clinical practice guidelines [18,42]. In the present study self-reported halitosis was lower in the intervention as compared to the control group.

With little evidence to date existing on the effectiveness of specific personalised instructional OHA videos on adult patients’ oral health, it is not possible to make direct comparisons between the findings of this study and those of others. However, a recent study comparing methods of delivery of OHA, including using video technology, was undertaken in children aged 8–9 years [43]. Children were randomly allocated to one of four OHA groups (verbal, verbal and written, verbal and teeth teaching model, and verbal and video) and significant differences in plaque levels in the groups were found. It was concluded that for this population verbal instruction supplemented by teaching model was the most effective for the improvement of oral health. The differences between the findings of [43] and the present study likely reflect the differences in the participant population recruited.

Studies that have personalised OHA in adults by using images captured by intra-oral scanner (IOS) or intraoral camera (IOC) have been published. Where OHA was augmented with an image taken with an IOC it was shown that in adults with gingivitis the image was of benefit, although, similar to the present study, plaque levels improved in both intervention and control groups [44], and in adults with gingivitis undergoing supportive periodontal therapy, BOP was significantly lower in the IOC intervention group [45]. More recent studies have shown similar outcomes with OHA delivered with IOS; in a pilot study of adults with gingivitis, a significant improvement in plaque but not gingivitis

Table 7
Patient attitudes to oral health at baseline and after 3 months.

Question ¹	Adjusted difference	95 % confidence limits		p-value
		Lower	Upper	
Gum disease serious health concern ²	-0.084	-0.921	0.754	0.842
Likelihood of gum disease if BOP untreated ²	-0.167	-0.775	0.441	0.585
Following plan will/has improved gum health ²	-0.151	-1.339	1.036	0.799
I know I can/have followed the plan ²	-0.124	-0.828	0.581	0.726
It will be/was difficult to follow the plan ²	0.034	-1.543	1.611	0.966
My gum disease concerns me ³	-0.582	-1.881	0.718	0.373
I will try to follow the plan for 3-months/in the future ³	0.372	-0.229	0.973	0.220

¹ All questions scored on a scale from 0 (not at all) to 10 (extremely so).

² Control, n = 29; Intervention, n = 28.

³ Control, n = 28; Intervention, n = 28.

score was seen in the IOS OHA intervention group [17], while a larger study demonstrated significant benefits of the IOS OHA as compared to control for both BOP and plaque scores [19]. None of these studies are directly comparable to the study reported here, but they support the use of images of patients mouths in OHA delivery, suggesting that having an image of their own mouth is very helpful to patients and allowing them to better focus on cleaning the oral areas that have been identified as inflamed. Without a study to directly compare IOC, IOS and video augmented OHA it is not possible to determine whether there is greater benefit when the image is a video.

In the present study the majority of participants who used the video technology for personalised oral hygiene advice to modify behaviour and enhance adherence reported finding the video useful and employed it at home as part of their daily oral hygiene routine, demonstrating this was an intervention well accepted. Further studies however should be undertaken to show efficacy of this complex intervention.

6. Conclusion

This study demonstrated clinical significant improvements in bleeding on probing could be achieved in adults with mild to moderate gingivitis with the provision of OHA, IDB and an anti-gingivitis toothpaste. These improvements were significantly greater where OHA was delivered using personalised video technology OHA. Plaque scores were also improved in both groups, but no significant differences were seen between them.

Data availability

The data that support the findings of this study will be stored in the publicly available University of Bristol Research Data Repository once the data has been published. Data will be made available to researchers subject to the agreement of the University of Bristol Data Access Committee.

CRedit authorship contribution statement

Derele Buck: Writing – review & editing, Investigation, Formal analysis. **Joon Seong:** Methodology, Investigation, Conceptualization. **Alaa Daud:** Investigation, Conceptualization. **Maria Davies:** Writing – review & editing, Writing – original draft, Formal analysis. **Robert Newcombe:** Writing – review & editing, Formal analysis. **Nicola X. West:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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