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Autonomy-supportive dental treatment, oral health-related eudaimonic well-being and oral health: a randomized clinical trial

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ABSTRACT

Objective: We tested the hypotheses that a dental intervention designed to promote oral care competence in an autonomy-supportive way, relative to standard care, would positively predict patients' perceived autonomy support from oral health-care professionals, increases in eudaimonic well-being (i.e. both personal growth and purposeful behaviour goals) and improved oral health (i.e. reduced dental bacterial plaque on tooth surface and reduced gingivitis) over 5.5 months. We also tested a self-determination theory model with the intervention positively predicting perceived autonomy support, which in turn would predict increases in eudemonic well-being, leading to improved oral health.

Design: A randomised two-group experiment was conducted at a dental clinic with 138 patients ($M_{age} = 23.31$ yr, $SD = 3.5$). Variables were measured before and right after the intervention and 5.5 months later.

Results: Overall, the experiment and hypothesised process models received strong support. The effect sizes were large for perceived autonomy support, change in personal growth, change in dental plaque and change in gingivitis, whereas the effect size for purposeful behaviour was moderate. The measurement and structural equation models for the SDT process model received good fit.

Conclusions: The current field experiment extends previous knowledge by showing that promoting patient oral care competence in an autonomy-supportive way improves oral health through patients' eudaimonic well-being.

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Autonomy-supportive oral health-care; eudaimonic well-being; personal growth; purposeful behaviour goals; dental plaque; gingivitis

Introduction

Autonomy-supportive health-care professionals relate to their patients by taking their perspective, encouraging initiation, supporting a sense of choice and being responsive to their thoughts, questions and initiatives (Deci & Ryan, 2000). In the dental field,

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randomised controlled trials (RCTs) have shown autonomy-supportive oral health-care professionals to motivate increases in patients' oral hygiene self-care behaviour and visits to their dentist, and to improve their oral health (Halvari & Halvari, 2006; Halvari, Halvari, Williams, & Deci, 2017). Could autonomy support affect patients' eudaimonic well-being as well? The eudaimonic concept of well-being was described by Aristotle as the highest human good, which includes activities of the soul that are in accord with virtue. This means that eudaimonia captures the striving to achieve the best that is within us or to fulfil our talents and become what we are (Aristotle, 1984). In the present study, we used two components of eudaimonia operationalised by Ryff (2014). That is, personal growth, that is, the extent to which people are making use of their personal talents and potential; and purpose in life, that is, the extent to which people feel their lives have meaning, purpose and direction. In the dental field, correlational studies have shown autonomy support positively related to well-being among dental patients (Halvari, Halvari, Bjørnebekk, & Deci, 2013), but this link has not yet been causally tested in a RCT. Hence, it is important to conduct RCTs to investigate whether an intervention intended to be more autonomy supportive facilitates change in eudaimonic well-being, and subsequent health, in the context of an intervention intended to enhance competence and autonomy. If such effects are present, they would represent important contributions to our oral health-care knowledge, and to the study of health interventions in general. If confirmed, this may elucidate additional pathways between need supportive interventions, improvements in quality of life and health. Grounded in self-determination theory (SDT; Deci & Ryan, 2000), a dental intervention was designed to promote oral care competence in an autonomy-supportive way and was compared to standard care for dental patients, that is, a standard dental exam followed by a standard teeth cleaning. The main difference between groups was that standard care did not include education in plaque-related diseases and did not include practice in tooth brushing and flossing, as well as a lower time-related dose of autonomy support. The dental care intervention aimed to influence patients' perceived autonomy support, their eudaimonic well-being and their oral health (i.e. dental plaque and gingivitis).

Following SDT (Deci & Ryan, 2000), the intervention focused on providing meaningful competence information provided in an autonomy-supportive way concerning oral health and disease. That is, the oral health-care professional was responsive to patients' questions, acknowledging and reflecting their perspectives, offering rationales when making recommendations to do oral self-care behaviours that are known to promote healthy teeth and gingiva and therefore to prevent plaque-related diseases. The oral health-care professional also emphasised choice when fostering oral-care skills with education, demonstrations and practice. Thus, compared to patients who received standard care, it was hypothesized that intervention patients would report higher levels of perceived autonomy support (Hypothesis 1), due to the higher dose of intervention focus on choice and volition. In addition, intervention patients were expected to respond with greater positive changes in eudaimonic oral-health-related personal growth (Hypothesis 2), due to the intervention focus on skill fostering, education in plaque-related diseases and demonstrations and practice in tooth-brushing and flossing, as well as greater positive changes in eudaimonic oral health-related

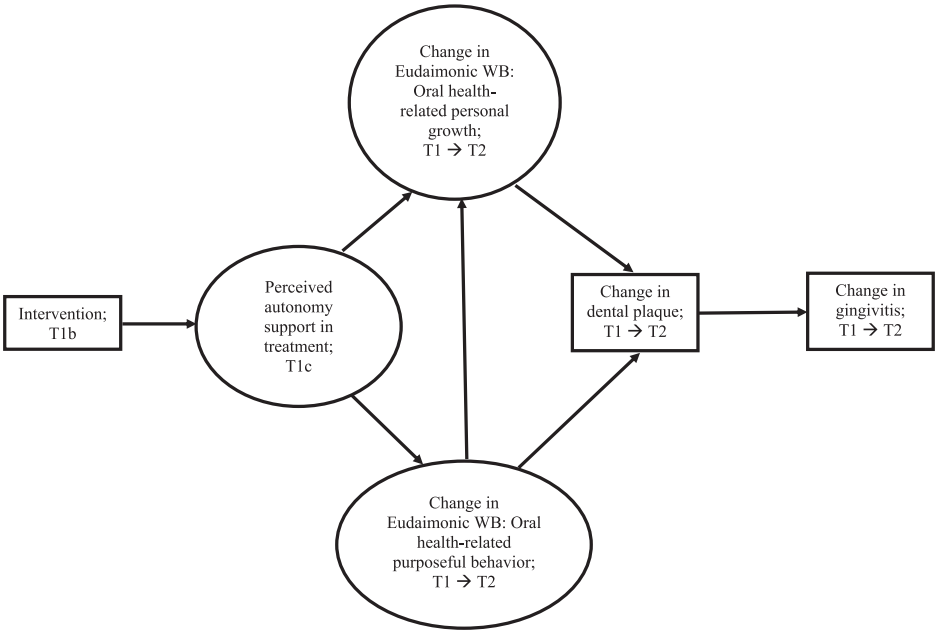

Figure 1. Theoretical model.

purposeful behavioural goals (Hypothesis 3), because of the intervention focus on rationales for behaviour when recommendations were given. Finally, intervention patients, relative to control patients, were expected to reduce their dental bacterial plaque on tooth surfaces (Hypothesis 4) and reduce their gingivitis or gum bleeding (i.e. improve their oral health) (Hypothesis 5), because of the active elements of education, and practice in tooth brushing and flossing in the intervention.

The SDT process model of eudaimonia and oral health

Following SDT (Deci & Ryan, 2000), the process model hypothesis (Hypothesis 6) is formulated as follows (see Figure 1): the intervention was expected to predict perceived autonomy support in treatment among patients, as shown by similar previous interventions in the dental field (Halvari & Halvari, 2006). Further, autonomy support was expected to positively predict changes in eudaimonic well-being, both oral health-related personal growth and purposeful behaviour goals, because autonomy has been critical for well-being globally, on multiple domains such as work, education, health, sport, relationships, religion and leisure (Black & Deci, 2000; Grolnick & Ryan, 1987; Niemiec, Ryan, Patrick, Deci, & Williams, 2010; Ryan, Bernstein, & Brown, 2010; Ryan, Curren, & Deci, 2013; Ryan & Deci, 2000). In addition, internalising purposeful behavioural goals would predict personal growth, as indicated in particular in life coaching interventions including training in goal-setting and goal-striving, and in research on self-concordant and autonomous goal strivings, as well as by intrinsic goal aspirations, which all have been shown to predict well-being in multiple domains (Brunstein, 1993; Green, Oades, & Grant, 2006; Montasem, Brown, & Harris, 2014; Romero, Gómez-Fraguela, & Villar, 2012; Sheldon & Elliot, 1999; Sheldon, Kasser, Smith, & Share, 2002).

We should also bear in mind that the strong positive correlation between purposeful behavioural goals and personal growth (Ryff, 1989), and the above studies described, might indicate that personal goal pursuits and goal attainments predict personal growth. Finally, positive changes in eudaimonic well-being (both oral health-related personal growth and purposeful behavioural goals) were expected to be associated with decreases of dental plaque or bacteria on tooth surfaces, which would improve oral health (i.e. reduce gingivitis). This last link is expected because clinical experimental evidence concludes that effective plaque removal causally influence lifelong dental and periodontal health (Löe, 2000). The expected link from well-being to dental plaque is also based on research indicating that higher levels of both personal growth and purpose in life are both linked to better physiological regulation, such as lower levels of daily salivary cortisol, lower pro-inflammatory cytokines, lower cardiovascular risk and longer-duration REM sleep compared to those with lower well-being (Ryff, Singer, & Love, 2004). Other research has found that eudaimonia was linked with downregulation of pro-inflammatory genes and increased expression of antibody synthesis genes (Fredrickson et al., 2013), reduced risk of stroke (Kim, Sun, Park, & Peterson, 2013) and reduced risk of myocardial infarction among patients with coronary heart disease (Kim, Sun, Park, Kubzansky, & Peterson, 2013).

The hypothesized process model direct and indirect links are illustrated in Figure 1.

Method

Participants

Patients were 138 students ($M_{age} = 23.31$ yr, $SD = 3.5$) from the (University of Oslo) (see study flowchart in Figure 2) who did not have periodontal pockets $\geq$4.0 mm, did not have significant additional diseases, were not pregnant, understood Norwegian language and gave informed consent. For additional information about participants, power analysis, inclusion/exclusion criteria, completers/dropouts and a full description of the experimental procedure, see Halvari, Halvari, Bjørnebekk, & Deci, (2012a). In the present article, the variables measuring eudaimonic well-being are original and new, though autonomy support and dental plaque were also reported in the previous study (Halvari et al., 2012a). Dental plaque and gingivitis were included in the current study because these variables have never been investigated in relation to eudaimonic well-being. Hence, possible links between eudaimonic well-being and both dental plaque and gingivitis would be novel. The trial is registered in NSD-Norwegian Centre for Research Data.

Questionnaire assessments

Perceived autonomy support (T1c)

was measured with the 6-item version of the modified Health-Care Climate Questionnaire (Williams, Grow, Freedman, Ryan, & Deci, 1996), which was adapted to oral health care. An item is: 'I feel that my oral health care professional has provided me choices and options'. Responses could vary from 1 (strongly disagree) to 7

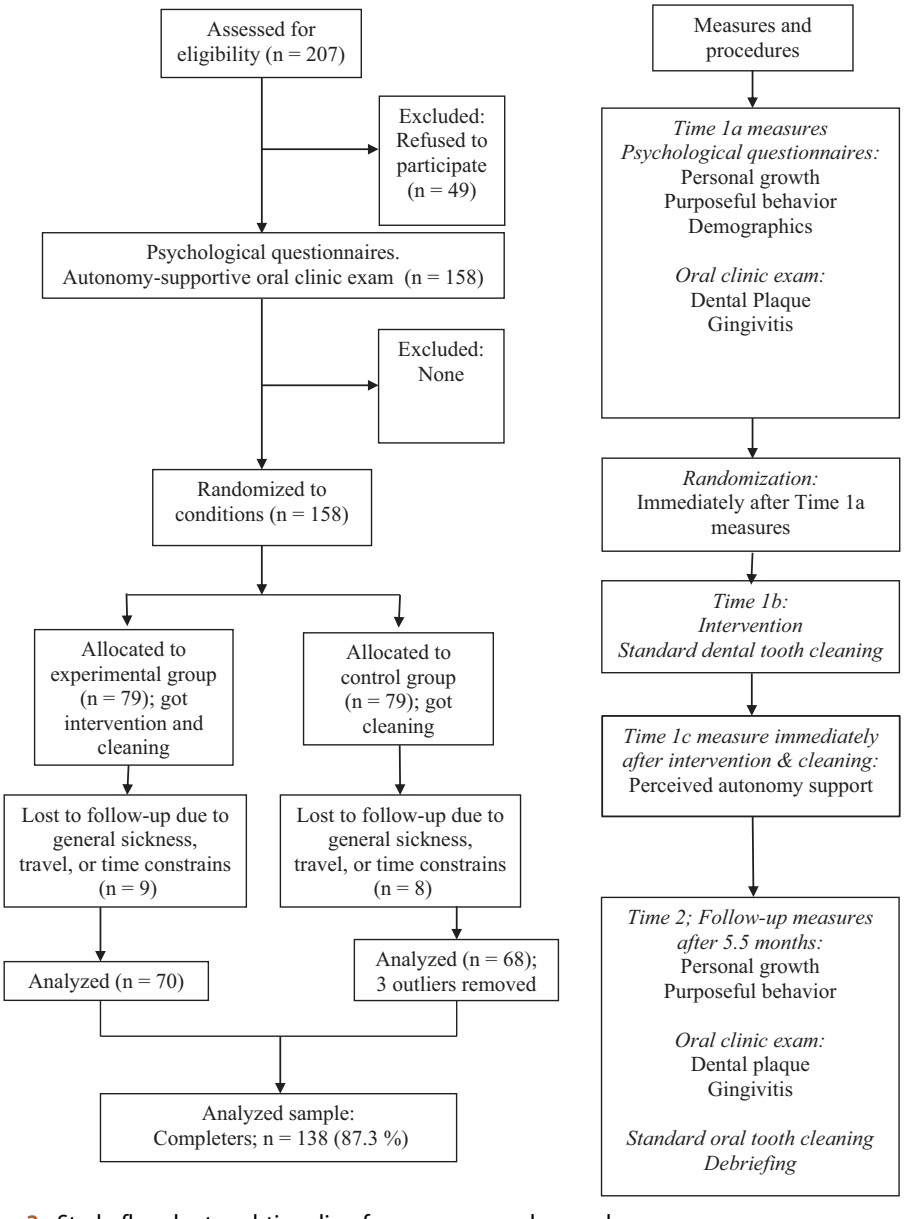

Figure 2. Study flowchart and time line for measures and procedures.

(strongly agree). Reliability and validity indications of this measure can be found in Williams et al., (1996) and in Halvari et al., (2012a).

Eudaimonic well-being (T1a and T2)

was measured with items from two subscales of the Psychological Well-Being scale developed by Ryff (1989). A short 3-item version was used and adapted to oral health for each of the measures of oral health-related personal growth and oral health-related purposeful behaviour. Sample items are: 'Recently, I feel I have learned more about my teeth and my oral health' (oral health-related personal growth) and 'I have

become more active in carrying out my oral health plans' (oral health-related purposeful behavioural goals). The responses varied from 1 (strongly disagree) to 6 (strongly agree). For reliability and validity indications of these scales, see Ryff (1989, 2014) and Ryff and Keyes, (1995).

Clinical assessments

Plaque (T1a and T2).

The dental plaque index (Löe, 1967) reflects soft deposits on the tooth surface and is anchored by a scale ranging from score 0 (absence of plaque) to score 3 (abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin).

Gingivitis (T1a and T2).

The dental gingival index (Löe, 1967) is anchored by scores ranging from 0 (absence of inflammation) to 3 (severe inflammation, marked redness and hypertrophy; tendency for spontaneous bleeding; ulceration). An Explorer Periodontal double-ended Probe LM23-52B was used for both dental plaque and gingivitis examination procedures.

Experimental procedure

A randomised two-group trial was conducted in a dental clinic. When participants first arrived at Time 1a (T1a; see Figure 2 for the time line of measures), they completed a survey assessing eudaimonic well-being, both oral health-related personal growth and purposeful behaviours, and demographics such as age and gender.

The standard oral examination (T1a).

The exam lasted about 45 min. The DH was trained to be autonomy supportive during the examination. She addressed: an exam introduction (5 min); measures of dental plaque and gingivitis on all tooth surfaces (20 min); clinical and X-ray exam for caries (5–10 min) and pocket exam (5 min). The final dialogue lasted about 10 min and included information on how caries looks and how to detect it on patients' own X-rays and in their own mouth; and the importance of choice and self-initiation regarding treatment options in order to promote an informed basis for patient choice and decision making. Patients with caries disease were referred to treatment at their dentist.

Randomization.

After the exam 79 participants were randomly assigned to each condition. Immediately thereafter a 45 min *intervention* took place for the experimental group, whereas control group participants went directly to a 45 min standard tooth cleaning (see description below). The cleaning in both groups was done in an autonomy-supportive way.

The intervention at T1b

(45 min) was designed to promote oral health care competence in an autonomy-supportive way. Based on an initial conversation with the patient the contents of the intervention were: (i) education in plaque-related diseases such as gingivitis, periodontitis and caries; (ii) demonstrating effective brushing and flossing, with participants practicing them and receiving positive feedback and corrections; (iii) giving health promotion and disease preventive information and offering rationales for the oral health and/or oral hygiene behaviours by explaining the relations of behaviours to disease prevention and health; (iv) giving information about the value of fluorides and regular meals and (v) offering choice concerning their oral self-care. For a full description of the intervention, see supplementary material in Halvari et al., (2012a).

The standard tooth cleaning at T1c.

This 45-min cleaning (removing calculus and stain, and finally polishing the teeth) was given to the control group after the exam and to the experimental group after the intervention. At T1c, right after the intervention and tooth cleaning, all participants responded to a questionnaire assessing perceived clinic autonomy support.

At T2 (after 5.5 months), 138 participants responded to all the same questionnaires they completed before the oral exam at T1a, except demographics which were not included. Finally, T2 measures of dental plaque, gingivitis, pockets and caries were performed.

Data analysis

The following data analysis procedures were performed: (1) Intervention effects were analysed with multivariate repeated-measures analysis of variance (MANOVA), followed by repeated measures ANOVAs to examine the hypothesis for eudaimonic well-being (personal growth and purposeful behaviour), dental plaque and gingivitis, with the intervention versus control groups as the between group factor crossed with the T1a and T2 assessments as the repeated-measures factor; (2) For autonomy support, univariate ANOVA was used; (3) Mplus (version 7.4, Muthén & Muthén, 1998–2012) was used to test the path model illustrated in Figure 3. Due to sample size limitations in relation to the number of variable indicators we tested a simplified model. We randomly assigned all six items for autonomy support at T1c into three parcels, as recommended by Little, Cunningham, Shahar, and Widaman, (2002). Personal growth and purposeful behaviour with its three items each were included at both T1a and T2. The intervention and change scores in dental plaque and gingivitis were treated as observed variables. As recommended for evaluating model fit in covariance structure analyses (Bollen, 1989; Hu & Bentler, 1999), a good fit should have values for the Root Mean Square Error of Approximation (RMSEA) and the Standardised Root-Mean-square Residual (SRMR) close to or lower than 0.06 and 0.08, respectively, accompanied by values for the Comparative Fit Index (CFI) and the Tucker Lewis Index (TLI) close to or higher than 0.95 (Hu & Bentler, 1999) and (4) the indirect links in Figure 3 were tested simultaneously as the structural model in Mplus, producing the indirect effects with standard errors, and 95% confidence intervals.

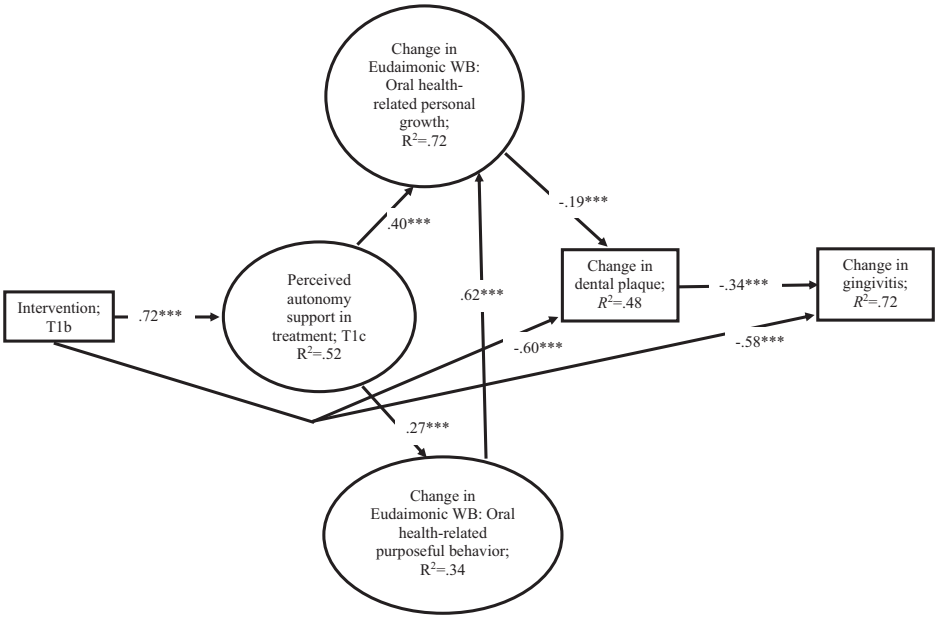

Figure 3. Standardized parameter estimates depicting the relations in the structural SDT process model of eudaimonic well-being, dental plaque, and gingivitis. *Mplus* analysis with a combination of latent and observed variables ($X^2 = 178.59$, df = 127, $p = .002$, X^2/df = 1.40; RMSEA = 0.054, 90% CI for RMSEA: 0.034–0.072; CFI = 0.96, TLI = 0.96, SRMR = 0.082). *Note.* [1]Latent change scores (standardized residuals) were created in *Mplus* by regression of T2 measures onto T1 measures. For presentation clarity factor loadings are not inserted in the Figure. Factor loadings for autonomy support were 0.92, 0.94 and 0.94. They were for the three indicators of personal growth at T1 0.73, 0.44 and 0.76 and at T2 0.72, 0.48 and 0.89. For purposeful behaviour at T1 they were 0.73, 0.88 and 0.69 and at T2 they were 0.68, 0.85 and 0.85. In the model, personal growth at T1 predicted personal growth at T2 (0.22), and purposeful behaviour at T1 predicted purposeful behaviour at T2 (0.52). $^{***}p < .001$.

Results

Descriptive statistics

Table 1 shows the means and standard deviations for variables at T1 and T2, and their internal consistencies (Cronbach's alpha, α).

Intervention effects

Repeated measures multivariate analysis of variance (MANOVA) was used to examine the hypothesis for oral health-related personal growth, oral health-related purposeful behaviour, dental plaque and gingivitis at T1a and T2, followed by four repeated-measures analyses of variance (ANOVA). For the one-time measure of autonomy support we used univariate analyses of variance. For the MANOVA, the intervention versus control groups was the between group factor crossed with the four T1a and T2 assessments as the repeated-measures factor. The analysis yielded two significant main effects and one interaction. For *condition*, $F(4, 132) = 16.04$, $p < .001$; for *time*, $F(4, 132) = 152.33$, $p < .001$ and for the interaction of condition by time

Table 1. Means and standard deviations for variables at time 1 and 2

Variable	*M*	*SD*	α	*M*	*SD*	α
	Autonomy support (T1c)		0.96			
Control group	4.14	1.73				
Intervention group	6.61	0.48				
	Personal growth (T1a)		0.67	Personal growth (T2)		0.75
Control group	3.22	0.97		3.24	0.95	
Intervention group	3.29	0.88		4.38	0.93	
	Purpose (T1a)		0.80	Purpose (T2)		0.84
Control group	3.47	1.09		3.40	0.96	
Intervention group	3.62	1.00		3.99	0.97	
	Plaque (T1a)		0.93	Plaque (T2)		0.95
Control group	1.27	0.26		0.90	0.27	
Intervention group	1.31	0.29		0.51	0.19	
	Gingivitis (T1a)		0.88	Gingivitis (T2)		0.94
Control group	1.44	0.15		1.49	0.16	
Intervention group	1.47	0.15		1.17	0.10	

Note. Control group: $N = 70$; intervention group: $N = 68$.

$F(4, 132) = 62.00$, $p < .001$. The effect was large for the interaction of condition by time, which indicates that the intervention group changed more from T1a to T2 than did the control group (see Table 1), thus, supporting our experimental hypothesis.

Results of repeated measures ANOVAs (see Table 2) yielded four significant interactions of the intervention by time which indicates as expected that the intervention, relative to the control group, resulted in increases of personal growth and purposeful behaviour, and resulted in decreases in dental plaque and gingivitis, from T1a to T2. For autonomy support measured only one time right after the intervention, univariate ANOVAs indicated that the intervention positively predicted perceived autonomy support. Hence, our five experimental hypotheses were supported.

Correlations

The sixth hypothesis concerned expected links within the SDT-based path model. As hypothesized, the zero-order correlations (see Table 3) indicate that the intervention condition was positively correlated with change in autonomy support, which was positively linked to changes in personal growth and purposeful behaviour, both of which, in turn, were negatively associated with change in dental plaque and gingivitis. Changes in dental plaque and gingivitis were positively associated. Personal growth and purposeful behaviour were also positively associated.

The SDT process path model

Mplus (version 7.4, Muthén & Muthén, 1998–2012) was used to test the process model illustrated in Figure 1. Missing data were handled using full information maximum likelihood (FIML) estimation, and analyses were performed using the robust MLR estimator. The measurement model yielded a good fit to the data ($X^2 = 108.93$, df = 80, $p = 002$, X^2/df = 1.36; RMSEA = 0.051, 90% CI for RMSEA: 0.023–0.074; CFI = 0.97, TLI = 0.96, SRMR = 0.064).

Next, in testing the SDT structural equation model, modification indices suggested a path from the intervention to both dental plaque and gingivitis. We added these

Table 2. ANOVA of study variables.

Effect	*F*	Effect size Cohen's *d*[a]
Autonomy support (T1c)		
Intervention	148.98***	1.38
Personal growth (T1a & T2)		
Intervention	19.66***	0.67
Time	46.01***	0.62
Intervention × time	41.41***	1.15
Purposeful behaviour (T1a & T2)		
Intervention	6.44**	0.41
Time	2.59	0.20
Intervention × time	6.14**	0.42
Plaque (T1a & T2)		
Intervention	23.67***	−0.86
Time	601.76***	−2.01
Intervention × time	77.04***	−1.44
Gingivitis (T1a & T2)		
Intervention	50.62***	−1.21
Time	103.82***	−0.71
Intervention × time	195.52***	−2.26

For autonomy support at Time 1c, only the intervention effect is available.
Note. Degrees of freedom are 1, 135 for all ANOVA's.
[a]*d* = difference or change given in *SD*; 0.20 = small, 0.50 = moderate and 0.80 = large (Cohen, 1992).
**$p < .01$.
***$p < .001$.

paths because they were experimentally hypothesized, and the final structural model yielded acceptable fit ($X^2 = 178.59$, df = 127, $p = .002$, X^2/df = 1.40; RMSEA = 0.054, 90% CI for RMSEA: 0.034–0.072; CFI = 0.96, TLI = 0.96, SRMR = 0.082). All of the hypothesized links were supported, except the link from oral health-related purposeful behaviour to dental plaque as its influence on dental plaque was indirect through oral health-related personal growth. The paths are illustrated in Figure 3.

Tests of indirect associations in Figure 3

The indirect links were tested with a bootstrapping procedure simultaneously with the structural model in Mplus. All indirect links were tested with the full model (Figure 3), controlling for all other paths. The results indicated that all indirect links were significantly supported (see Table 4).

Discussion

The experimental test of the autonomy-supportive competence-enhancing intervention, relative to standard care and the SEM test of the SDT process model of eudaimonic well-being and oral health received strong support. The intervention positively predicted perceived autonomy support measured right after the intervention, as well as increases in both oral health-related behaviour goals and personal growth, and reductions in bacterial dental plaque and gingivitis. The effect sizes (Cohen, 1992) were large for all dependent measures, except a moderate effect size for oral health-related behavioural goals. Regarding the SDT process model, the intervention positively predicted perceived autonomy support, which positively

Table 3. Correlations among the intervention, autonomy support at Time 1, well-being and dental plaque measures at Times 1 and 2, and change[a] in variables ($N = 138$).

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Intervention (T1b)	–													
2. Autonomy support (T1c)	0.70**	–												
3. Personal growth (T1a)	0.01	0.11	–											
4. Personal growth (T2)	0.52**	0.46**	0.43**	–										
5. Personal growth (T1a–T2)	0.56**	0.45**	0.00	0.91**	–									
6. Purposeful behaviour (T1a)	0.07	0.12	0.66**	0.32**	0.03	–								
7. Purposeful behaviour (T2)	0.29**	0.27**	0.39**	0.61**	0.50**	0.46**	–							
8. Purposeful behaviour (T1a–T2)	0.29**	0.25*	0.09	0.53**	0.54**	0.00	0.89**	–						
9. Dental plaque (T1a)	0.02	−0.03	−0.25**	0.01	0.13	−0.13	−0.04	0.04	–					
10. Dental plaque (T2)	−0.64**	−0.41**	−0.30**	−0.49**	−0.40**	−0.29**	−0.30**	−0.19*	0.28**	–				
11. Dental plaque (T1a–T2)	−0.69**	−0.42**	−0.23*	−0.51**	−0.45**	−0.25*	−0.30**	−0.21*	−0.01	0.96**	–			
12. Gingivitis (T1a)	0.07	0.00	−0.04	−0.04	−0.02	0.08	0.05	0.02	0.35**	0.08	−0.04	–		
13. Gingivitis (T2)	−0.77**	−0.46**	−0.05	−0.44**	−0.46**	−0.05	−0.23*	−0.23*	0.14	0.73**	0.71**	0.23*	–	
14. Gingivitis (T1a–T2)	−0.81**	−0.49**	−0.04	−0.45**	−0.47**	−0.08	−0.25*	−0.24*	0.05	0.73**	0.74**	0.00	0.97**	–

[a]T1a–2 represent variable change. Change scores (standardised residuals) were created by regression of T2 measures onto T1 measures.
*$p < .01$.
**$p < .001$.

Table 4. Mplus bootstrapping[a] tests of indirect associations.

Independent variable (IV)	Mediator (M)	Dependent variable (DV)	Estimate	*SE*	Estimate/ *SE*	95% CI Lower	95% CI Upper
Indirect associations emerging in Figure 2							
1. Intervention	→ Autonomy support	→ Personal growth	0.29	0.06	4.93***	0.18	0.41
2. Intervention	→ Autonomy support	→ Purposeful behavior	0.20	0.06	2.95***	0.06	0.34
3. Intervention	→ Dental plaque	→ Gingivitis	−0.20	0.05	−4.34***	−0.30	−0.11
4. Autonomy support	→ Purposeful behavior	→ Personal growth	0.17	0.05	3.11***	0.06	0.28
5. Autonomy support	→ Personal growth	→ Dental plaque	−0.07	0.04	−1.99*	−0.15	−0.002
6. Purposeful behavior	→ Personal growth	→ Dental plaque	−0.11	0.05	−2.03*	−0.22	−0.004
7. Personal growth	→ Dental plaque	→ Gingivitis	−0.06	0.03	−1.91*	−0.13	−0.002

[a]All indirect links were tested with the full model (Figure 2), controlling for all other paths.
*$p < .05$.
***$p < .001$.

predicted changes in purposeful behavioural goals and changes in personal growth. Increase in personal growth was negatively associated with change in dental plaque, and increases in purposeful behavioural goals was indirectly negatively linked with increases in dental plaque through increases in personal growth. Change in dental plaque predicted change in gingivitis. In addition, the intervention directly reduced dental plaque and gingivitis.

This is the first autonomy-supportive dental intervention predicting increases in eudaimonic well-being, and at the same time affected improvements in oral health, or any other physical health outcome. This is also the first study indicating that the association between perceived autonomy support and change in dental plaque is mediated by change in components of eudaimonic well-being. The links from the intervention to autonomy support, changes in both purposeful behaviour and personal growth, and changes in oral health indications as dental plaque and gingivitis are considered causal because the study was designed as a randomised controlled field experiment. This is important because effective plaque removal is causally linked to life-long oral health (Löe, 2000).

Physical health and safety have been demonstrated to be intrinsic aspirations for humans in cultures around the world (Grouzet et al., 2005) and this intervention facilitated internalisation of a value for purposeful oral health behavioural goals and increased perception of personal growth which resulted in better oral health. Since personal growth is an indicator of learning, future interventions could include broader measures of learning as mediating variables in the eudaimonic well-being and oral health model. According to SDT, meeting this challenge to improve one's health through internalization of a value for the behaviour, and experiencing personal growth is eudaimonic as it satisfies basic psychological needs for autonomy and competence. This is likely an important pathway by which an autonomy supportive dental health intervention can improve quality of life related to oral health. Since previous studies have demonstrated significant links between perceived autonomy support, and quality of life for patients with diabetes (Williams, Lynch, & Glasgow, 2007; Williams et al. 2009), and for patients on dialysis (Chen, Chang, Tsai, & Hou, 2018), future SDT interventions in the broader health care domain can be tested to confirm if they have their effect on quality of life, physical and mental health outcomes by enhancing eudaimonic well-being.

This study strongly supported the hypothesized SDT process model with one exception. Change in purposeful behaviour goals was not directly associated with change in dental plaque, but was indirectly predictive of it through personal growth. Thus, personal growth might be more strongly related to health indicators than purposeful behavioural goals, as shown by Ryff (1989) and in the results in the current study. It is possible that internalising purposeful goals may precede experiences of personal growth, but further study with the appropriate lagged design is needed to determine this. In addition, because the intervention still had a direct effect on change in dental plaque and gingivitis after the three mediators were added to the model, other mediating variables would be of interest for future testing in the eudaimonic well-being and oral health model. According to Sheldon and Elliot, (1999), patients' goal efforts and goal attainment in the oral health field would be good candidates, as well as their cumulative need satisfying experiences related to their oral health. Need-support from multiple sources might also be of importance, that is, from oral health care professionals, friends, romantic partners and family (Ratelle, Simard, & Guay, 2013).

Regarding the psychological processes that may explain the current findings are bottom-up and top-down theories (Diener, 1984). The accumulation of need-satisfying experiences affect well-being and better health (bottom-up), as proposed in SDT. Need-satisfaction may also affect a broader top-down effect of purposeful behavioural goal effort and attainment producing personal growth and wellness, resulting in better health. For example, goal attainment may be associated with higher perceived competence, a SDT motivational variable linked to positive health evaluations, improved oral health status (Halvari, Halvari, Bjørnebekk, & Deci, 2012a, 2012b), health-related quality of life (as described previously) and a deeper interest in oral health issues. Thus, future research should include additional measures of motivation and behaviour, and need-satisfying experiences from multiple sources.

A weakness of the current study is the lack of a long-term follow-up, so we do not know if the effects are maintained beyond six months. Changes in purposeful behavioural goals, changes in personal growth and changes in dental plaque and gingivitis were measured at the same time, so changes in the eudaimonic well-being variables cannot be said to have produced the changes in dental plaque and gingivitis.

Conclusions

The results from this study have important practical implications for dental treatment, oral health-related eudaimonic well-being and oral health. Considering the large effects of the intervention on oral health-related well-being, dental plaque and gingivitis, an intervention that adds autonomy support to standard care would indeed be worth the modest additional cost.

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