
Article:
Hasmun, N., Vettore, M.V., Lawson, J.A. et al. (3 more authors) (2020) Determinants of children's oral health-related quality of life following aesthetic treatment of enamel opacities. Journal of Dentistry, 98. 103372. ISSN 0300-5712

https://doi.org/10.1016/j.jdent.2020.103372

Title Page

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Determinants of children's oral health-related quality of life following aesthetic treatment of enamel opacities

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Key words: children, oral health-related quality of life, enamel opacities, molar incisor hypomineralisation, aesthetic treatment

Funding
This study was supported by funding from the Malaysian Government and Universiti Teknologi MARA which allowed Dr Noren Hasmun to undertake a clinical PhD at the University of Sheffield, UK.

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Abstract

Objectives: To identify clinical and psychosocial predictors of oral health-related quality of life (OHRQoL) in children with molar incisor hypomineralisation (MIH) following aesthetic treatment of incisor opacities.

Methods: Participants were 7- to 16-year-old children referred to a UK Dental Hospital for management of incisor opacities. Prior to treatment (T_o), participants completed validated questionnaires to assess OHRQoL and overall health status (C-OHIP-SF19), and self-concept (Harter's Self-Perception Profile for Children [SPPC]). Interventions for MIH included microabrasion, resin infiltration, tooth whitening or composite resin restoration. Children were reviewed after six months (T_1) when they completed C-OHIP-SF19 and SPPC questionnaires. The relationships of predictors with improvement of children's OHRQoL (T_1-T_o) and children's overall health status at T_1 were assessed using linear and ordinal logistic regression, respectively, guided by the Wilson and Cleary's theoretical model.

Results: Of 103 participants, 86 were reviewed at T_1 (83.5% completion rate). Their mean age was 11-years (range=7-16) and 60% were female. Total and domain OHRQoL scores significantly increased (improved OHRQoL) following MIH treatment. There was a significant positive change in SPPC physical appearance subscale score between T_o and T_1. A higher number of anterior teeth requiring aesthetic treatment were associated with poor improvement of socio-emotional wellbeing at T_1 (Coef =-0.43). Higher self- concept at T_o was associated with greater improvement of socio-emotional wellbeing at T_1 (ß=3.44). Greater orthodontic treatment need (i.e. higher IOTN-AC score) at T_0 was linked to worse overall oral health at T_1 (OR=0.43).

Conclusions: Minimal interventions for incisor opacities can improve children's OHRQoL, although psychosocial factors and dental clinical characteristics may influence outcomes.

Clinical significance: MIH is a common condition and clinicians should be aware of the negative impacts some children experience, particularly those with multiple anterior opacities, poor tooth alignment and low self-concept. However, simple, minimally invasive treatments can provide good clinical and psychosocial outcomes and should be offered to children reporting negative effects.

Introduction

Perceptions around what constitutes an attractive smile, in terms of soft tissue and tooth aesthetics, vary in different societies and cultures [1, 2]. However, smiling is integral to social interactions throughout life and is widely associated with intelligence, social status and happiness [3]. Individuals who are embarrassed or unhappy about their dental appearance, because of real or perceived differences, may avoid 'smiling freely' in everyday encounters. Some will consciously alter their behaviours, for example smiling without showing their teeth, covering their mouth with a hand when talking, or actually avoiding social interactions [4]. A growing literature supports the effect of dental appearance on a person's quality of life, confidence, self-esteem, social relationships, and even career prospects [5-8]. These impacts may be particularly acute during adolescence, when young people develop their sense of self, form relationships and try to find their place in society.

A common developmental dental condition presenting in childhood, with both aesthetic and functional implications, is molar incisor hypomineralisation (MIH) [9]. The precise aetiology remains elusive, although there is general consensus that MIH is multifactorial with polygenetic and environmental influences [10-12]. The most recent global estimates suggest that 13-14% of children have some degree of MIH, making it an undisputed public health concern [13, 14]. In addition to having poorly mineralised and compromised first permanent molars, children may also have one or more hypomineralised incisors or, less commonly, canines [15-17]. Affected anterior teeth present with asymmetric discrete enamel opacities ranging in colour from bright white through to cream, yellow or brown. The enamel opacities are highly variable in size but tend to be located towards the incisal third of the labial surfaces, sparing the cervical and palatal/lingual enamel [18]. In contrast to affected permanent molars, hypomineralised anterior teeth tend not to be thermally sensitive or at risk of post-eruptive breakdown, unless the opacity involves the incisal edge. The altered enamel appearance and mechanical properties relate to a systemic 'insult' during the maturation phases of enamel formation. In simplistic terms, this qualitative defect produces weak and porous enamel with an abnormally high protein content and lower calcium:phosphorus ratio [19, 20]. In addition, the presence of voids between the normally densely packed enamel rods [21, 22] alters the refractive index of the defective enamel making it appear more opaque [23].

Visible differences in dental appearance, such as the presence of enamel opacities, may have considerable impact on children's oral health-related quality of life (OHRQoL) [5, 8, 24, 25]. To date, research exploring the psychosocial impacts of enamel defects has focussed on populations with dental fluorosis [26, 27] but MIH-related enquires are now receiving considerable attention [8, 25, 28-31]. The first intervention study to explore the effect of aesthetic treatment for MIH patients was published in 2018 and showed a significant improvement in children's self-report OHRQoL after one month [32]. However, no MIH studies have yet fully explored the interplay of clinical and psychosocial variables in predicting patient-reported outcomes over time.

Therefore, the aim of this longitudinal intervention study was to investigate the relationship of socio-demographic, dental and psychosocial factors with improvement of OHRQoL and overall health status in children with MIH who received dental treatment to reduce the visibility of their enamel opacities according to the theoretical model of health-related quality of life.

Methods

Ethical approval

This study received ethical approval from the UK National Research Ethics Committee (ref: 17/WA/0096, April 2017). Written child assent and parental consent were obtained for all patients and their parents before participation.

Participants

Children, aged 7-16 years, who were diagnosed with MIH and requested treatment for visible enamel opacities involving one or more of their permanent incisors were invited to participate. These patients were initially referred to the Paediatric Dentistry Department, Charles Clifford Dental Hospital, Sheffield, UK for specialist treatment. Children were excluded if they were due to have orthodontic treatment or extractions of hypomineralised first permanent molars during the study period, thereby limiting the confounding effects of change to dental status on OHRQoL other than from the aesthetic intervention itself.

A sample size comprising 86 children to obtain an adjusted R2 of 42%, would lend a power of 95% and to estimate a multivariable linear regression model with 8 variables, assuming a 5% statistical significance [33]. Assuming a dropout rate of 20%, the intention was to recruit 103 patients.

Clinical intervention

Due to the diversity of opacity presentation, treatment regimens were pragmatic and tailored for individual patients. All interventions were minimally invasive and comprised one or more of the following approaches: microabrasion (Opalustre™, Optident Ltd, Ilkley, UK); resin infiltration (ICON™, DMG, Hamburg, Germany); home use tooth whitening gel (Opalescence™ 15% carbamide peroxide, Optident Ltd, Ilkley, UK), and direct composite resin restoration 'camouflage' (Filtek™, 3M ESPE, Bracknell, UK). All procedures were carried out using rubber dam and according to well-established clinical protocols and manufacturers' instructions [34-39]. Standard clinical images were taken using a digital SLR camera (Nikon D3400, Nikon UK Ltd, Kingston upon Thames, UK) at every visit.

Assessment of OHRQoL, overall health and self-concept

Children were asked to complete a number of validated measures, described below, at two time points: T_0=baseline (pre-treatment) and T_1=six-months following treatment. In total, there were 45 items, collated in a booklet, which took approximately 15 minutes to complete.

The impact of having MIH on children's OHRQoL was measured using the Child Oral Health Impact Profile Short Form 19 questionnaire (C-OHIP-SF19) [40,41]. This self-report instrument has been widely used in clinical and general populations to measure both positive and negative impacts of various oral conditions [42]. The short form has 19 items encompassing three domains: oral health (five items), functional wellbeing (four items), and socio-emotional wellbeing (10 items). Children are asked how often they have experienced an impact because of their teeth, mouth or face, as described by each item, during the past three months. The response format is a 5-point Likert scale

ranging from 'almost all the time' (score=0) to 'never' (score=4). The total C-OHIP-SF19 score is obtained by summing the total scores of all three domains with a range from zero (worst OHRQoL) to 76 (best OHRQoL) [41,43]. C-OHIP-SF19 also includes a global question: 'Overall, how healthy do you think your teeth are?' Participants respond to this question using a 5-point Likert scale from: poor (score=0), fair (score=1), average (score=2), good (score=3) to excellent (score=4).

A global question was used to record children's views of their own overall health status: 'Overall, how would you say your general health is?' [44]. The response format was a 5-point scale from poor (score=1), fair (score=2), good (score=3), very good (score-4) to excellent (score=5).

The Self-Perception Profile for Children (SPPC) is a valid and reliable measure of self-concept [45,46]. The original SPPC scale has five subscales but only two subscales most relevant to the study context (social acceptance and physical appearance) were used together with a global self-worth item. Participants were asked to decide, using a tick box response format, how closely they aligned themselves to the given statements. Each subscale comprised six items with a score from least positive (score=1) to most positive (score=4). A total mean score for each domain was computed by summing all scores and then taking an average for each subscale [47,48].

Sociodemographic and clinical data

Children's age was recorded in years from their dental records. For the purposes of subsequent analysis they were then categorised as being primary school-aged (7-10 years) or secondary school-aged (11-16 years).

The Index of Multiple Deprivation (IMD) score was determined from each patient's postal address to assess social deprivation [49,50]. The IMD is an official measure of relative deprivation for small geographical areas in England and can be used to rank an individual's postal address as falling into one of five areas (quintiles) from 1 (least deprived) to 5 (most deprived). For the purposes of this study, children were divided into three subgroups: least deprived (children from the upper and upper middle quintiles) average (children from the middle quintile) and most deprived (children from the lower middle and lower quintiles).

Caries experience (dmft/DMFT) was gathered from the child's dental records following their initial clinical and radiographic assessment with a specialist in paediatric dentistry. The child's orthodontic appearance was determined by two experienced clinical researchers (NH and JL) using the Aesthetic Component the Index Orthodontic Treatment Need (IOTN-AC) [51-53]. The IOTN-AC was further categorised into one of three subgroups: 1=no/slight need for treatment (AC scores of 1-4); 2=moderate/borderline need for treatment (AC scores of 5-7); 3=substantial need for treatment (AC scores of 8-10) [54].

Calibration and reliability of instruments

Training and calibration was undertaken before the main study by two clinical researchers (NH and JL) who carried out all data collection and MIH treatment. Training in use of IOTN-AC was provided by an orthodontic colleague using 20 study models. The researchers graded these models from 1 to 10, according to the ten-point IOTN-AC system, with reference to the standard accompanying photographs [55]. Each examiner then repeated the scoring exercise a week later. Examiner agreements were very good to excellent with all Kappa coefficients and Intra-class Correlation

Coefficient (ICC) scores falling within a range of 0.91-0.98 [56]. Data entry was repeated for a randomly selected 50% (n=43) of participants three months after data collection to check the accuracy of data entry. ICC scores were between 0.99 and 1.00, indicating substantial reliability and high accuracy in data entry.

Theoretical model and data handling

The outcomes were improvement of child-reported OHRQoL (total COHIP-S19 score) and children's overall health status (C-OHIP-SF19) six-months following treatment. Relationships between the predictors of children's OHRQoL following treatment were examined according to the theoretical framework proposed by Wilson and Cleary [57]. This conceptual and biopsychosocial model of HRQoL was adopted to support the selection of variables and to guide the analysis (Figure 1).

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The study predicted *a priori* that age, gender, socio-economic status, caries experience, orthodontic treatment need, number of permanent anterior teeth with enamel opacities needing aesthetic treatment and self-concept (SPPC) at baseline (T_0) would predict overall oral health at the six-month follow-up (T_1) and improvement of socio-emotional wellbeing between baseline and six-month follow-up (T_1 - T_0).

Statistical analysis

Demographics, social deprivation, self-concept and OHRQoL were presented through means (standard deviations) and proportions for the studied sample at baseline (T_0) and six-month follow-up (T_1). The mean for dental caries experience and number of treated teeth, as well as the frequencies of categories for orthodontic treatment need and treatment regimen were also reported. The Statistical Package for the Social Sciences (SPSS v24.0, IBM Corp., Chicago, IL, USA) was used for the descriptive analysis. Friedman's two-way analysis was used to determine if there were any statistically significant differences in mean C-OIDP-S19 and SPCC scores at T_0 and T_1 as these data were not normally distributed.

The difference between total COHIP-S19 score at baseline and six-month follow- up (T_1 - T_0) was used to measure the improvement of child-reported OHRQoL. The distribution of the variation of total COHIP-S19 score was normally distributed according to Shapiro-Wilk test (p=0.167). Principal Component Analysis (PCA) was used to generate SPPC variable (factor) based on the scores of the subscales social acceptance and physical appearance, and global self-worth item. The eigenvalues were 2.13, 0.33 and 0.54; Kaiser-Meyer-Olkin (KMO) value was 0.673 and Bartlett's test of sphericity was significant (p<0.001).

The relationship of demographics (gender and age), social deprivation (IMD scores), clinical variables (caries experience, orthodontic treatment need, number of hypomineralised permanent anterior teeth needing aesthetic treatment), self-concept, and socio-emotional wellbeing at baseline with improvement of socio-emotional wellbeing (T_1 - T_0) was assessed through multivariable linear regression to obtain adjusted coefficients and 95% Confidence Intervals (CIs). Ordinal logistic regression was used to examine the relationship of the above mentioned predictors and overall oral health at baseline (T_0) with overall oral health at six-month follow- up (T_1) to estimate Odds Ratios (OR) and 95% CIs. Initially, crude analysis was performed between each predictor and the outcomes. All independent variables were retained in the multivariable linear and ordinal logistic regression analyses to obtain adjusted associations.

Results

Participant characteristics and treatment received (see Table 1)

Recruitment and treatment of participants was carried out between June 2017 and November 2018. Of the 111 children who met the inclusion criteria, 103 consented to participate, giving a response rate of 92.8%. The completion rate at T_1 was 83.5% (n=86). At the start of the study, there was a slightly higher proportion of female than male patients (60% vs 40% respectively) and the majority (n=94, 91.3%) identified as White English, Welsh, Scottish, Northern Irish or British. The mean age of the participants was 11.0 years (SD=2.6; range=7-16). Over a third of participants (n=40, 38.8%) lived in areas of greatest deprivation (4^{th} and 5^{th} IMD quintiles). Participants had a mean of three permanent anterior teeth treated (range=1-12). The most common treatment regimen was a combination of microabrasion followed by resin infiltration (n=64, 62.1%). Only five (5.8%) children required composite resin restorations to achieve optimum aesthetics. For illustrative purposes, an example of a participant's incisor opacities pre- and post-treatment is shown in Figure 2.

Oral health-related quality of life and self-concept

At T_0 the mean C-OHIP-SF19 total score was 47.4 (SD=9.34; range=0-76) and this increased significantly to 59.8 at T_1 (SD= 9.7; range=0-76) (p<0.001) indicating significantly improved OHRQoL. Additionally, participants self-rated a significant difference (improvement) in the SPPC physical appearance subscale from T_0 to T_1. However, there were no significant changes for the social acceptance subscale or global self-worth.

Linear regression analysis
Results of univariate and multivariate linear regression models examining the relationship between predictors and improvement of socio-emotional wellbeing between baseline and six-month review visit is presented in Table 2. The adjusted analysis showed that the number of anterior teeth requiring aesthetic treatment (Coeff = -0.43; 95% CI, -0.92, -0.06) was associated with lower improvement on socio-emotional wellbeing. Greater self-concept was related to greater improvement on socio-emotional wellbeing (Coeff = 3.44; 95% CI, 1.26, 5.62). Higher socio-emotional wellbeing at baseline was associated with lower improvement of socio-emotional wellbeing (Coeff = -0.62; 95% CI, -0.80, -0.45). The adjusted model explained 42% of the variability in the variation of socio-emotional wellbeing scores between baseline and six-month follow- up (R^2 = 0.42).

Ordinal logistic regression analysis
Table 3 includes the univariate and multivariate logistic ordinal regression on the association between predictors and overall oral health at six-month follow-up. Children with greater orthodontic treatment need (i.e. higher IOTN-AC score) at baseline were less likely to report better overall oral health at six-month review visit (OR=0.43; 95% CI, 0.22, 0.87). Better overall oral health at baseline was associated with improved overall oral health at six-month review visit (OR=3.78; 95% CI, 1.93, 7.40).

Discussion

Over the past three decades, there has been growing understanding of the impact that various dental conditions may have on children and their families. However, it is only relatively recently that interest has turned to the impact and burden of MIH. This novel study has employed a theoretical model to explore the psychosocial benefit of simple aesthetic treatment for children with enamel opacities of cosmetic concern.

The study had high response and completion rates; children and their families were very motivated

to pursue 'aesthetic' treatment, rarely missed appointments and proved enthusiastic research participants. It is also worth noting the higher proportion of female (59.3%) participants. As there are no data to suggest that MIH is actually more common in females [58] it can only be assumed that girls (and/or their parents/carers) are more concerned about the visibility of enamel opacities and are proactive in seeking referral for specialist treatment. It is also important to recognise that not all children with visible enamel opacities experience negative impacts and may not wish to pursue treatment. There may also be other barriers to children seeking treatment for MIH, such as dental anxiety or lack of family support. Thus, the scope of the study is limited as it only includes children who viewed their teeth as unattractive, wished for aesthetic treatment and were able to access this.

Children engaged well with C-OHIP-SF19 as the primary outcome measure and it was easy for them to understand and complete. Importantly, it proved sensitive enough to measure change in OHRQoL following an MIH intervention. The study therefore provides verification for the suitable psychometric properties of C-OHIP-SF19 when used with children with MIH. During protocol development consideration was given to the use of an alternative child-report questionnaire on incisor aesthetics, originally developed to measure impacts relating to dental fluorosis: the Child and

Parent Questionnaire about Tooth Appearance [59]. This 12-item instrument was developed with children and parents in the USA and Mexico and it has been translated into Spanish and Portuguese and is applicable for children aged 7 years and above (and their parents). Previous researchers have used this questionnaire to assess the impact of dental appearance (i.e. incisor aesthetics) in Brazilian children with and without MIH [25]. However, this instrument has not been validated for an English-speaking European population and would need further validation testing in terms of language and cultural adaptation before use in the UK. Furthermore, as the focus of this questionnaire is entirely on aesthetics, any impacts relating to function would not have been captured.

Findings from the regression analyses revealed the predictors of changes in OHRQoL (the primary outcome measure) six months after MIH treatment in children who sought and received aesthetic treatment for their incisor opacities. Firstly, it was interesting, but unsurprising, that poorer orthodontic aesthetics were linked to worse overall oral health at the six-month review. This resonated with clinical impressions; even when the visibility of opacities was reduced, children with a visible malocclusion (e.g. incisor crowding, spacing or proclination) reported still being negatively affected by their overall dental status. It is thus imperative that clinicians are able to elicit from children, exactly what it is about their teeth or mouth that concerns them, rather than making assumptions. The number of teeth requiring aesthetic treatment was a clinical predictor of change of OHRQoL following MIH intervention. This association conflicts with a previous study involving British children with traumatised permanent incisors, which found that the number of injured teeth (or indeed the severity of the injury) did not predict OHRQoL [60]. Further research is therefore needed to explain this finding as perhaps clinical outcomes for multiple hypomineralised teeth are inferior to the outcomes achieved for an isolated opacity. Another key variable to highlight from the analysis is self-concept, which was found to be important in predicting OHRQoL both at baseline and following cosmetic treatment. The importance of self-concept, as well as sense of self and self-esteem, is well recognised in dental appearance-related research [5,7]. The present study further highlights the need to consider these aspects when exploring OHRQoL, particularly with respect to treatment-related changes.

In terms of socio-demographic variables, it would seem that children's age was not relevant to the final model but there are sparse studies to support or refute this finding. A simple observational study, involving 8-year-old Brazilian children with MIH, suggested that younger children did not experience negative OHRQoL impacts in relation to their incisor opacities [31]. The authors proposed that these children were not yet concerned about their dental appearance, as they were in the early mixed dentition phase, with teeth still erupting. One explanation for the lack of age-related differences observed in the present study may relate to the fact that the UK is a more developed country than Brazil, with different social and health contexts. However, when it comes to age-related differences in self-concept, data from the present study concur with previous work, with children becoming more self-critical about their physical features and social abilities as they reach adolescence [45,61].

A key strength of the study was its underpinning by a theoretical model. Failure to employ such models, and appropriate statistical analysis, is a recognised shortcoming of previous paediatric dentistry OHRQoL research [62]. The present study was guided by the well-established Wilson and Cleary model for HRQoL which has been widely applied in previous dental health research [7,63-66]. However, this is the first study to test the adaptability of this model to conceptualise the relationships between various psychosocial and clinical variables and OHRQoL, following an

intervention, in young patients with MIH. It therefore provides novel data to justify and inform the design of future clinical studies.

The current study also evaluated the longitudinal impact of dental treatment for MIH on children's OHRQoL, as participants were reviewed six-months after their treatment. This provided a unique opportunity to review the stability of clinical and patient-reported outcomes. It should be emphasised that OHRQoL can vary according each child's stage of overall development as well as the influence of external factors, such as changing schools or other important life events [67]. Interestingly, OHRQoL generally remained stable for participants in the six-month follow-up period between their first intervention and their final review. However, a longer follow-up period would be of value throughout adolescence, to determine whether positive effects of the aesthetic dental treatment are maintained.

In terms of the study's limitations, a justifiable criticism is the lack of a control group. Children's OHRQoL could have theoretically changed (improved) over time without any intervention, thus the findings cannot be attributed exclusively to the aesthetic treatment provided. Clearly, it would be unethical to withhold treatment for children with MIH who had psychosocial concerns about their incisor opacities, but an acceptable approach may be to delay treatment for some children so that they could act as a control group. However, this was not possible in the present study due to enforced public health service waiting list timelines and targets.

It is also acknowledged that some important variables, known to predict children's OHRQoL, were omitted from the present model. For example, a previous longitudinal study in Thai adolescents revealed that sense of coherence was a key influence on OHRQoL [64]. A more recent Turkish study, which aimed to develop and validate a conceptual model of factors affecting children's OHRQoL, highlighted the influence of parental dental anxiety [68]. Inclusion of additional clinical and psychosocial variables would certainly be helpful in developing and testing a more holistic model in this target population, but would require a considerably larger sample size. The use of a purely quantitative approach to capture children's perspectives of having visible incisor opacities and corrective treatment also has inherent limitations. Whilst quantitative enquiries have value in providing a well-accepted evidence-base and allowing comparison with data from other studies, they fail to generate any new or deeper insights into children's thoughts, feelings and behaviours. The data showed that there was a significant improvement in OHRQoL following MIH intervention, but could not identify how this was perceived by children in their own daily lives and activities. Anecdotally, many children (and their parents) told the investigators how their treatment had made a difference to them, in terms of being happier and more confident at school, but these narratives warrant further exploration using qualitative approaches. Indeed, there seems to be a paucity of qualitative research with children with MIH, either in relation to aesthetic concerns, or functional ones. Ideally, future studies on this topic should try to incorporate a mixed-method approach to gain greater understanding of the impact of enamel opacities, and related treatments, on children's lives.

Some children undoubtedly suffer profound negative psychosocial impacts from having visible enamel opacities that may have lifelong consequences. Children who express concern should therefore be offered minimally invasive and timely interventions, with the expectation that these may measurably improve their wellbeing.

In conclusion, children with MIH, referred to specialist services because of concerns about the appearance of their incisor opacities, were found to be willing and engaged research participants. Minimally invasive dental treatment, which aimed to reduce the visibility of anterior enamel opacities, was found to have a significantly positive effect on children's self-reported OHRQoL. Self-concept, the need for orthodontic treatment and number of teeth needing aesthetic treatment were also relevant predictor for children's OHRQoL and socio-emotional wellbeing after MIH treament.

Declaration of interest

None.

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Acknowledgement

The authors are grateful to the children and their parents who were so willing to participate in this research. Thanks are also extended to all staff in the Department of Paediatric Dentistry, Charles Clifford Dental Hospital, Sheffield, UK for their support, especially Joanne Ellis and Katy D'Apice. Finally, the authors would like to recognise DMG, Hamburg, Germany for providing the ICON material that was used for many of these patients.

Credit Author Statement

Noren Hasmun: Conceptualisation, Methodology and developed the original study and it formed part of a PhD thesis awarded to NH (University of Sheffield, UK, 2020). Investigation. Formal analysis. Data Curation. Writing-review & editing, Visualisation. **Jennifer Lawson:** Investigation. Writing-review & editing. **Mario V Vettore:** Conceptualisation, Methodology and developed the original study and it formed part of a PhD thesis awarded to NH (University of Sheffield, UK, 2020). Formal analysis. Writing-original draft. **Claire Elcock:** Conceptualisation, Methodology and developed the original study and it formed part of a PhD thesis awarded to NH (University of Sheffield, UK, 2020). Supervision. **Halla Zaitoun:** Supervision. Project administration. **Helen D Rodd:** Conceptualisation, Methodology and developed the original study and it formed part of a PhD thesis awarded to NH (University of Sheffield, UK, 2020). Supervision. Project administration. Led on the writing-original draft of the manuscript with critical input from all co-authors in the final version. Visualisation.

Table 1. Socio-demographic and clinical characteristics of participants at baseline and six-months.

		Baseline, T_0		6-month follow-up, T_1	
		Mean (SD, range)	n (%)	Mean (SD, range)	n (%)
Age (years)	All participants	11.02 (2.59, 7-16)		10.93 (2.49, 7-16)	
	7-10		55(53.4)		47(54.7)
	11-16		48(46.6)		39(45.3)
Gender	Male		41(39.8)	34 (45.3)	35(40.7)
	Female		62(60.2)	41(54.7)	51(59.3)
Ethnic background	White British/Northern European		94(91.3)		79(91.9)
	Any other group		9(8.7)		7(8.1)
Social deprivation score	High (1^{st} & 2^{nd} quintiles -least deprived)		46(44.7)		41(47.7)
	Middle (3^{rd} quintile)		17(16.5)		10(11.6)
	Low (4^{th} and 5^{th} quintiles – most deprived)		40(38.8)		35(40.7)
Number of treated teeth		3.09 (2.65, 1-12)		3.20 (2.73, 1-12)	
Treatment regimen	Microabrasion		9(8.74)		4(4.65)
	ICON™		6 (5.83)		4(4.65)
	Tooth whitening		4 (3.88)		4(4.65)
	Composite restoration		2 (1.94)		2(2.32)
	Microabrasion followed by ICON™		64 (62.14)		54 (62.79)
	Microabrasion followed by tooth whitening		8 (7.77)		8(9.3)
	Microbrasion followed by ICON™ and resin composite restoration		3 (2.91)		3(3.49)
	Tooth whitening followed by microabrasion and/or ICON™		7(6.80)		7(8.14)

Table 2. Associations of at baseline with change of socio-emotional wellbeing between baseline and six-month review visit among 86 children using linear regression.

Variables	Univariate analysis		Multivariable analysis[b]	
	Coef (95% CI)	*P*	Coef (95% CI)	*P*
Sociodemographic variables				
Age	0.33 (-0.32, 0.97)	0.313	0.06 (-0.48, 0.61)	0.823
Gender[a]	1.63 (-1.62, 4.88)	0.322	0.74 (-1.86, 3.23)	0.574
Index of Multiple Deprivation	-0.08 (-0.18, 0.02)	0.100	-0.08 (-0.16, 0.01)	0.069
Clinical variables				
Caries experience, dmft/DMFT	0.10 (-0.52, -0.71)	0.756	0.25 (-0.26, 0.75)	0.334
Orthodontic Treatment Need (IOTN-AC)	-1.18 (-3.63, 1.27)	0.342	-1.29 (-3.16, 0.77)	0.082
Number of anterior teeth requiring aesthetic treatment	-0.06 (-0.65, 0.53)	0.848	-0.43 (-0.92, -0.06)	0.025
Self-concept at baseline				
Self-concept	2.46 (1.91, 3.01)	<0.001	3.44 (1.26, 5.62)	0.002
OHRQoL *at baseline*				
Socio-emotional wellbeing (C-OHIP-SF-19)	-0.61 (-0.77, -0.46)	<0.001	-0.62 (-0.80, -0.45)	<0.001

Abbreviations: CI, Confidence interval
[a] Male *vs* female
[b] $R^2 = 0.42$

Table 3. Associations of sociodemographic and clinical data, self-concept, socio-emotional wellbeing and overall oral health at baseline with overall oral health at six-month review visit among 86 children using ordinal logistic regression.

Variables	Univariate analysis		Multivariable analysis	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Sociodemographic variables				
Age	1.29 (0.95, 1.34)	0.160	1.20 (0.97, 1.49)	0.086
Gender[a]	0.85 (0.37, 1.94)	0.695	1.02 (0.40, 2.61)	0.962
Index of Multiple Deprivation	0.97 (0.94, 0.99)	0.021	0.98 (0.95, 1.02)	0.127
Clinical variables				
Caries experience, dmft/DMFT	0.94 (0.80, 1.11)	0.466	1.11 (0.91, 1.36)	0.288
Orthodontic Treatment Need (IOTN-AC)	0.46 (0.24, 0.86)	0.016	0.43 (0.22, 0.87)	0.019
Number of anterior teeth requiring aesthetic treatment	1.07 (0.91, 1.25)	0.411	1.03 (0.85, 1.26)	0.735
Self-concept at baseline				
Self-concept	1.35 (0.64, 2.85)	0.437	0.96 (0.39, 2.39)	0.936
OHRQoL and overall oral health *at baseline*				
Socio-emotional wellbeing (C-OHIP-SF-19)	1.04 (0.98, 1.10)	0.186	1.03 (0.96, 1.10)	0.470
Overall oral health[b]	3.12 (1.70, 5.71)	<0.001	3.78 (1.93, 7.40)	<0.001

Abbreviations: CI, Confidence interval
[a] Male *vs* female
[b] Excellent/Good vs Average vs Fair/Poor

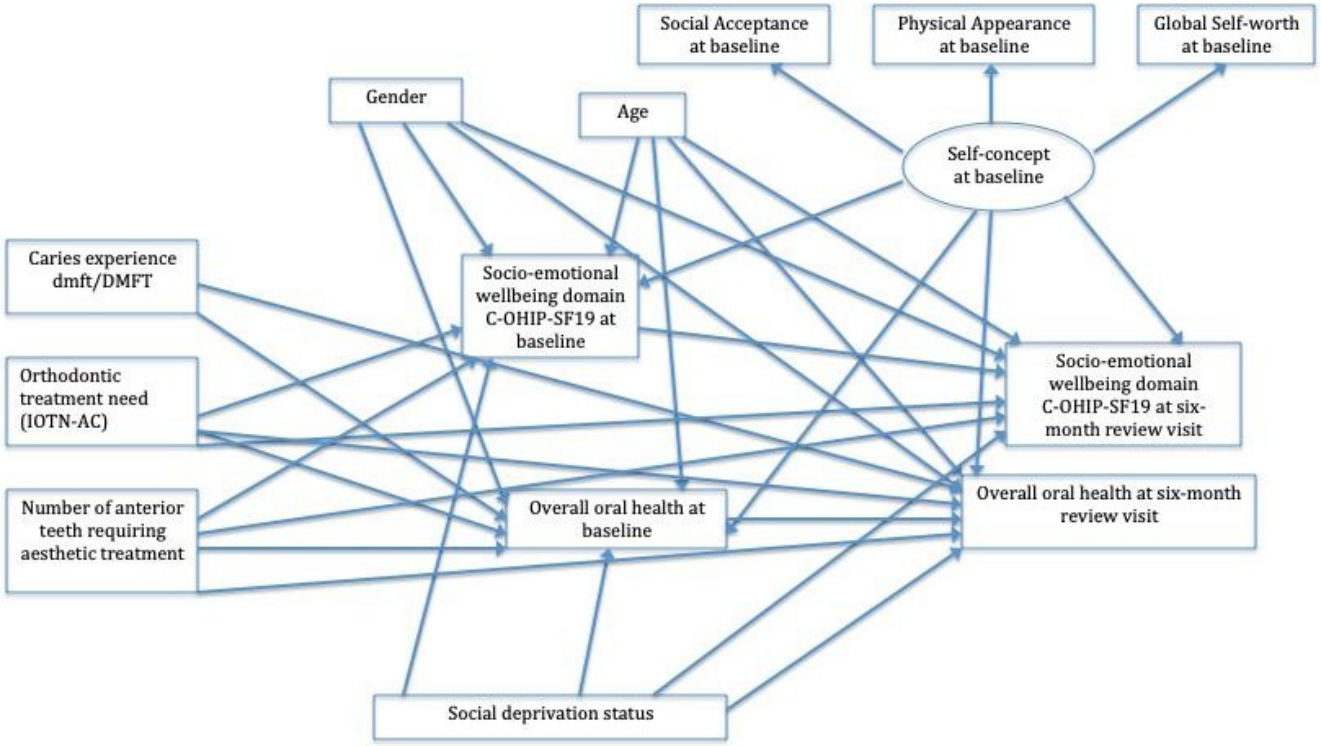

Figure 1. Proposed structural equation model adapted from Wilson and Cleary's theoretical model of health-related quality of life (1995).

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Comment [2]: To be changed with a amended version

Figure 2. Pre- and post-treatment views of an 8-year-old girl with MIH who underwent microabrasion and resin infiltration (Icon™ DMG) of her maxillary central incisors to reduce the visibility of white opacities.