Pediatric patients' orthodontic treatment need, quality of life, and smiling patterns – an analysis of patient, parent, and provider responses

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Abstract

Objectives: The objectives of this study is to explore the relationship between pediatric patients' orthodontic treatment need, the patients' assessments of their smile-related quality of life (QoL), their parents' proxy assessment of their child's QoL and own assessments of their child's smile, and the patients' objectively assessed smiling patterns.
Methods: Survey data were collected from 102 patients (53 boys/49 girls; age range: 9–13 years) and their parents. Orthodontic treatment need was assessed with the Index of Complexity, Outcome, and Need (ICON). Smiling patterns were determined by videotaping patients' smiles while they watched a cartoon. Thirty predetermined sections of these tapes were then assessed by two independent raters to measure the patients' smiling patterns.
Results: The aesthetic component and total ICON scores correlated with the patients' smile-related QoL ($r = 0.25$; $P = 0.014$/$r = 0.23$; $P = 0.024$), parental proxy assessments of the child's smile-related QoL ($r = 0.29$; $P = 0.004$/$r = 0.26$; $P = 0.009$), the parents' own assessments of their child's smile ($r = 0.32$; $P = 0.002$/$r = 0.29$; $P = 0.005$), and the number of negative adjectives chosen by the parents to describe their child's smile ($r = 0.32$; $P = 0.002$/$r = 0.30$; $P = 0.004$). Although the smiling patterns were correlated with the patients' smile-related QoL responses (height of smile: $r = 0.29$; $P = 0.005$/number of teeth shown: $r = 0.30$; $P = 0.004$), the ICON scores were not correlated with the patients' smiling patterns.
Conclusions: Objectively assessed orthodontic treatment need correlates with the patients' and parents' assessments of the child's smile-related QoL scores. However, while objective smiling patterns are related with the patients' smile-related QoL, they are not correlated with the patients' orthodontic treatment need.

Introduction

Every year, over 5.75 million patients seek orthodontic treatment in the United States and Canada, a number that has grown by 43.75 percent over the last 10 years (1). Of these 5.75 million patients, 81 percent are under the age of 17 years. In addition to these patients who receive treatment for malocclusion, significant numbers of patients with an orthodontic treatment need are not able to access orthodontic health care services. A recent study by Christopherson *et al.* (2), with 1,566 socio-economically disadvantaged 8- to 11-year-old preadolescents, showed that based on orthodontic treatment need assessments with the Index of Orthodontic Treatment Need (IOTN) (4), over 17 percent of these respondents required or greatly required orthodontic treatment; also, based on the aesthetic component of the IOTN, 16.7 percent had a definite treatment need. Given that these and other socio-economically disadvantaged children and adults are not likely to receive orthodontic treatment, it is interesting to reflect what the psychosocial consequences of this lack of

orthodontic treatment in children in general might be. In particular, it would be interesting to assess whether malocclusion affects these patients' smile-related quality of life (QoL) and their actual smiling patterns as well as their parents' perceptions of their child's smile. This study therefore explores whether there is a relationship between the pediatric patients' objectively determined complexity of orthodontic treatment need, the self-perceptions of their smiles – assessed as their smile-related QoL – and their actual objectively assessed smiling patterns. In addition, it is of interest to determine whether there is a relationship between malocclusion, the children's smile-related QoL and objective smiling patterns, and the parents' proxy perceptions of their child's smile-related QoL as well as the parents' own assessments of their child's smile.

Analyzing how orthodontic treatment need relates to children's oral health-related QoL (OHRQoL) is a quite timely topic as OHRQoL is a term that has received increasingly more attention over the past decade (4). OHRQoL can be defined as that part of a person's QoL that is affected by oral health. Four aspects of a person's OHRQoL can be differentiated, namely how oral health affects a person's functioning (such as speaking, biting, and chewing), experiences of pain/discomfort, and a person's psychological state and social relationships. Research showed that orthodontic patients' OHRQoL is on one hand correlated with their orthodontic treatment need (2,3), and on the other hand is also affected by their orthodontic treatment (5,6). However, it could also be interesting to explore whether patients' own assessment of their smile-related QoL is also correlated with other persons' perceptions of their QoL and the attractiveness of their smile. This study therefore includes parent responses to explore these issues further. Parents are asked to first assess their child's OHRQoL. These proxy assessments of children's OHRQoL have been used widely as assessments of children's OHRQoL (7,8). Although research showed that there are significant relationships between children's and parents' ratings of the child's OHRQoL, it is important to note that Zhang and colleagues showed that parents were not able to correctly identify their child's oral health status and that there were considerable differences between their perceptions and their children's perceptions (6). This study therefore explores the relationship between patients' own smile-related OHRQoL assessments and their parents' proxy assessments of their child's smile-related OHRQoL as well as the parents' own assessments of their child's smile.

In addition, the relationships between these subjective responses and the objectively determined orthodontic treatment need will be explored as well. Research showed that malocclusion can have a clear impact on a person's QoL (9). A cross-sectional study compared children with and without malocclusion, and showed that malocclusion affected adolescents' OHRQoL in a negative manner (10). After orthodontic treatment, patients tended to have better OHRQoL than adolescents who never had orthodontic treatment or who were currently in treatment (11). Research even demonstrated that the severity of malocclusion clearly affected patients' QoL (12). In addition, school-aged children's self-perceptions also depended on their orthodontic treatment need: children with a definite treatment need rated their smile as worse than children who had no need or who had a borderline need for treatment (1,2,13). The acknowledgment of malocclusion by children themselves or by parents may be a motivating factor for receiving orthodontic treatment (14). Overall, these findings point to the significance of investigating the relationship between objectively determined malocclusion and patients' self perceptions.

Malocclusion also affects other persons' evaluations of a patient's facial attractiveness (9). A comparison of patient profiles with Class I, Class II, and Class III malocclusion found that those patients who had a more straight face were perceived by others as being more attractive (15). In one study, parents felt even more strongly than the child patients themselves that malocclusion affected their child's self-image, oral function, and social life (16). Based on this prior research, it will be interesting to assess how the patients' objectively assessed orthodontic treatment need correlates with a) their parents' proxy assessments of their child's OHRQoL; and b) the parents' own ratings of their child's smile.

In addition to analyzing the relationship between orthodontic treatment need and patients' and parents' smile-related QoL assessments, it is also interesting to reflect whether the child's actual smiling pattern is affected by their malocclusion. Prior research showed that patients' smiling patterns were significantly correlated with their oral health. In 2007, Patel *et al*. found that there was a significant negative correlation between a child's oral health status and a child's smiling pattern (17). For example, children without caries revealed more teeth while smiling than children with caries. In 2008, Patel *et al*. demonstrated that there was a relationship between adult patients' periodontal health and their smiling patterns (18). Both studies by Patel *et al*. also showed that patients' own OHRQoL was correlated with their objectively assessed smiling patterns. This study will therefore explore whether there is a relationship among pediatric patients' orthodontic treatment need and their own smile-related QoL, their parents' proxy assessments of their child's OHRQoL, and their own assessments of their child's smile as well as the child's objectively determined smiling patterns. The fact that the complexity of the children's orthodontic treatment need was determined objectively and that their smiling patterns were determined objectively offers a first opportunity to analyze the way children's own smile-related and OHRQoL assessments as well as their parents' proxy and own assessments are related to these objectively determined factors.

Methods and materials

This study was approved by the Institutional Review Board for the Health Sciences at the University of Michigan, USA (HUM#000017684).

Respondents

Survey data were collected from a convenience sample of 102 dental patients (53 male/49 female; average age, 10.85 years; age range, 9 to 13 years) and their parents who came for regularly scheduled pediatric appointments to a university-based dental clinic. The statistical program package G*Power 3.1.2 (19) was used to compute the required sample size needed to test for a significant correlation of $r = 0.25$ with alpha = 0.05, Power being 0.80, and a correlation of $r = 0.0$ for the null hypothesis. This sample size was $n = 97$. Two orthodontic care providers conducted oral health screening exams and assessed the pediatric patients' need for orthodontic treatment with the Index of Complexity, Outcome and Need (ICON) (20). The pediatric patients' objective smiling patterns were assessed with the help of videotapes that were rated by two independent raters.

Procedure

Parents and pediatric patients were recruited to participate in this study when they arrived for a regularly scheduled appointment in a pediatric dental clinic. Parents and patients responded to self-administered surveys. The children's orthodontic treatment need was then assessed with the ICON (20). The children's smiling patterns were measured by videotaping their smiles while they watched a 6.5-minute long section of a "Bugs Bunny" cartoon. The parents received free parking for their participation in the study.

Materials

Pediatric patients' pain and function-related and smile-related QoL was assessed with the Michigan Oral Health-related Quality of Life (MOHRQoL) Scale – Child Version (21). This scale consists of 14 items with a simple "yes/no" answer format. The wording of the items is included in Table 1. In order to create the pain and function QoL index, one point for every "yes" response to the six items a to f (see Table 1) were added. A score of "0" therefore indicates the best possible pain and function QoL score, and a score of "6" indicates the poorest score. The Smile-related QoL Index was computed by adding one point for every "yes" response to the eight items g to n, after the responses to items g through k had been recoded because they were formulated in the opposite direction from items l through n. In addition, an overall QoL index was computed by adding the values of the two sub indices.

The parents' proxy assessment of their child's OHRQoL was measured with the MOHRQoL Scale – Parent Version (21). The wording of these questions is included in Table 2. This scale consists of 11 items in a Likert-style format. The parents indicated on a five-point answer scale ranging from 1 = "disagree strongly" to 5 = "agree strongly" how much they agreed with the statements. Again, a pain and function index was computed. This parental pain and function index was computed by averaging the responses to items a to f (see Table 2). The scores could therefore range from "1" = "best QoL" to "5" = "worst QoL." The proxy smile-related index was computed by averaging the responses to the items g through i after items h and i had been recoded. A third sub-index referred to as Consequences-related QoL index was computed by averaging the responses to items j and k. Finally, the proxy Overall QoL index was computed by averaging the answers to all 11 questions. In addition, the parents indicated their own assessment of the attractiveness of their child's smile by choosing descriptors from a list with four positive and five negative adjectives, and by responding to three additional items. These items had been originally developed and used by Patel *et al.* (17). Three indices based on these responses were included. The first index was the number of positive adjectives chosen to describe the child's smile. The second index was the number of negative adjectives chosen, and the third index was the average of the responses to three items that asked the parents to rate how much the child's occlusion status affected their child's smile.

The assessment of the patients' orthodontic treatment need was determined with ICON (20). This index does not provide any information about the type of malocclusion a patient has. Instead it provides one measure that assesses the complexity of a patient's malocclusion and need for treatment. This variable can be categorized (see Table 1 for example), but is actually a continuous variable. The ICON is constructed by assessing a child's malocclusion indicators concerning: a) aesthetics; b) maxillary crowding; c) cross bite; d) overbite; e) overjet; and (f) buccal segment. The total score is computed into a combined ICON Index by weighting the single indicators according to the instructions given by Daniels and Richmond (20) and then averaging the scores. In addition to this combined ICON, an aesthetic score is determined by having the provider compare the patient's occlusion status with 10 photos that range from a perfect occlusion depicted in the first photo to a person with the highest complexity of malocclusion presented in the tenth photo. The provider chooses the photo that most resembles the child patient's occlusion status. This aesthetic score was included as a measure of subjective aesthetic judgment of the degree to which a patient has an orthodontic treatment need. In order

Table 1 Overview of Malocclusion Findings and Patients' Smile-Related Quality of Life Responses

Malocclusion scores	Percentage of responses
Aesthetic component:	
No treatment need (Scores 1 to 4)	39.4%
Borderline need (Scores 5 to 7)	53.6%
Definite need (Scores 8 to 10)	7%
ICON combined score:	
No treatment need (Scores <31)	18.2%
Borderline need (Scores 31 to 43)	38.4%
Definite need (Scores > 43)	43.4%
Patients' oral health-related quality of life scores	% YES
Pain and function responses	
a. Do your teeth hurt you now?	8.8%
b. Do your teeth hurt when you eat something hot or cold?	38.6%
c. Do your teeth hurt when you eat something sweet?	10.9%
d. Does a toothache wake you up at night?	7.9%
e. Does a hurting tooth stop you from what you are doing?	21.8%
f. Is it hard for you to chew and bite?	14%
Pain and function index*	Average sum = 1.03
Smile-related quality of life responses	% YES
g. Do you like your teeth? (recoded)	86.1%
h. Do you like the appearance of your teeth? (recoded)	57.4%
i. Are you happy with your teeth and smile? (recoded)	81.2%
j. Do you have a nice smile? (recoded)	87.1%
k. Do you show your teeth when you smile? (recoded)	71%
l. Do other people or kids make fun of your teeth?	6%
m. Do you want braces to straighten your teeth?	68.3%
n. Would you like to have braces?	66.3%
Smile-related index†	Average sum = 2.59
Overall quality of life index‡	Average sum = 3.63

* The pain and function related index was computed by adding "1" point for each "Yes" response to items a to f.

† The smile related index was computed by adding "1" point for a "No" response to items g to k and for a "Yes" response to items l to n.

‡ The total OHRQoL index is the sum of the two sub indices.

to determine whether the orthodontic treatment need was assessed in a reliable fashion by the two providers, the ICON scores of 21 subjects were assessed by both raters. The comparison of the measurements of the two raters showed that there was a high inter-rater consistency (aesthetic assessment: $r = 0.96$; total score: $r = 0.97$).

The patients' smiling patterns were assessed while the patients watched a 6.5-minute-long segment of a "Bugs Bunny" movie. A part of these patient recordings that began 5 seconds before a particularly funny sequence of the movie started and that lasted for 2 minutes and 30 seconds was transferred to a hard drive connected to a computer. A compact disk was burned with the movie files. Two raters were asked to watch these compact disks independently and to measure each patient's smile at 30 specific time points after it began. These 30 measurements were spaced every 5 seconds from the time the funny sequence started. For each measurement point, the raters measured the opening/height of the patient's mouth in millimeter and the number of teeth shown. These indicators were chosen based on considerations concerning the measurement of facial expressions (22). The average "mouth opening/height" scores and the average scores for the "number of teeth shown" were determined for each patient based on the 30 ratings for each rater separately. The inter-rater reliability for "height" was $r = 0.98$, and for the "number of teeth shown" it was $r = 0.99$. The scores of the two raters were therefore averaged, and the average ratings were used as indicators of the patients' smiling patterns.

Statistical methods

The data were analyzed with SPSS (Version 17.0) (23). Descriptive statistics were used to provide information about the distribution of responses and Pearson correlation coefficients were computed between the different constructs of interest to test for the predicted relationships.

Results

Five sets of data were collected in this study. First, the patients' objectively assessed orthodontic treatment need was determined with the ICON (20). This index consists of an aesthetic

Table 2 Overview of the Parent Responses

Parents' OHRQoL proxy assessment	1 and 2 (%)*	3 (%)	4 and 5 (%)	Mean
Pain and function related QoL:				
a. My child has difficulty chewing.	88.2	6.9	4.9	1.46
b. My child has difficulty biting hard.	88.3	6.9	4.9	1.48
c. My child's teeth are sensitive to hot or cold.	74.5	16.7	8.8	1.85
d. My child's teeth are sensitive to sweet food.	86.3	9.8	3.9	1.54
e. My child has a toothache or pain now.	89.2	2.9	7.8	1.44
f. My child complains about his / her teeth.	64.7	18.6	16.7	2.25
Pain and function index†	–	–	–	1.67
Smile-related QoL:				
g. The way my child's teeth look keeps my child from smiling happily.	64.7	18.6	16.6	2.04
h. My child is happy with his/her teeth. (recoded)	23.5	31.4	45.1	3.27
i. My child likes his / her smile. (recoded)	26.8	20.8	52.5	3.43
Smile-related index‡	–	–	–	2.46
Consequences-related QoL:				
j. My child's toothache keeps my child from sleeping through the night.	94.1	1.0	4.9	1.22
k. My child's toothache keeps my child from playing with other kids.	96.0	1.0	2.9	1.17
Consequences-related index¶	–	–	–	1.19
Overall QoL Index§	–	–	–	1.80
Parents' own responses				
How much do you think that your child's teeth affect the way your child smiles?	52.1	14.6	33.3	2.61
How much do you think the condition of your child's teeth affects the way your child feels about her/himself?	52.1	15.6	32.3	2.59
How much would you like to get braces for your child's teeth?	28.4	18.9	52.7	3.52
Parents' own response index•	–	–	–	2.89
Number of positive adjectives (happy/wide smile/shows teeth/open mouth)	–	–	–	2.06
Number of negative adjectives (reserved / hides teeth/hesitant/shy/closed mouth)	–	–	–	0.93

* Answers were given on a five-point scale ranging from 1 = "disagree strongly" to 5 = "agree strongly."

† Average response to items a to f.

‡ Average response to item g and recoded items h and i.

¶ Average response to items j and k.

§ Average response to items a to k.

• Answers were given on 5 point answer scales ranging from 1 = "not at all" to 5 = "very much."

OHRQoL, oral health-related quality of life; QoL, quality of life.

assessment, as well as an objective assessment of a patient's orthodontic treatment need which can be added to a combined continuous score. For the aesthetic assessment, the provider compares the patient's occlusion with 10 photos that range from a stable occlusion to a severe malocclusion. Table 1 shows that both the continuous aesthetic score as well as the continuous combined total score can be categorized to indicate which patients have no treatment need, a borderline treatment need and a definite treatment need. Based on the aesthetic ICON component, 39.4 percent of the patients did not require treatment, 53.6 percent were borderline, and 7 percent had a definite treatment need. Based on the categorized combined score which includes the aesthetic assessment, plus the objectively assessed criteria of malocclusion, 18.2 percent of the patients did not need treatment, while 38.4 percent were borderline, and 43.4 percent had a definite need for treatment. However, in all following analyses (see, for example, Tables 3 and 4), the continuous scores were used.

Second, the patients' OHRQoL was assessed with their responses to the Michigan Oral Health-Related Quality of Life (MOHRQoL) Scale (21). The 14 items of this scale were divided into six statements describing pain and function-related OHRQoL, and eight statements related to appearance/smile-related QoL (see Table 1). The responses to the six pain and function-related statements were combined to construct a pain and function QoL index. An analysis of the responses to the eight smile-related items showed that despite the fact that large percentages of children liked their teeth (86.1 percent) and thought they had a nice smile (87.1 percent), the majority of children wanted to have braces to straighten their teeth (68.3 percent), and wanted braces (66.3 percent). The responses were added up by adding one point each for responding "no" to items g through j, and one point each for responding "yes" to items k through n. The average sum score of the smile-related quality of life scores was 2.59, with the scores ranging from "0," the best OHRQoL, to "8," a very poor OHRQoL.

The third set of data was the parents' proxy assessments of their child's OHRQoL. In order to assess the parents' proxy assessment of their child's OHRQoL, they responded

Table 3 Correlations between Malocclusion Scores, Patient, and Parent Responses

	Malocclusion scores		Patient responses		
Patient responses	Aesthetic score	ICON combined score	Pain and function index	Smile-related index	Overall QoL
Pain and function index	0.03	0.02	–	0.02	0.50¶
Smile-related index	0.25†	0.23†	0.02	–	0.78¶
Overall QoL	0.25†	0.21†	0.50¶	0.78¶	–
Parent Responses					
Pain and function index	0.04	0.02	0.38¶	0.00	0.27‡
Smile-related index	0.29‡	0.26‡	0.01	0.28‡	0.24†
Consequences-related index	–0.02	–0.05	0.19*	–0.03	0.16
Overall QoL index	0.15	0.12	0.31‡	0.12	0.33¶
Parents' own response	0.32‡	0.29‡	0.06	0.36¶	0.33¶
Number of positive adjectives	–0.16	–0.16	–0.04	–0.19*	–0.21†
Number of negative adjectives	0.32‡	0.30‡	0.05	0.16	0.23†

* $P \leq 0.10$.
† $P \leq 0.05$.
‡ $P \leq 0.01$.
¶ $P = 0.001$.
ICON, Index of Complexity, Outcome, and Need; QoL, quality of life.

to the 11 items of the parent version of the MOHRQoL Scale (see Table 2). The average OHRQoL score was 1.80. Three statements were used to assess the parents' perceptions of their child's smile-related QoL. The responses showed that 16.6 percent of the parents agreed/strongly agreed with the statement "The way my child's teeth look keeps my child from smiling happily," while 23.5 percent disagreed/strongly disagreed with the statement "My child is happy with his/her teeth," and 26.8 percent also disagreed/strongly disagreed with the statement "My child likes his/her smile." Parental pain and function OHRQoL scores and consequences-related OHRQoL scores were computed as well (see Table 2).

Table 4 Correlations between Smile Indicators and the Patient and Provider Responses as well as the Orthodontic Treatment Need Assessment

Orthodontic treatment need assessment	Height	Number of teeth
Aesthetic assessment	0.02	0.00
ICON combined score	0.01	–0.03
Patient responses:		
Pain and function index	–0.02	–0.07
Smile-related index	–0.23†	–0.29†
Overall quality of life index	–0.21†	–0.22*
Parent responses:		
Pain and function index	0.16	0.02
Smile-related index	–0.06	–0.03
Consequences-related index	0.24†	0.02
Overall QoL index	0.13	0.00
Parents own response index	–0.02	0.06
Number of positive adjectives	0.09	–0.03
Number of negative adjectives	–0.10	–0.01

* $P \leq 0.10$.
† $P \leq 0.05$.
ICON, Index of Complexity, Outcome, and Need; QoL, quality of life.

The fourth type of data collected were the parents' own responses concerning their child's smile. Approximately one-third of the parents thought that their child's teeth affected the way their child smiled (33.3 percent), and that the condition of their child's teeth affected the way their child felt about him/herself (32.3 percent). Over half of the parents wanted braces for their child (52.7 percent). In addition to the responses to the three rating scale items, the parents were also asked to select descriptors of their child's smile from a list of four positive terms ("happy," "wide smile," "shows teeth," and "open mouth") and five negative terms ("reserved," "hides teeth," "hesitant," "shy," and "closed mouth"). The parents chose on average 2.06 positive and 0.93 negative items to describe their child's smile.

Table 3 presents the correlations between the pediatric patients' need for orthodontic treatment, their OHRQoL responses, and their parents' responses. The patients' smile-related QoL indices as well as their overall QoL scores were significantly correlated with the aesthetic component of the ICON ($r = 0.25$; $P = 0.014/r = 0.25$; $P = 0.013$) and with the combined ICON score ($r = 0.23$; $P = 0.024/r = 0.21$; $P = 0.042$). In addition, the parents' proxy assessments of their child's smile-related QoL, their own response to their child's smile, and the number of negative adjectives chosen to describe their child's smile were correlated with the aesthetic ICON scores ($r = 0.29$; $P = 0.004/r = 0.32$; $P = 0.002/r = 0.32$; $P = 0.002$) and the total score ($r = 0.26$; $P = 0.009/r = 0.29$; $P = 0.005/r = 0.30$, $P = 0.004$). These results showed that children's and parents' assessments of the children's smile-related QoL were correlated with the objectively assessed orthodontic treatment need, namely the ICON scores. As

expected, the aesthetic and the combined ICON scores did not correlate with the patients' and the parents' pain and function scores.

The results also showed that the child and parent overall QoL responses ($r = 0.33$; $P = 0.001$), as well as their pain and function indices ($r = 0.31$; $P = 0.002$) and their smile-related scores ($r = 0.28$; $P = 0.005$) were correlated as well. These correlations support the assumption that parents' proxy assessments of their children's OHRQoL are valid indicators of their children's OHRQoL. In addition, the parents' own responses to their child's smile correlated significantly with the children's smile-related index ($r = 0.36$; $P < .001$), and the number of negative adjectives that parents chose to describe their child's smile correlated significantly with the child's overall QoL ($r = 0.23$; $P = 0.025$).

The fifth set of data was the objectively assessed smile indicators. Table 4 shows that the children's smile-related QoL index correlated significantly with the height of the children's smiles ($r = -0.23$; $P = 0.024$) and the number of teeth shown ($r = -0.29$, $P = 0.022$). The poorer the children's smile-related QoL was, the lower the height of their smiles and the fewer teeth they showed. In addition, the overall QoL index was also correlated with the height of their smiles ($r = -0.21$; $P = 0.043$). However, the height of the children's smiles and the number of teeth they showed when they smiled did not correlate with their parents' proxy assessment of their child's smile-related QoL nor with the parents' own responses concerning their child's smile. In addition, the smiling patterns also did not correlate with the ICON scores. In summary, smiling patterns were correlated with the children's own subjective assessments of the attractiveness of their smiles, but they were not correlated with the objectively assessed need for orthodontic treatment, or with the parents' assessments of the patients' smiles.

Discussion

These data showed again that significant percentages of children have an orthodontic treatment need – which in many cases might not result in the treatment needed to correct their malocclusion (24). Findings so far showed that malocclusions can affect patients' lives because they can be quite conspicuous and therefore can have negative social reactions (25-28), which in turn can affect patients' self-esteem and eventually even their behavior (29). Longitudinal research over 15 years even documented that the negative effects of malocclusion continued from adolescence into adulthood (30). However, no research explored so far how malocclusion might affect the objective smiling patterns and smile-related QoL. These findings provide some insights into these issues. First, they showed that the orthodontists' aesthetic assessments of a child's orthodontic treatment and the ICON scores correlated with the children's own smile-related QoL scores. Children between the ages of 9 and 13 years are apparently aware of the attractiveness of their smiles. These results support findings from earlier studies (2,3) that showed that even pediatric dental patients as young as 9 years of age were able to assess their smile-related QoL in a valid way.

Second, the findings also showed that the parents' assessment of their child's smile-related QoL also correlated significantly with the child's objective treatment need. These findings provided further support for the fact that parents can make valid proxy assessments of their child's smile-related QoL. They also point to the fact that others can perceive a child's orthodontic treatment need and how it might affect the child's QoL. This finding is interesting because it points to the fact that although parents might not be able to correctly identify their child's oral health status per se [see for example the findings by Zhang *et al.* (6)], they are aware of one specific aspect of their child's oral health, namely whether their child had a malocclusion and an orthodontic treatment need. Third, as predicted, the children's and the parents' smile-related indices correlated significantly. These findings support the results of earlier studies (8) which showed that parents can indeed validly assess their children's OHRQoL.

The data also showed that the children's smile-related QoL responses correlated significantly with the aesthetic component of the ICON and the combined ICON score (see Table 4). It is important to note that the combined ICON score (20) is computed by weighting the single assessed components and then combining them to one score. The orthodontist's classification of a patient's aesthetics is weighted by a factor of seven, which is the highest weighted part in the formula used to compute the ICON score. The fact that the children's self-perceptions correlated with the orthodontist's aesthetic assessment adds further value to the assumption that even young patients can have a basic awareness of their orthodontic treatment need. In the study by Christopherson *et al.*, pediatric residents' recommendations for orthodontic treatment had a significant relationship with the objective and subjective assessment of treatment need. Malocclusion indicators also correlated with patients' self-perceptions as well as their desire for braces. This desire for braces also correlated with the children's smile-related QoL (3). These findings that there are clear relationships between objective orthodontic treatment need and preadolescents' own smile-related QoL assessments and their desire to have braces should be considered in the context of a lack of orthodontic care for significant numbers of socio-economically disadvantaged adolescents and adults in the United States (24).

In addition, the findings that the parents' proxy assessments of their child's smile-related QoL, the parents' own assessments of their child's smile, and the number of negative adjectives chosen by the parents to describe their child's smile were all correlated with the aesthetic component of the ICON

and the combined ICON score, underscored the fact that parents can have a valid sense of awareness of their child's orthodontic treatment need. Communication with the parents about treatment recommendations can therefore build on the parents' basic understanding of the situation.

Ultimately, the most interesting question concerning these findings might be whether the children's actual smiling patterns, namely how openly they smile and how many teeth they show when they smile, are related to the self-perceptions of their smiles, their parents' perceptions, as well as their orthodontic treatment need. It was expected that a person's smiling pattern would be affected by their malocclusion. Given that previous studies had shown that children's smiling patterns were affected by their oral health, especially the degree to which they had caries (17), and that adults' smiling patterns were affected by their periodontal health (18), it is interesting to explore how malocclusion might affect smiling patterns. The data showed that orthodontists' assessments of a child's orthodontic treatment need did NOT correlate with the children's smiling pattern. However, the more the children themselves reported that their smile-related QoL was impaired, the less openly they smiled. This finding is interesting because it points to the significance of understanding that a certain sense of self-consciousness concerning one's malocclusion might determine whether one's smile is affected. It is possible that younger children might not have this sense of self-consciousness (1), but that older teenagers and adults might be much more aware of their malocclusion and thus, might be more likely to show clear relationships between objective indicators of orthodontic treatment need and smiling patterns. Future research needs to explore this hypothesis.

In addition to the limitation that this study was not designed to explore age effects or effects of other demographic factors such as gender, it is also important to note that this study merely explored the multiple relationships between the concepts of interest without correcting for multiple correlations.

In summary, no research so far assessed both children's orthodontic treatment need as well as their actual smiling patterns objectively, and then analyzed the relationship of these two factors with children's and parents' perceptions of their child's QoL. Gaining a better understanding of these relationships will hopefully alert policy makers and clinicians alike to consider the importance of malocclusion for children's QoL and the way that the children's experienced smile-related QoL affects the way they smile and thus ultimately their social interactions.

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