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Associations between oral health impacts attributed to malocclusion and normative and self-perceived orthodontic treatment need in Turkish adolescent patients

Asuman Deniz Gümrü Çelikel[1*], Muhsin Çifter[1], Beyza Tağrikulu[1] and Kadriye Peker[2]

Abstract

Background In the socio-dental approach, the integration of normative oral health-related quality of life (OHRQoL) and behavioral propensity measures should be considered when assessing treatment needs and planning oral services. Therefore, this study aimed to evaluate the relationship between oral health impacts attributed to malocclusion and normative and self-perceived orthodontic treatment needs in adolescent patients and to determine the clinical, sociodemographic, and behavioral factors affecting their OHRQoL.

Methods This cross-sectional study was conducted using a convenience sample size of 105 adolescent patients aged 11–14 years who were referred to the Orthodontics Clinic in the Faculty of Dentistry, Istanbul. Data were collected using clinical examinations and a self-reported questionnaire, including the condition-specific Child Oral Impact on Daily Performances (CS-COIDP) attributed to malocclusion and sociodemographic, clinical, and behavioral factors. The index of complexity, outcome, and need (ICON), gingival index, and Decayed, Missing, Filled Teeth index was used to assess oral health status. Descriptive statistics and bivariate and multivariate regression analyses were used for the data analyses.

Results A total of 70 patients (66.7%) reported at least one impact. Furthermore, 47% of the adolescents had very difficult and difficult complexity grades. The most affected performances were "emotional (52.4%) and smiling (40%)". No significant differences were found in the total CS-COIDP scores according to caries experience; however, the gingival status was associated with the total OHRQoL. Lower tooth brushing frequency, increased malocclusion complexity, and subjective treatment need were the most important predictors of worse OHRQoL, accounting for 39.3% of the variance in the scores. ($R^2 = 0.422$; $p < 0.001$)

Conclusions Oral health professionals should consider oral behaviors, malocclusion complexity, and subjective treatment need when planning orthodontic treatment plans. Integrating ICON, CS-COIDP, and behavioral assessment will help identify adolescents who should be prioritized for treatment.

*Correspondence:
Asuman Deniz Gümrü Çelikel
denizgmr@istanbul.edu.tr
[1]Faculty of Dentistry, Department of Orthodontics, Istanbul University, Istanbul, Turkey
[2]Faculty of Dentistry, Department of Basic Medical Science, Istanbul University, Istanbul, Turkey

Introduction

As a framework, a socio-dental approach for assessing children's orthodontic treatment needs and outcomes is recommended because normative orthodontic treatment needs do not reflect children's perceptions of their dental appearance and oral functions or their impacts on their life [1–3]. Therefore, the integration of normative oral health-related quality of life (OHRQoL) and behavioral propensity measures (such as oral hygiene and dental attendance) is important for assessing orthodontic needs, planning oral services, and increasing the success and effectiveness of orthodontic treatment [1]. Oral health-related quality of life (OHRQoL) has become an important metric in assessing the impact of oral health on overall well-being. In recent studies, oral health-related quality of life (OHRQoL) is widely measured due to its great importance and reliability in many different patient groups with oral diseases (e, g. dental carries, periodontal and oral mucosal diseases), and systemic diseases (e.g. diabetes and congenital heart anomalies) [4–6].

OHRQoL measures and clinical indices are necessary for diagnosis and treatment planning in evidence-based patient-centered care [7, 8]. Among the existing OHRQoL measures, the Child-Oral Impacts on Daily Performance (C-OIDP) allows the evaluation of condition-specific oral impacts attributed to specific diseases [9]. C-OIDP and condition-specific C-OIDP (CS-COIDP) have been widely used in the general and school-based adolescent population [10]. To our knowledge, only two studies have used the CS-COIDP index attributed to malocclusion in adolescents [11, 12].

Orthodontists should be aware of their patients' OHRQoL and their expectations for improvements in specific domains of OHRQoL [13]. In addition, assessing orthodontic treatment needs and complexity using an occlusal orthodontic index is necessary for planning orthodontic services for any specific population [14].

Recent evidence on the relationship between malocclusion and OHRQoL among adolescents has shown that adolescents with severe malocclusion may have worse OHRQoL, especially in the psychological domain. The strength of this relationship may be influenced by age, culture, and living environment [15–17]. In children and adolescents, self-perceived malocclusion may be impacted by dental aesthetics, psychological state, and daily social activities [18, 19].

In Turkey, the index of complexity, outcome, and need (ICON) scores ≥ 0.43 are used as a cut-off by the Social Security Institution to determine the orthodontic treatment needs of individuals aged <18 years and to enable them to receive free treatment at public oral care institutions [20]. As a multifunctional, simple, user-friendly, reliable, and valid index, ICON has significant advantages over orthodontic treatment need indices because it can assess the complexity of malocclusion and the treatment need [14, 21].

There are few studies in the literature examining the relationship between orthodontic treatment need and OHRQoL in Turkish adolescent patients [22–26]; however, there are no published studies on the need for orthodontic treatment, condition-specific impacts, and their severity on separate daily performances in Turkish adolescent patients using the ICON and CS-COIDP. As a main study strength, the results of this study will provide valuable insight into the integration of OHRQoL measures in assessing oral health needs of orthodontic patients. In addition, this study provides a novel perspective to determining the patient's oral health needs according to the socio-dentistry approach, analyzing condition-specific oral effects in a specific population, planning orthodontic care services, and evaluating comprehensive need assessment for oral health professionals [1, 2, 27].

Therefore, this study aimed to evaluate the relationship between malocclusion-induced oral impacts and normative and self-perceived orthodontic treatment needs and to determine the clinical, sociodemographic, and behavioral factors affecting adolescent patients' OHRQoL.

Materials and methods

Participants

This cross-sectional study included 105 consecutive patients aged 11–14 years who were referred to the Department of Orthodontics, Faculty of Dentistry, Istanbul University, between February 2014 and March 2015. To the best of our knowledge, no study has examined the association between ICON and CS-COIDP scores in Turkey. Therefore, a pilot study was performed in a group of 32 patients seeking orthodontic treatment, taking into account the general rule of thumb to recruit at least 30 participants or higher for parameter estimation [28, 29]. The minimum required sample size was determined to be 94 using an online sample size calculator for correlation studies, with a correlation coefficient of 0.30 between the ICON and CS-COIDP scores obtained from the pilot study with a power of 80%, a significance level of 0.05, and a 10% dropout rate [30]. Pilot study participants were not included in the main study. The inclusion criteria were, no history of previous and undergoing any orthodontic treatment, a consent form signed by parents, age 11–14, Turkish literacy, and mental and psychomotor skills. Exclusion criteria were, having any psychiatric disorder, neurological disease, intellectual disabilities, systemic disease, visual and hearing impairments, high caries activity, an active disease affecting the periodontium, cleft lip and palate, need for orthognathic surgery, and congenitally missing teeth.

Procedure

This study was approved by the Clinical Research Ethics Committee of the Istanbul Faculty of Medicine (No. 2014/274) and was conducted according to the principles of the Declaration of Helsinki. Written parental informed consent and adolescent assent were obtained from all participants.

Data were collected using clinical examinations and self-reported questionnaires. To overcome social desirability bias, MÇ explained the study purpose and assured voluntary participation, the anonymity and confidentiality of participants [31]. The self-reported questionnaire was administrated by MÇ in a waiting room before the oral examination. Their personal identifications remained anonymous, and the code numbers were used for obtaining the confidentiality.

Subsequently, clinical examinations were performed by DG in the examination room.

Measures

The self-reported questionnaire consisted of two parts. The following sociodemographic information about the adolescents and their parents was included in the first part: parents' sex (male vs. female), parents' educational level (≤8 years vs. >8 years) [32], family monthly income (Turkish Lira, TL), adolescents' age (years), and adolescents' sex (male vs. female).

The second part consisted of questions regarding self-perceived treatment needs, oral health behaviors, and the Turkish version of the C-OIDP index.

Self-perceived need for orthodontic treatment was assessed using the question "Do you need orthodontic treatment?" on a 3-point response scale (yes/no/do not know) [33]. For data analysis, responses were classified into two groups (yes vs. no/do not know).

In this study, the following oral health behaviors of adolescents were assessed and dichotomized: the frequency of tooth brushing (≥twice a day vs. ≤ once a day) [34], use of dental floss (use vs. do not use) [35], dental visiting pattern (regular dental check-up at least once a year vs. symptom-oriented) [36], and daily between-meal frequency of sugar intake (<thrice daily vs. ≥ thrice daily) [37].

Adolescents' OHRQoL was assessed using the Turkish version of the C-OIDP index [37]. The C-OIDP index developed by Gherunpong et al. [38] consists of 17 oral health problems and eight daily performances: eating, speaking, cleaning the mouth, relaxing, smiling, studying, emotion, and social contact. To calculate the malocclusion-induced condition-specific C-OIDP, oral impacts associated with "bad position of teeth," "space between teeth," and "deformity of mouth or face" were considered in the analysis. Each performance score was estimated by multiplying the corresponding frequency (range, 1–3) and severity (range, 1–3) scores. The total CS-COIDP score is the sum of the eight performance scores (ranging from 0 to 72) multiplied by 100 and divided by 72 [39]. The prevalence of oral impact was calculated as the percentage of adolescents with a CS-COIDP score>0. The intensity of impact in adolescents with reported impacts based on each performance score was classified into five levels: very little (1), little (2), moderate (3–4), severe (6), and very severe (9) [39].

ICON index was used to evaluate treatment needs, outcomes, and complexity. ICON index consists of five components: an aesthetic component, dental arch crowding or spacing assessment, presence of crossbite, degree of incisor overbite or open-bite, and antero-posterior relationship in buccal segments. Occlusal anomalies are scored, then all scores are summed to have a final score. Normative treatment need was determined according to the recommended cutoff criteria (≤43 [No]; > 43 [Yes]), and orthodontic complexity was categorized into five grades (<29 [easy], 29–50 [mild], 51–63 [moderate], 64–77 [difficult], and >77 [very difficult]) [40]. Adolescents were classified into two groups according to caries experience (dmft+DMFT=0 vs. DMFT+dmft≥1) [41, 42]. Gingival health status was evaluated using the Gingival Index (GI), and adolescents were categorized into two groups (GI≤1 vs. GI>1) [43].

Statistical analyses

Descriptive statistics and bivariate and multivariate linear regression analyses were used to analyze the data. The normality of the data was tested using the Kolmogorov–Smirnov test. The internal consistency of the CS-COIDP was assessed using Cronbach's alpha coefficient. The Mann–Whitney U and Kruskal–Wallis tests were used to determine intergroup differences. The Dunn test with Bonferroni correction for pairwise comparisons and Spearman's correlation coefficients for categorical data and continuous variables with non-normal distribution were used. A chi-squared test was used to determine the association between normative and perceived orthodontic needs. The correlation coefficients were interpreted as follows: $r \leq 0.49$, weak relationship; $0.50 \leq r \leq 0.74$, moderate relationship; and $r \geq 0.75$, strong relationship [44]. Multiple linear regression analysis with backward elimination was performed to identify significant predictors of adolescents' OHRQoL. All variables were included in the final multivariable models if their corresponding p-value was ≤0.05. The total CS-COIDP score was the dependent variable. After reviewing the published literatures [1, 12, 45, 46], the factors affecting the oral health related quality of life of orthodontic patients including child's gender and age, education levels of mother and father, caregivers' gender, caries experience, gingival health status, monthly income, ICON treatment need, ICON complexity grade

scores, dental attendance pattern, use of dental floss, daily sugar intake, the frequency of tooth brushing, self-perceived treatment need were included in the analysis as independent variables. Among these independent variables, monthly income and ICON complexity grade scores were entered as continuous variables in the model. The R^2 statistic was used to determine the proportion of the variance caused by the predictors. Standardized β coefficients were calculated for all variables. The tolerance value < 0.10 and/or variance inflation factors (VIF) test > 10 was used as cut-off values to detect multicollinearity among the variables [47]. In addition, a post hoc power analysis for linear regression was conducted to obtain information about the reliability and reproducibility of statistical findings and to examine the study effect sizes [48]. A post-hoc power analysis for multiple linear regression was conducted using 105 patients, a significance level of 0.05, and 15 tested predictors via online statistical calculator [49]. Additionally, Cohen's effect size (f^2) for multiple regression was estimated using the following formula $f^2 = R^2 / 1 - R^2$. According to Cohen's guideline, $f^2 \geq 0.02$, $f^2 \geq 0.15$, and $f^2 \geq 0.35$ were interpreted as small, medium, and large effect size [50]. Data were analyzed using IBM SPSS version 23 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

Table 1 Sociodemographic, clinical, and behavioral characteristics of adolescents and their parents

Characteristics	Parameters	*n* (%)
Child's gender	Male	44 (41.9)
	Female	61 (58.1)
Age (years), mean ± SD		12.51 ± 1.15
Mothers' level of education	≤ 8 years (*n* = 49)	46.7
	> 8 years (*n* = 56)	53.3
Fathers' level of education	≤ 8 years (*n* = 32)	30.5
	> 8 years (*n* = 73)	69.5
Parent's gender	Female	74(70.5)
	Male	31(29.5)
Income		2953.80 ± 910.82
Caries experience	DMFT + dmft = 0	34 (32.4)
	DMFT + dmft ≥ 1	71 (67.6)
Gingival health status	GI ≤ 1	47 (44.8)
	GI > 1	58 (55.2)
ICON treatment need	No	35 (33.3)
	Yes	70 (66.7)
ICON complexity	Easy	8 (7.6)
	Mild	35 (33.3)
	Moderate	12 (11.4)
	Difficult	3 (2.9)
	Very difficult	47 (44.8)
Self-perceived treatment need	Yes	66(62.9)
	No	39(37.1)
Tooth brushing	≥ twice a day	52 (49.5)
	≤ once a day	53 (50.5)
Dental attendance	Regular dental check-up	34 (32.4)
	Symptom-oriented	71 (67.6)
Dental flossing	Use	14 (13.3)
	Don't use	91 (86.7)
Daily between meals frequency of sugar intake	≥ 3 a day	8 (7.6)
	< 3 a day	97 (92.4)
The CS-COIDP score, mean ± SD		9.48 ± 13.52

SD: standard deviation; CS-COIDP: Condition-specific child oral impact on Daily performances

Results

Of the 105 adolescents, 58.1% were female, 67.6% had caries experience, 55.2% experienced gingival bleeding, and 66.7% had normative treatment needs. The mean age of the adolescents was 12.51 (standard deviation [SD] = 7.64) years. In addition, 32.4% of the adolescents visited dentists for check-ups, 49.5% brushed their teeth ≥ twice daily, 7.6% consumed sugar-added products three or more times between meals, and 13.3% used dental floss. Among the parents, 70.5% were female. Furthermore, 46.7% and 30.5% of mothers and fathers, respectively, had a formal education attainment of ≤ 8 years. The mean monthly family income was TL 2953.80 ± 910.82 (or $ 1312 ± 404) (Table 1).

The mean CS-COIDP score was 9.48 (SD = 13.52). Furthermore, 47.7% of adolescents had very difficult and difficult complexity grades, 11.4% had a moderate grade, and 41.2% had a mild/easy grade (Table 1). Cronbach's alpha for the condition-specific C-OIDP was 0.73. A total of 70 adolescents (66.7%) reported at least one oral impact within the last 3 months. The most affected performances according to condition-specific impacts were "emotional (52.4%) and smiling (40%)," whereas the daily performances with the lowest impact were "relaxing (1%) and studying (1%)." Among children with impacts, 70% reported impacts of severe or very severe intensity in all domains except for relaxing and studying (Table 2).

In the total CS-COIDP and its domain scores, no significant differences were found in caregivers' and adolescents' sex ($p > 0.05$). The condition-specific C-OIDP scores for mouth-cleaning negatively correlated with adolescents' age (r=-0.203, $p < 0.05$) and income (r=-0.206, $p < 0.05$). Brushing > twice a day ($p < 0.001$) and dental floss use ($p = 0.025$) were associated with lower CS-COIDP total scores. Brushing ≥ twice daily was associated with lower scores in the eating, cleaning, speaking, emotional, and social contact domains, whereas symptom-oriented dental attendance pattern was associated with higher scores in the speaking, cleaning, emotional, and social contact domains ($p < 0.05$). Higher daily sugar consumption was associated with higher scores in the relaxing domain ($p < 0.001$; Table 3).

As seen Table 3, no significant differences were found in the total CS-COIDP and all domain scores according to caries experience ($p > 0.05$). Poor gingival status was

Table 2 Prevalence and intensity of malocclusion-induced impacts

Prevalence of impacts (*n* = 105)	**Eating *n* (%)**	**Speaking *n* (%)**	**Cleaning *n* (%)**	**Relaxing *n* (%)**	**Smiling *n* (%)**	**Emotional *n* (%)**	**Studying *n* (%)**	**Contact-people *n* (%)**
	10 (9.5)	**15(14.3)**	**17(16.2)**	**1(1)**	**42(40)**	**55(52.4)**	**1 (1)**	**13(12.4)**
Intensity of impacts (*n* = 70)	**Eating n (%)**	**Speaking n (%)**	**Cleaning n (%)**	**Relaxing n (%)**	**Smiling n (%)**	**Emotional n (%)**	**Studying n (%)**	**Contact-people n (%)**
Very little	0 (0)	5 (33.3)	6 (35.3)	1 (100)	10 (23.8)	13 (23.6)	1 (100)	5 (38.5)
Little	1 (10)	2 (13.3)	0 (0.0)	0 (0.0)	2 (4.8)	1 (1.8)	0 (0.0)	0 (0.0)
Moderate	4 (40)	4 (26.7)	10 (58.9)	0 (0.0)	18 (42.9)	17 (30.9)	0 (0.0)	5 (38.5)
Severe	0 (0)	0 (0.00)	0 (0.0)	0 (0.0)	1 (2.4)	2 (3.6)	0 (0.0)	0 (0.0)
Very severe	5 (50)	4 (26.7)	1(5.8)	0 (0.0)	11 (26.2)	22 (40.0)	0 (0.0)	3 (23.1)

associated with total and all domain CS-COIDP scores ($p<0.05$), except for eating, relaxing, and studying.

Orthodontic treatment complexity was significantly associated with the total CS-COIDP ($p<0.001$) and its four domain scores: speaking ($p<0.001$), cleaning ($p=0.002$), smiling ($p<0.001$), and emotional ($p<0.001$). In addition, the normative and subjective need for orthodontic treatment was associated with the total CS-COIDP and its speaking, cleaning, smiling, emotional, and social contact domains ($p<0.05$; Table 3).

Significant differences were found in the total CS-COIDP ($p<0.001$), speaking ($p<0.001$), cleaning ($p=0.002$), smiling ($p<0.001$), and emotional domain scores ($p<0.001$) according to malocclusion complexity.

Post hoc group comparisons revealed that adolescents with very difficult treatment grades had worse OHRQoL than those with easy and mild treatment grades in terms of the total CS-COIDP and its smiling and emotional domains ($p<0.05$).

Significant associations were found between normative and perceived orthodontic needs ($p<0.001$). We found a moderate positive correlation between the total CS-COIDP score and ICON complexity grade ($r=0.522$; $p<0.01$).

As shown in Table 4, the multiple linear regression analysis revealed that lower tooth brushing frequency (β=-0.294, $p<0.001$), increased malocclusion complexity grade (β=0.379, $p<0.001$), and subjective orthodontic treatment need (β=0.175, $p=0.043$) were the most important predictors of worse OHRQoL in adolescents, accounting for 42.2% of the variance in scores. (adjusted $R^2=0.393$; $p<0.001$). All tolerance values were higher than 0.33 and the VIF values were no higher than 2.98, indicating no multicollinearity in the model. With the sample size of 105 patients, the post- hoc power calculation for multiple linear regression analysis showed adequate power (power=99%) to detect an interaction and large effect size (f2=0.73).

Discussion

To the best of our knowledge, this is the first study to assess the association between oral health impacts attributed to malocclusion and normative and self-perceived orthodontic treatment needs in Turkish adolescent patients, considering the main elements of the socio-dental approach to orthodontic needs assessment.

In Turkey, ICON scores≥0.43 are used as a cut-off by the Social Security Institution to determine individuals aged<18 years who are eligible for treatment priority under state-funded orthodontic treatment [20].

In this study, we evaluated the OHRQoL and its related factors (normative need assessment, perceived treatment needs, oral health impacts, and propensity to adopt health-promoting behaviors) in the socio-dental approach to orthodontic needs assessment [2] among orthodontic-seeking patients.

The CS-COIDP index attributed to malocclusion was used in this study because of its better ability to differentiate groups [51].

In this study, 66.7% of adolescents reported at least one oral impact within the last 3 months. The most affected performances according to condition-specific impacts were emotional (52.4%) and smiling (40%). Consistent with our study, Wan Hassan et al. [12] found that the smiling activity had more impacts (50.8%), whereas the emotional activity had lower impacts (24.6%) in adolescents with normative needs. In addition, they reported that other domains had greater impacts in Malaysian adolescent patients. The differences in the reported oral impacts may have been caused by the study design. In this study, we estimated the prevalence of condition-specific oral impact among adolescent patients seeking orthodontic treatment. Additional studies are needed to evaluate the impacts among orthodontics-seeking patients with normative needs because reduced treatment need was observed when malocclusion-induced oral impacts were considered [1, 12, 52].

Our findings are consistent with those of previous studies on school-going adolescents and adolescent patients, suggesting that self-perceived malocclusion primarily affects daily psychological and social activities

Table 3 The relationships among the CS-COIDP, sociodemographic, and clinical factors

	CS-COIDP	Eating	Speaking	Cleaning	Relaxing	Smiling	Emotional	Studying	Contact-people
Child's gender[a]									
Male ($n=44$)	7.98 ± 12.88	0.29 ± 1.47	0.54 ± 1.91	0.45 ± 1.57	0.00 ± 0.00	1.45 ± 2.60	2.65 ± 3.38	0.00 ± 0.00	0.34 ± 1.47
Female ($n=61$)	10.56 ± 13.97	0.81 ± 2.36	0.60 ± 1.86	0.57 ± 1.35	0.01 ± 0.12	2.08 ± 3.12	2.88 ± 3.72	0.01 ± 0.12	0.60 ± 1.85
P value	0.313	0.144	0.773	0.526	0.396	0.385	0.843	0.396	0.376
Child's age (mean ± SD) (r)	-0.105	-0.007	0.038	**-0.203***	-0.042	0.084	-0.135	-0.042	0.010
Mothers' education level [a]									
≤ 8 years ($n=49$)	13.91 ± 16.78	0.91 ± 2.37	1.22 ± 2.60	0.77 ± 1.78	0.02 ± 0.14	2.16 ± 3.09	4.06 ± 3.93	0.00 ± 0.00	0.85 ± 2.31
> 8 years ($n=56$)	5.60 ± 8.19	0.32 ± 1.68	0.01 ± 0.13	0.30 ± 1.04	0.00 ± 0.00	1.51 ± 2.75	1.67 ± 2.80	0.01 ± 0.13	0.17 ± 0.76
P value	**0.009**	0.032	**< 0.001**	**0.036**	0.285	0.178	**0.001**	0.350	0.072
Fathers' education level [a]									
≤ 8 years ($n=32$)	14.58 ± 17.68	1.21 ± 2.80	1.28 ± 2.72	1.12 ± 2.12	0.03 ± 0.17	1.71 ± 2.83	4.15 ± 4.04	0.03 ± 0.17	0.93 ± 2.34
> 8 years ($n=73$)	7.24 ± 10.63	0.32 ± 1.55	0.27 ± 1.25	0.26 ± 0.92	0.00 ± 0.00	1.86 ± 2.97	2.19 ± 3.19	0.00 ± 0.00	0.30 ± 1.30
P value	0.079	**0.032**	**0.001**	**0.005**	0.131	0.956	**0.018**	0.131	**0.011**
Caregivers' gender [a]									
Female ($n=74$)	10.84 ± 14.75	0.70 ± 2.19	0.68 ± 1.97	0.55 ± 1.54	0.00 ± 0.00	2.05 ± 2.98	3.12 ± 3.63	0.00 ± 0.00	0.68 ± 1.99
Male ($n=31$)	6.22 ± 9.43	0.35 ± 1.64	0.32 ± 1.62	0.45 ± 1.20	0.03 ± 0.17	1.25 ± 2.70	2.00 ± 3.33	0.03 ± 0.17	0.03 ± 0.17
P value	0.179	0.473	0.142	0.961	0.122	0.289	0.120	0.122	0.060
Income (mean ± SD) (r)	-0.047	-0.062	-0.149	**-0.206***	-0.170	-0.160	0.017	0.162	0.056
Tooth brushing [a]									
≤ once a day ($n=53$)	14.59 ± 16.12	0.98 ± 2.54	1.05 ± 2.49	0.96 ± 1.87	0.01 ± 0.13	2.18 ± 3.10	4.37 ± 3.81	0.01 ± 0.13	0.90 ± 2.27
≥ twice a day ($n=52$)	4.27 ± 7.29	0.21 ± 1.27	0.09 ± 0.56	0.07 ± 0.55	0.00 ± 0.00	1.44 ± 2.69	1.17 ± 2.41	0.00 ± 0.00	0.07 ± 0.55
P value	**< 0.001**	**0.048**	**0.002**	**< 0.001**	0.322	0.083	**< 0.001**	0.322	**0.001**
Dental attendance [a]									
Regular ($n=34$)	6.04 ± 9.65	0.79 ± 2.59	0.26 ± 1.54	0.11 ± 0.68	0.00 ± 0.00	1.50 ± 2.59	1.55 ± 2.56	0.00 ± 0.00	0.11 ± 0.68
Symptom-oriented ($n=71$)	11.13 ± 14.81	0.50 ± 1.73	0.73 ± 2.00	0.71 ± 1.66	0.01 ± 0.11	1.97 ± 3.06	3.38 ± 3.84	0.01 ± 0.11	0.67 ± 1.99
P value	0.106	0.946	**0.027**	**0.012**	0.489	0.343	**0.030**	0.489	**0.045**
Dental flossing [a]									
Don't use ($n=91$)	10.45 ± 14.13	0.69 ± 2.18	0.64 ± 1.99	0.56 ± 1.49	0.01 ± 0.10	1.98 ± 3.04	3.04 ± 3.69	0.01 ± 0.10	0.57 ± 1.82
Use ($n=14$)	3.17 ± 5.51	0.00 ± 0.00	0.14 ± 0.53	0.28 ± 1.06	0.00 ± 0.00	0.71 ± 1.48	1.14 ± 1.99	0.00 ± 0.00	0.00 ± 0.00
P value	**0.025**	0.195	0.403	0.346	0.695	0.117	0.087	0.695	0.134
Daily sugar intake [a]									
≥ 3 a day ($n=8$)	3.99 ± 4.02	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 1.41	0.12 ± 0.35	1.00 ± 1.41	1.25 ± 2.37	0.00 ± 0.00	0.00 ± 0.00
< 3 a day ($n=97$)	9.93 ± 13.93	0.64 ± 2.12	0.62 ± 1.94	0.52 ± 1.45	0.00 ± 0.00	1.88 ± 3.00	2.91 ± 3.63	0.01 ± 0.10	0.53 ± 1.76
P value	0.541	0.343	0.234	0.806	**< 0.001**	1.00	0.136	0.774	0.272
ICON treatment need [a]									
No ($n=35$)	1.66 ± 2.81	0.25 ± 1.52	0.00 ± 0.00	0.02 ± 0.16	0.00 ± 0.00	0.37 ± 1.13	0.54 ± 1.17	0.00 ± 0.00	0.00 ± 0.00
Yes ($n=70$)	13.39 ± 15.01	0.77 ± 2.25	0.87 ± 2.24	0.77 ± 1.72	0.01 ± 0.11	2.54 ± 3.25	3.91 ± 3.83	0.01 ± 0.11	0.74 ± 2.04
P value	**< 0.001**	0.109	**0.003**	**0.008**	0.480	**< 0.001**	**< 0.001**	0.480	**0.007**
Self-perceived treatment need [a]									
Yes ($n=66$)	13.27 ± 15.27	0.81 ± 2.31	0.86 ± 2.27	0.81 ± 1.76	0.01 ± 0.12	2.39 ± 3.14	3.84 ± 3.90	0.01 ± 0.12	0.78 ± 2.10
No ($n=39$)	3.06 ± 5.86	0.23 ± 1.44	0.10 ± 0.64	0.02 ± 0.16	0.00 ± 0.00	0.84 ± 2.20	1.00 ± 1.87	0.00 ± 0.00	0.00 ± 0.00
P value	**< 0.001**	0.068	**0.009**	**0.003**	0.442	**0.002**	**0.001**	0.442	**0.003**
ICON complexity [b]									

Table 3 (continued)

	CS-COIDP	Eating	Speaking	Cleaning	Relaxing	Smiling	Emotional	Studying	Contact-people
Easy (A, *n* = 8)	0.17 ± 0.49	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.12 ± 0.35	0.00 ± 0.00	0.00 ± 0.00
Mild (B, *n* = 35)	2.53 ± 3.00	0.25 ± 1.52	0.00 ± 0.00	0.02 ± 0.16	0.00 ± 0.00	0.65 ± 1.41	0.82 ± 1.40	0.00 ± 0.00	0.05 ± 0.23
Moderate (C, *n* = 12)	4.51 ± 3.65	0.75 ± 2.59	0.00 ± 0.00	0.33 ± 1.15	0.08 ± 0.28	0.58 ± 1.16	1.50 ± 1.88	0.00 ± 0.00	0.00 ± 0.00
Difficult (D, *n* = 3)	16.20 ± 17.25	0.00 ± 0.00	0.00 ± 0.00	1.66 ± 2.08	0.00 ± 0.00	4.33 ± 4.50	4.33 ± 4.50	0.00 ± 0.00	1.33 ± 2.30
Very difficult (E,	17.08 ± 16.45	0.95 ± 2.41	1.29 ± 2.64	0.95 ± 1.92	0.00 ± 0.00	3.14 ± 3.51	4.93 ± 4.01	0.02 ± 0.14	0.97 ± 2.40
n = 47)	**< 0.001**	0.220	**< 0.001**	**0.002**	0.101	**< 0.001**	**< 0.001**	0.872	0.055
P value	A vs. E		B vs. E	B vs. E		A vs. E	A vs. E		
Post hoc group	B vs. E		*P* < 0.001	*P* = 0.023		*P* = 0.013	*P* = 0.004		
comprasion[c]	*P* < 0.001					B/E	B vs. E *P* < 0.001		
						P = 0.002			
Caries experience [a]									
DMFT + dmft = 0	7,96 ± 12.61	0.26 ± 1.54	0.44 ± 1.67	0.35 ± 1.15	0.00 ± 0.00	1.44 ± 2.60	2.70 ± 3.56	0.00 ± 0.00	0.52 ± 1.77
(*n* = 34)	10.21 ± 13.97	0.76 ± 2.23	0.64 ± 1.97	0.60 ± 1.57	0.01 ± 0.11	2.00 ± 3.05	2.83 ± 3.59	0.01 ± 0.11	0.47 ± 1.68
DMFT + dmft ≥ 1	0.295	0.122	0.589	0.185	0.489	0.201	0.945	0.489	0.924
(*n* = 71)									
P value									
Gingival health status [a]									
GI ≤ 1 (*n* = 58)	5.36 ± 9.72	0.56 ± 2.06	0.32 ± 1.39	0.12 ± 0.56	0.00 ± 0.00	0.98 ± 1.97	1.62 ± 2.56	0.00 ± 0.00	0.24 ± 1.28
GI > 1 (*n* = 47)	14.56 ± 15.76	0.63 ± 2.03	0.89 ± 2.31	1.02 ± 1.97	0.02 ± 0.14	2.85 ± 3.52	4.23 ± 4.09	0.02 ± 0.14	0.80 ± 2.08
P value	**< 0.001**	0.737	**0.021**	**0.003**	0.267	**< 0.001**	**0.002**	0.267	**0.014**

SD: standard deviation; CS-COIDP: Condition-Specific Child Oral Impact on Daily Performances; [a] statistical evaluation using Mann–Whitney U test; [b]Kruskal–Wallis test, [c] Dunn test with Bonferroni correction; r: Spearman's rank correlation coefficient, *$p < 0.05$

Table 4 Predictors of the adolescents' overall CS-COIDP score according to the multiple linear regression analysis with backward elimination

Variable	B	Standart error	β	*P*
Tooth brushing frequency	-7.918	2.174	-0.294	< 0.001
ICON complexity	3.388	0.773	0.379	< 0.001
Subjective treatment need	4.881	2.380	0.175	0.043

B: Unstandardized Regression Coefficients; β: Standardized Regression Coefficient; Tooth brushing: ≤ once daily (referent) and ≥twice daily; ICON complexity grade scores (continuous); Subjective treatment needs: yes (referent) and no

[12, 18, 23]. Patients seeking orthodontic treatment are more concerned about improving their facial appearance, social acceptance, interpersonal interactions, and communication [13]. School-going adolescents with malocclusions may experience problems (such as name tagging and teasing) and feelings (such as feelings of inferiority and low self-esteem) due to the position of their teeth/jaws in social interactions and interpersonal relationships [53].

The prevalence of malocclusion-induced oral impacts was higher in this study than in previous studies on school children and adolescents (ranging from 20.3 to 22.9%) in Thailand [1], Brazil [52, 54], England [55], and Peru [18]. In Turkey, no population-based study has examined the OHRQoL associated with malocclusion using a condition-specific measure. Future studies based on the socio-dental approach may provide valuable insights to identify the individuals who would most benefit from orthodontic treatment, as this information may be used in the planning and reorienting oral health services in terms of allocation and resources [1, 52].

In this study, among children with impacts, 70% reported impacts of severe or very severe intensity in all domains except for relaxing and studying, which is higher than the reported value in previous studies on school children [18, 54].

According to the present study's results, 47.7% of adolescents had difficult and very difficult complexity grades. This value was lower than those reported in the studies by Maurya et al. [56] and Öğütlü et al. [57] conducted on Indian and Turkish late adolescent patients, whereas the value was higher than those reported in previous studies conducted on Nigerian [58] and Lithuanian [59] adolescent patients in a similar age group.

Furthermore, in this study, more than half of the adolescents (66.7%) were found be in need of orthodontic treatment considering a cut-off of ICON scores ≥ 0.43, which is higher than the value obtained in previous studies on Nigerian and Lithuanian adolescent patients [58, 59] but lower than the reported value in a Turkish study by Öğütlü et al. [57]. The discrepancies among these studies may be associated with study design, sample characteristics, type of institution giving oral care, and the use of different cut-off points for the ICON.

In previous studies on adolescents, oral hygiene status, periodontal health status, dental caries status, dental attendance, and diet management were assessed as propensity factors for orthodontic treatment [1, 12, 45, 46]. In the present study, a wide range of propensity factors contributing to orthodontic treatment, including

caries status, gingival health status, frequency of tooth brushing, use of dental floss, dental visiting pattern, and frequency of sugar intake between meals, were studied. Bivariate analyses showed that gingival status was associated with adolescents' OHRQoL but not with caries experience. Consistent with the study by Wan Hassan et al. [12], we found a lower prevalence of caries but a higher prevalence of gingival health problems. Furthermore, we found that higher tooth brushing frequency and use of dental floss were associated with better OHRQoL; symptom-oriented dental attendance pattern was associated with worse OHRQoL in the speaking, cleaning, emotional, and social contact domains, and higher consumption of sugars between meals was associated with worse OHRQoL in the relaxation domain. Consistent with our study, García Pérez et al. [46] reported that poor oral hygiene, lack of dental visits had a negative impact on OHRQoL. Consistent with the present study, Miloğlu et al. reported that a regular dental visiting pattern was associated with better OHRQoL [23]. The proportion of Turkish adolescents with regular dental attendance was lower than that reported by Gherunpong et al. [1] but higher than the estimated value in a Turkish study by Miloğlu et al. [23]. Dental visiting patterns in all age groups in the Turkish population are predominantly problem-oriented, resulting in more oral health problems and decreased OHRQoL [60]. Turkish parents have decision-making responsibility for child's oral health and access to dental care. The existing oral health education programs for parents and children should be extended to include the importance of regular dental visit, malocclusion and orthodontic consultations for improving the awareness and knowledge about orthodontics of parents and children [61].

Among the sociodemographic factors, adolescents' age and monthly family income were found to be adversely associated with the OHRQoL cleaning domain. This may be explained by increased psychomotor skills and awareness of oral hygiene and tooth brushing with advancing age, as well as the opportunity to buy and use oral hygiene products with higher income. These findings are consistent with those of previous studies, indicating that the OHRQoL may be influenced by sociodemographic factors, including age and income, clinical factors, culture, and environment in an adolescent with malocclusion [10, 15, 16, 46, 62, 63].

Inconsistent with our study, some researchers have found a significant relationship between sex and OHRQoL [10, 17, 63, 64]. This discrepancy may be due to the differences in culture and adolescent age among countries. Consistent with our study, the mother's educational level (<9 years) was found to be associated with worse OHRQoL in the García Pérez et al. study [46]. This finding may be explained by the fact that the parental educational level plays a critical role in decision-making processes for their children's orthodontic care and oral health [65].

This study found significant associations between normative and perceived orthodontic needs, which is consistent with previous studies on adolescent patients [22, 66, 67].

Inconsistent with our study, Hamdan [68] found no association between normative and perceived treatment needs. This discrepancy may be explained by the fact that discomfort is experienced due to limitations in physiological and sociocultural functions (social interaction, work, appearance, smiling, habits) of daily life and that different socioeconomic status may affect self-perceived oral health and orthodontic treatment need [69, 70].

The present study found that the normative and subjective need for orthodontic treatment was associated with the OHRQoL and its speaking, cleaning, smiling, emotional, and social contact domains. In addition, malocclusion complexity was associated with the OHRQoL and its speaking, cleaning, smiling, and emotional domains.

Similarly, previous studies in different countries have reported that malocclusion severity [15, 63] and normative treatment need [62] are associated with adolescents' OHRQoL.

Miloğlu et al. [23] reported that subjective treatment needs were associated with better OHRQoL, which is inconsistent with the present study's results. Furthermore, some studies in Turkey reported that children's OHRQoL was not associated with their normative and subjective orthodontic treatment needs [22, 71] or orthodontic treatment complexity [25], which is inconsistent with the present study's results. Consistent with the present study's results, previous studies conducted in Turkey reported that normative orthodontic treatment needs were associated with the OHRQoL of Turkish adolescents [24], and the psychological domains of the C-ODIP were more affected [23]. These discrepancies among Turkish studies may be associated with the sample characteristics, age of adolescents, use of the index evaluated in normative and subjective treatment needs, OHRQoL, and personality traits of adolescents [24].

Multiple linear regression analysis revealed that lower toothbrushing frequency, increased malocclusion complexity grade scores, and subjective orthodontic treatment need account for 42.2% of the variance in the scores for worse adolescents' OHRQoL. As a behavioral propensity measure, toothbrushing frequency was identified as a more powerful predictor of adolescents' OHRQoL.

Self-reported toothbrushing frequency can be used as a indicator for oral hygiene [72]. To assess the propensity-related need for orthodontic treatment, oral hygiene and regular dental visiting are accepted as the two significant propensity factors [1]. Poor tooth brushing behavior

increases the risk of caries and gingival diseases during orthodontic treatment. The determination of adolescents with poor tooth brushing behavior may provide an opportunity for identifying at-risk patients. Health education programs should be planned to increase the oral hygiene of adolescents and to control the risk of disease that will occur during orthodontic treatment.

Normative treatment need was not found be a predictor of OHRQoL in Turkish adolescent patients. A possible explanation may be that the cut-off points of the ICON used in Turkey differ from those used in many countries [21]. However, the cut-off points for eligibility to receive treatment in publicly funded programs and their validity should be tested in different regions and populations [73].

One strength of this study is that we assessed adolescent patients' OHRQoL using the CS-COIDP and its predictors, using the main elements of the socio-dental approach to orthodontic needs assessment. Another strength is associated with the statistical analyses. Compared with previous studies that used descriptive and bivariate analyses, multivariate analysis was used to identify the most important factors affecting adolescents' OHRQoL in this study. To find the important predictors of OHRQoL attributed to maloclusion, the multiple linear regression with backward elimination was preferred. The sample size for this study was calculated based on the correlation between ICON and CS-COIDP scores obtained from pilot study. Therefore, post-hoc power analysis for multiple linear regression was performed and it revealed adequate power (power=99%) to detect an interaction and large effect size (f2=0.73), indicating practical significance of study findings.

However, this study had some limitations, which might affect its external validity. First, this study was conducted on early adolescents who sought orthodontic treatment at a state university hospital. Therefore, future studies with a more representative sample are needed to assess and confirm the relationship between OHRQoL and subjective orthodontic treatment needs among different groups of adolescents who use state and private oral health services and the general population. Second, we estimated the prevalence of condition-specific oral impacts among adolescent patients seeking orthodontic treatment. However, additional studies are needed to evaluate the impacts in orthodontics-seeking patients with normative needs because reduced treatment need was found when malocclusion-induced oral impacts were considered [1, 12, 52].

Third, the CS-COIDP attributed to malocclusion was used to assess OHRQoL. Because of the selection system used to identify patients with treatment priority, more patients cannot benefit from government-funded orthodontic treatment and they can experience more psychosocial impacts. Therefore, future studies are needed to evaluate the orthodontic treatment needs in different age groups of population in Turkey via the integration of general and malocclusion-specific self-reported instruments (such as the Psychosocial Impact of Dental Aesthetics) within the socio-dental approach, which may provide valuable information for oral health policy makers and professionals to develop evidence-based and people-centered orthodontic treatment plans and services [12]. Propensity-related need assessment was not conducted in this study. Therefore, future studies assessing propensity-related needs may be valuable to determine the need for dental health education of patients and increase the treatment success [1, 12].

A fourth limitation is that self-reported data may lead to social desirability bias. We studied the internal validation of the self-reporting instrument through comparing the self-reported data with clinical indices to check the social desirability bias. The existing relationship between normative and subjective need assessments and between the OHRQoL and ICON complexity supported the agreement between self - reported data and clinical assessment.

Future studies using social desirability scales such as the Marlowe–Crowne Social Desirability Scale may provide would be valuable to determine and evaluate the social desirability in the self-reported data [31].

Finally, sociodemographic, clinical, and behavioral factors affecting OHRQoL were evaluated in this cross-sectional study. Considering the Wilson–Cleary model [74], future studies are needed to explain the impact of the interaction between psychosocial and contextual factors on Turkish adolescents' OHRQoL as well as the agreement between the perceived and normative treatment needs using a combination of generic and orthodontic-specific measures [75]. In addition, longitudinal studies are recommended to investigate the cause-and-effect relationships.

This study primarily relays the intensity and prevalence of malocclusion-induced oral impacts using a condition-specific OHRQoL measure. In addition, this study suggests that integrating normative and subjective treatment needs and behavioral measures within the socio-dental approach may provide valuable insights for oral health professionals when assessing treatment needs and planning oral care services.

Conclusion

Oral behaviors, malocclusion complexity, and subjective treatment needs were associated with adolescents' OHRQoL. Oral health professionals should consider this when planning orthodontic treatment plans. Integrating ICON, CS-COIDP, and behavioral assessment will help to identify adolescents who should be prioritized for

treatment. Health education programs should be planned to increase the oral hygiene and regular dental visiting of adolescents during orthodontic treatment.

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Author contributions
KP, ADGÇ, MÇ, and BT were responsible for the study concept, design, and supervision. KP managed data analysis and interpretation. ADGÇ performed clinical examinations, and MÇ and BT collected the self-reported data. KP, ADGÇ, and MÇ drafted the manuscript. All the authors have read and approved the final manuscript.

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Data availability
The data analysis during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Clinical Research Ethics Committee of the Istanbul University Faculty of Medicine, approval number 2014/274; and conducted according to the World Medical Association Declaration of Helsinki. Written parental informed consent and adolescent assent were obtained from all participants.

Consent for publication
Not applicable.

Conflict of interest
The authors declare that there are no conflicts of interest regarding the publication of this article.

Competing interests
The authors declare no competing interests.

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