
Article:
Peter, E., Monisha, J., Benson, P.E. orcid.org/0000-0003-0865-962X et al. (1 more author) (2023) Does orthodontic treatment improve the Oral Health-Related Quality of Life when assessed using the Malocclusion Impact Questionnaire—a 3-year prospective longitudinal cohort study. European Journal of Orthodontics, 45 (6). pp. 773-780. ISSN 0141-5387

https://doi.org/10.1093/ejo/cjad040

Does orthodontic treatment improve the Oral Health-Related Quality of Life when assessed using the Malocclusion Impact Questionnaire? - A 3-year prospective longitudinal cohort study

Peter E, Monisha J, Benson PE, George SA

Corresponding author. Department of Orthodontics and Dentofacial Orthopedics, Government Dental College, Kottayam, Kerala 686008, India.

E-mail: petertheorthodontist@gmail.com

Summary

Objectives: To assess the change in Oral Health-Related Quality of Life (OHRQoL) following orthodontic treatment using the Malocclusion Impact Questionnaire (MIQ) and to test the responsiveness of MIQ to treatment-associated changes.

Methods: A longitudinal prospective cohort study, in an orthodontic post-graduate centre, Kerala, India. Patients under 18 years were invited to complete the MIQ before the start of treatment (T_0) and one month after treatment completion (T_1). IOTN and PAR scores were assessed at both time periods as well as a global transition judgement at T_1.

Results: 210 participants were recruited and 162 completed both questionnaires (45.1% males; 54.9% females; age=12-18 years, mean=16.8; SD=1.7). There was large reduction in MIQ scores from T_0 (mean=28.1,SD=6.1) to T_1 (mean=3.7,SD=2.6). 53% reported a large improvement in oral health and related life quality after treatment, 32% minimal change, and 15% no change. None reported worsening in OHRQoL at T_1. There was a significant positive correlation between change in MIQ score and change in PAR score (r=0.358), pre-treatment IOTN-DHC (rho=0.491) and AC (rho=0.467), and treatment time (rho= 0.502). Regression analysis revealed the change in PAR score and pre-treatment IOTN-DHC to be independent predictors of change in MIQ score. Standardized effect size (4.0) and standardized response mean (2.9) were large and the minimal important difference was 7.7. ROC analysis reported a high diagnostic accuracy of MIQ.

Conclusions: There was significant improvement in OHRQoL following orthodontic treatment when assessed using a condition-specific measure for malocclusion. MIQ was found to be responsive to changes associated with orthodontic treatment.

Keywords: health-related quality of life, patient reported outcome measures, psychological well-being.

Introduction

The aim of orthodontic treatment is primarily to improve dentofacial aesthetics and function. There is little evidence that orthodontic treatment can improve the dental health of the population, but there is increasing evidence that malocclusion has a significant social and emotional impacts on individuals, which can be assessed using measures of oral health-related quality of life (OHRQoL) (1). There is also some evidence that orthodontic treatment to correct malocclusion might improve OHRQoL (2, 3).

Many of the measures used to assess OHRQoL are generic and can be used for a range of dental conditions; however, these might not capture the full range of impacts of a specific condition (4); therefore condition-specific measures of OHRQoL have been developed, such as the Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ) for young adults (5). The Malocclusion Impact Questionnaire (MIQ) was developed and initially tested in the UK, as a condition-specific measure to evaluate the impacts of malocclusion on young people (6, 7).

The original English version of MIQ has been tested in New Zealand (8) and Nigerian (9) populations and was found to exhibit good validity and reliability. Chinese (10), Moroccan Arabic (11), Spanish (12), Serbian (13) versions of MIQ have also been developed and tested and more recently, a cross-cultural adaptation in the Malayalam language has been undertaken and been validated (14). Limited longitudinal research has been undertaken to measure the OHRQoL of young people before and after orthodontic treatment using a condition-specific measure of OHRQoL.

Thus, the objectives of the present study were: (a). to investigate if there is a change in OHRQoL following orthodontic treatment using a condition-specific measure of OHRQoL (MIQ). (b). to test the responsiveness of the measure to the treatment-associated changes, as reported by patient-assessed Global Transition Judgements (GTJ).

Methods

This prospective, longitudinal cohort study was undertaken in a single post-graduate teaching centre at the Department of Orthodontics & Dentofacial Orthopedics, Government Dental College, Kottayam, Kerala, India. The Institutional Review Board of the Government Dental College, Kottayam approved the protocol (IEC/M/13/2017/DCK). The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (15).

Participants

All patients awaiting comprehensive fixed orthodontic treatment were invited to participate. The inclusion criteria were those under 18 years, willing to participate, and either the young person or their parent/ care-provider giving informed consent. Those with a prior history of orthodontic treatment and/or unable to provide consent were excluded. Participants were enrolled after obtaining signed informed consent. They were treated by two orthodontic Junior Residents and a Senior Resident (JM) under the guidance of the Principal Investigator (PI). The recruitment period lasted for six months from May 2018 to October 2018.

Condition-specific OHRQoL measure

The original MIQ comprises 17 items and 2 global questions; however, the cross-cultural adaptation of the measure into Malayalam found that one item (Shy) consistently exhibited cross-loading and was eliminated (14). The item responses are based on a 3-point severity scale (0- 'don't' or 'doesn't', 1- 'a bit', 2- 'very or a lot'). The total score can range from 0 to 34 obtained by summing up the individual item scores. The responses for global questions are based on a 5-point severity scale (0- 'not at all', 1- 'a little bit', 2- 'a bit more', 3- 'a lot', and 4- 'very much'); the scores of which are presented separately.

Study procedure

The regional version of the MIQ was administered to the participants in the presence of their parents in a visit to the orthodontic department before the start of their orthodontic treatment (T_0) (14). The malocclusion was assessed normatively using the Dental Health Component of the Index of Orthodontic Treatment Need (IOTN-DHC) and the Peer Assessment Rating (PAR) Index. The weightings devised by Richmond and colleagues were used for calculating the total PAR score (16). The patient-reported Aesthetic Component of the IOTN (IOTN-AC) was also recorded. Data collection was repeated one month after completion of orthodontic treatment (T_1).

The MIQ data collection as well as IOTN and PAR assessment were carried out by a single investigator (JM), who was trained and calibrated by the principal investigator before the start of the study. The occlusal data were double-checked by the PI. The pre-treatment PAR evaluation of the randomly selected 30 participants was repeated after 14 days for intra-observer reliability assessment.

The perception of change in the OHRQoL of participants following orthodontic treatment was assessed using a single item Global Transition Judgement 'How do you rate the change in your oral health and related life quality after orthodontic treatment?' The item had the following response scale: 'Worsened a lot', 'Worsened a little', 'Remained the same', 'Improved a little', and 'Improved a lot'. Global transition judgements are considered as the gold standard in assessing the sensitivity to change in OHRQoL measures (17).

The responsiveness assessment also involved an estimation of the minimally important difference (MID) (18). MID is the smallest difference in score which participants consider beneficial in the absence of bothersome side-effects and excess costs (19).

No specific guidelines exist for an appropriate sample size in responsiveness assessments (20). Considering the sample size in similar studies (21, 22) and assuming high attrition (20%), it was decided to follow up a total of 210 subjects.

Statistical analysis

Data were entered into SPSS software (version 16.0, Chicago, IL, USA) by one of the co-investigators (JM) and cross-checked by the principal investigator. The raw scores were subsequently converted to their corresponding interval scale scores (available in MIQ handbook) to calculate change following treatment (7). This would allow more accurate calculation of change at all points along the scale. The intra-class correlation coefficient (ICC) ensured the intra-observer reliability in PAR assessment.

Responsiveness testing

The change in MIQ scores was determined by subtracting the post-treatment scores (T_1) from that at baseline (T_0). A positive change in scores would indicate an improvement in OHRQoL and vice-versa. The responsiveness was assessed using standardized effect size (SES) and standardized response mean (SRM) (23). Both of these determine the magnitude of change, which can be graded as small (≤0.2), moderate (0.3-0.7), and large (≥0.9) based on their values (23).

In line with the previous studies (21, 22), the significance of within-subject change of those who reported improvement and those who did not was assessed using paired t-tests. The former should be significant and the latter non-significant, if the scale is responsive. The MID for the scale was assessed by subtracting the mean change score of participants with no change from the mean change score of those who reported little change in their OHRQoL post-treatment (24). This value was also used to estimate the Guyatt's responsiveness statistic. As suggested by Guyatt *et al.* (18) the most appropriate responsiveness indicator relates the variability in scores in participants who reported no change to the clinically important difference. This is given by the ratio of the minimally important difference to the variability in stable participants.

Longitudinal construct validity

The association between change in MIQ-Malayalam scores (T_1 - T_0) and Global Transition Judgement was assessed using one-way ANOVA. The longitudinal construct validity is considered good if participants who reported improvement in the Global Transition Judgement have positive mean change in scores, those reported worsening have a negative change in scores, and those who expressed no change show little or no difference in scores (20).

Change scores as diagnostic tests

The participants who showed improvement can be differentiated from those who did not using change scores as diagnostic tests (25). Receiver Operating Characteristic curves were plotted using different cut-off scores, with Global Transition Judgement as the external criterion for change. This was done to assess the diagnostic performance of MIQ and to identify the optimum cut-off score where it shows maximum sensitivity and specificity. The area under the curve was calculated to determine the accuracy of the questionnaire in correctly identifying participants who improved and who did not, with a value of 0.5 indicating no accuracy and 1 perfect accuracy (26).

Predictors of change in MIQ score

A bivariate correlation was performed to determine the association between the change in total MIQ score and the independent variables such as age, gender, socio-economic status, total treatment time, pre-treatment IOTN-DHC & AC scores, and change in weighted PAR score. A multivariate prediction model was developed including the significant variables of the bivariate correlation.

Results

Participant and Operator characteristics

The baseline MIQ was completed by a total of 210 participants (47.2% males; 52.8% females) with ages ranging from 12 to 18 years (mean=15.3; SD= 1.9). The start and end dates of the study were May 18, 2018 and December 27, 2021 respectively. The mean length of time between T_0 and T_1 was 2.1 years (range= 1.5 to 3.5 years). 48 participants (22.8%) were lost to follow-up resulting in 162 participants (45.1% males; 54.9% females; mean age= 16.8, SD= 1.7) with baseline (T_0) and follow-up (T_1) data for responsiveness assessment. Figure 1 presents the flow of participants at various stages of the study.

All the questionnaires were completed successfully by the follow-up participants with no missing data. Table 1 provides the socio-demographic and clinical characteristics of the participants. The majority of the participants were judged to be of a 'definite treatment need' category of IOTN-DHC (57.1%). The global transition judgements indicated that a large proportion of participants considered that their OHRQoL had improved following orthodontic treatment (85.2%) (Table 2).

The operators were post-graduate trainees, including two junior residents in their second year of training and one senior resident in the fourth year. The supervisor (EP) had 20 years of orthodontic clinical experience. The intra-observer reliability was high (ICC- 0.991, 95% CI: 0.988-0.993).

Responsiveness

With respect to the Global Transition Judgement categories, a majority of participants (n= 86, 53.1%) reported to have improved a lot, while 24 participants (14.8%) revealed no change (Table 2). None reported worsening of OHRQoL. The mean change in the total MIQ scores was greater for participants who reported improvement (GTJ 4; 19.3, GTJ 5; 24.7) than those with no change (GTJ 3; 11.6) (Table 3). Likewise, the effect size was found to be large (9.9) for those who improved a lot and small for participants who were stable (2.2) (Table 3). The pre- (T_0) and post-treatment (T_1) MIQ scores were significantly different ($P < 0.05$) for those who improved (GTJ 4 and 5) as well as who did not (GTJ 3), when assessed using paired t-tests (Table 3). The minimally important difference was 7.7 and the Guyatt's responsiveness statistic was estimated to be 1.75, which indicated a sample size of approximately 7 per group will be required to detect the minimally important difference in a clinical trial using a one-sided test.

Longitudinal construct validity

The mean change in the MIQ scores were highest (24.7) for participants who reported "improved a lot", intermediate (19.3) for those who improved a little, and least (11.6) for the ones with no change (Table 3). However, all groups had a positive mean change in scores with differences in the magnitude of change as mentioned above.

Change scores as diagnostic tests

The sensitivities and false-positive rates for different cut-off points are shown in Table 4. With a change score of 22.5 (raw score) as the cut-off point, 85% participants who reported improvement were identified correctly with a false-positive rate of only 11.1%. The points were quite far from the diagonal line when the Receiver Operating Characteristic curve was plotted, indicating good accuracy. The area under the curve (0.89) was significantly different ($P < 0.001$) from the null value, confirming the diagnostic accuracy of MIQ. Figure 2 shows the plotted Receiver Operating Characteristic curve.

Predictors of change in MIQ score

The bivariate analysis showed statistically significant ($P< 0.001$) positive correlation between change in total MIQ score and change in weighted PAR score (r= 0.358), pre-treatment IOTN-DHC and AC (rho= 0.491 and 0.467 respectively), and overall treatment time (rho= 0.502). Variables such as age, gender, and socio-economic status showed no statistically significant ($P> 0.05$) association.

The multivariate linear regression analysis revealed the change in weighted PAR score and pre-treatment IOTN-DHC to be independently influencing ($R^2= 0.302$) the change in total MIQ score and were positively related ($B= 2.373$ and 3.746 respectively, $P< 0.001$) (Table 5).

Discussion

There is an increasing emphasis on the use of patient-reported outcomes to assess health interventions in recent years; however, there is limited longitudinal PRO data in the orthodontic literature. This study has demonstrated a large reduction in the MIQ scores after orthodontic treatment, with large effect sizes, indicating a significant improvement in OHRQoL.

Orthodontic treatment and Change in OHRQoL

It has been established that malocclusion can have a negative influence on an individual's QoL (1) while orthodontic treatment improves it (2). But none of the studies that assessed the pre- and post-treatment

change in QoL have used OHRQoL scales specific to malocclusion (27, 28). As mentioned in the systematic review by Javidi *et al.* (2), the use of generic scales may not assess the specific impacts associated with malocclusion and orthodontic correction. Additionally, the scales developed for adults may not address the issues of the younger population, who form the majority of the orthodontic patients (2).

The majority (85.2%) of the participants in the current study reported an improvement in their OHRQoL following treatment, highlighting the benefit of orthodontic care to an individual's OHRQoL. The bivariate analysis demonstrated total treatment time and occlusal indices such PAR and IOTN-DHC to be significantly associated with change in OHRQoL. However, the multivariate linear regression model found only the occlusal indices to be significant predictors of change in OHRQoL score, indicating that patients with severe malocclusion demonstrated greater improvement in OHRQoL score at the end of orthodontic treatment. Nevertheless, the R^2 was 0.302 indicating only 30% change in MIQ score could be explained by this model.

Studies have shown that gender has an impact on OHRQoL, with females expressing greater concern about their dentofacial aesthetics (29, 30). However, the current study found no significant association of gender with change in OHRQoL scores, which is in line with a previous longitudinal study (31). The socio-economic status, which has shown to influence the pre-treatment OHRQoL in previous studies, (32, 33) does not seem to influence the change in OHRQoL in the present study. This might be because of the institutional nature of treatment where all subjects, irrespective of the socio-economic status, were registered and placed in the waiting list before providing orthodontic care.

It was also surprising to note that a smaller proportion (14.8%) of participants reported no change in their OHRQoL, despite an obvious improvement in the malocclusion status when assessed using weighted PAR scores and IOTN-DHC grades. The reason may be that nearly one-fifth of the participants were judged to have low orthodontic need using IOTN-DHC before treatment. It might also be explained by the findings of Birkeland *et al.* (34) that some patients are dissatisfied with their dental aesthetics both before and after treatment, while others are happy at both times. It is important in identifying these individuals before the start of treatment so that unrealistic expectations, if any, can be identified and dealt with. Socio-cultural factors might also explain for the inconsistencies in the relationship between malocclusion and OHRQoL and a definite improvement in the normative condition may not always bring about a change in OHRQoL (35).

There has been a recent rise in the use of psychometric scales to assess change in OHRQoL following different orthodontic treatment modalities (36, 37). Most of them have assessed the OHRQoL change a few weeks after appliance wear and reported a transient decline, which improved at the end of treatment. These transient changes in OHRQoL, however, are merely the result of appliance-induced discomfort rather than a true change in OHRQoL. Also, it is unclear whether the improvement in OHRQoL, reported in some studies, at the end of treatment is due to an actual improvement in the normative condition or possibly due to appliance removal. Locker has rightly mentioned that 'QoL' is being indiscriminately and sometimes inaccurately used by researchers in the wrong context (38).

Oral health-related quality of life, being a multi-dimensional construct, need not necessarily be influenced by change in a single dimension brought about by orthodontic correction (39). More longitudinal studies, involving orthodontic patients before and after treatment, are required to investigate the extent that orthodontic treatment changes OHRQoL; however, the results of long-term follow-up will be complicated by the recalibration of patient perceptions known as response shift (40). The present study is one of the few such longitudinal ones available in orthodontics. In addition, the use of condition-specific scales should be encouraged, along with generic measures to assess any changes in OHRQoL associated with the treatment of malocclusion.

Responsiveness of MIQ

The responsiveness of a scale is its ability to detect change in an outcome following treatment (18) and is an important property, along with validity and reliability (21).

Two major approaches exist in responsiveness assessment: Anchor-based and Distribution-based. The former is termed "external responsiveness" while the latter "internal responsiveness" (41). Anchor-based methods use subjective Global Transition Judgements while the other rely on SES and SRM. As

there is no consensus as to which method is reliable or how exactly responsiveness should be measured, both approaches were adopted in the current study (22).

The fact that there was a positive correlation between the change in total MIQ score and change in weighted PAR score implies that the questionnaire is responsive to occlusal changes. There was a large decrease in the mean MIQ scores after treatment. None of the participants in the present study reported an increase in MIQ scores following treatment, which reaffirms the positive impact of orthodontic treatment on OHRQoL using this condition-specific measure. The within-subject change in scores was significant even for the 'no change' category and demonstrates the dichotomy that sometimes exists in normative and psychometric measurements of malocclusion. Also, the magnitude of change assessed using SES and SRM are very large compared to those involving other dental procedures (22, 42, 43), as well as surgical interventions in medicine (44), which could be attributed to the nature of orthodontic correction.

With respect to longitudinal construct validity, the patients who reported improvement had a positive mean change in scores, as did those who reported no change. Nevertheless, the magnitude of change differed with an expected gradient across the different Global Transition Judgement categories.

The loss to follow-up (LTFU) accounted for 22.8% of the initial sample size which was expected a priori, thus a sample size larger than required was selected. Moreover, the LTFU here may be attributed to the "missing completely at random" mechanism, in which case any bias correction is not required, as suggested by Kristman *et al*. (45) The authors reported that an unbiased estimate of effect is possible with as much as 60% LTFU with the "missing completely at random" mechanism (45). The treatment being free of cost and the prolonged treatment duration might have contributed to the large drop-out in the current study. The COVID-19 pandemic was also a significant factor.

The MIQ, thus, proved to be responsive to treatment change. Nevertheless, evidence shows that different versions of the same questionnaire can respond differently depending on the study population (46, 47). This highlights the need to assess responsiveness for the different versions of MIQ before clinical use.

Strengths, Limitations, and Future Directions

The present study is prospective and longitudinal with a high response rate. The novelty of the study is the use of a culturally-adapted condition-specific measure of OHRQoL, developed for young people. The findings from the current study that orthodontic treatment has a positive impact on the OHRQoL using this condition-specific measure is quite encouraging. However, it was carried out in one cohort of patients and the generalisability need to be confirmed by further studies involving different populations.

The orthodontic treatment was carried out by more than one operator, which would introduce potential confounders. However, it was minimized by strict supervision by the principal investigator and by the choice of operators with nearly the same experience levels. The data were collected by a single operator (JM) and cross-checked by the PI. Moreover, having a number of operators, some of whom might get better results than others would increase generalisability as this is what happens in the real-world scenario.

The present study lacked a control group. Nevertheless, the inclusion of participants without delivery of care would raise potential ethical issues. The study did not include a measure of psychological well-being, enabling further examination of the relationship between OHRQoL and psychological well-being (48). Future studies should include such a measure, as well as a generic measure of OHRQoL so that any differences between changes in OHRQoL due to orthodontic treatment can be compared with the treatment of other dental conditions.

Conclusion

The Malocclusion Impact Questionnaire was found to be responsive to changes associated with orthodontic treatment. The MIQ proved to be a useful yet simple condition-specific OHRQoL scale suitable for younger adolescents. This study has demonstrated that orthodontic treatment reduced the negative impacts of malocclusion on OHRQoL as assessed by a condition-specific measure; however, the multi-dimensional nature of the oral health-related quality of life should also be considered.

Data Availability

The data underlying this article will be shared on request to the corresponding author.

Conflicts of Interest

None to disclose.

Funding

Self-funded; no external source.

References

1. Dimberg, L., Arnrup, K. and Bondemark, L. (2014) The impact of malocclusion on the quality of life among children and adolescents: A systematic review of quantitative studies. *European Journal of Orthodontics*, 37, 238-247.
2. Javidi, H., Vettore, M.V. and Benson, P.E. (2017) Does orthodontic treatment before the age of 18 years improve oral health related quality of life? A systematic review and meta analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*, 151, 644-655.
3. Ferrando-Magraner, E., García-Sanz, V. Bellot-Arcis C., *et al.* (2019) Oral health-related quality of life of adolescents after orthodontic treatment. A systematic review. *Journal of Clinical and Experimental Dentistry,* 11, e194–e202.
4. Marshman, Z., Gibson, B.J. and Benson, P.E. (2010) Is the short-form Child Perceptions Questionnaire meaningful and relevant to children with malocclusion in the UK? *Journal of Orthodontics,* 37, 29–36.
5. Klages, U. (2005) Development of a questionnaire for assessment of the psychosocial impact of dental aesthetics in young adults. *European Journal of Orthodontics*, 28:103–111.
6. Patel, N., J Hodges, S., Hall, M., *et al.* (2016) Development of the Malocclusion Impact Questionnaire (MIQ) to measure the oral health-related quality of life of young people with malocclusion: part 1 - qualitative inquiry. *Journal of Orthodontics,* 43, 7-13.
7. Benson, P.E., Cunningham, S., Shah, N., *et al.* (2016) Development of the Malocclusion Impact Questionnaire (MIQ) to measure the oral health-related quality of life of young people with malocclusion: part 2 – cross-sectional validation. *Journal of Orthodontics,* 43, 14-23.
8. Benson, P.E., Gilchrist, F. and Farella, M. (2019) The Malocclusion Impact Questionnaire (MIQ): Cross-Sectional Validation in a Group of Young People Seeking Orthodontic Treatment in New Zealand. *Dentistry Journal,* 7, 24.
9. Kolawole, K.A. and Ayodele-Oja, M.M. (2021) Oral health–related quality of life of adolescents assessed with the Malocclusion Impact and Child Perceptions questionnaires. *American Journal of Orthodontics and Dentofacial Orthopedics*, 159, e149–e156.
10. Li, M-Y., He, S-L. and Wang, J-H. (2021) Validation of the Chinese version of the Malocclusion Impact Questionnaire (MIQ). *Clinical Oral Investigations*, 25, 2419-2427.
11. Bourzgui, F., Diouny, S., Mkhantar, H., *et al.* (2020) Cross-Cultural Adaptation and Validation of "Malocclusion Impact Questionnaire" into Moroccan Arabic. *International Journal of Dentistry*, 2020, 8854922.
12. Hope, B., Zaror, C., Sandoval, P., *et al.* (2020) Cross-cultural adaptation and validation in spanish of the malocclusion impact questionnaire (MIQ). *Health and Quality of Life Outcomes*, 18, 146.
13. Vucic, L., Juloski, J., Stefanovic, N., *et al* (2022) Validation of the translated and cross-culturally adapted Malocclusion Impact Questionnaire in young people seeking orthodontic treatment in Serbia. *Srpski Arhiv Za Celokupno Lekarstvo,* 149, 63.
14. J., M., Peter, E., R.M., B., Benson, P.E. and George, S.A. (2023) Cross-cultural Adaptation of the Condition-Specific Malocclusion Impact Questionnaire for the Malayalam-speaking Population- A Psychometric Scale Validation Study. *Journal of Indian Orthodontic Society*, 57, 84-90.

15. von, Elm, E., Altman, D.G., Egger, M., Pocock, S.J., Gotzsche, P.C., Vandenbroucke, J.P.; STROBE Initiative. (2007) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet.* 20, 1453-1457.
16. Richmond, S., Shaw, W.C., O'Brien, K., *et al.* (1992) The development of the PAR Index (Peer Assessment Rating): Reliability and validity. *European Journal of Orthodontics*, 14, 125–139.
17. Ziebland, S. (1994) Measuring changes in health status. In: Jenkinson, C., (ed.), *Measuring health and medical outcomes*. UCL Press, London.
18. Guyatt, G., Walter, S. and Norman, G. (1987) Measuring change over time: Assessing the usefulness of evaluative instruments. *Journal of Chronic Disorders,* 40, 171–178.
19. Jaeschke, R., Singer, J. and Guyatt, G. (1989) Measurement of health status. Ascertaining the minimal clinically important difference. *Controlled Clinical Trials*, 10, 407—415.
20. Beaton, D., Hogg-Johnson, S. and Bombardier, C. (1997) Evaluating Changes in Health Status: Reliability and Responsiveness of Five Generic Health Status Measures in Workers with Musculoskeletal Disorders. *Journal of Clinical Epidemiology*, 50, 79–93.
21. Locker, D., Jokovic, A. and Clarke, M. (2004) Assessing the responsiveness of measures of oral health-related quality of life. *Community Dentistry and Oral Epidemiology,* 32, 10–18.
22. Abanto, J., Tsakos, G., Ardenghi, T.M., *et al.* (2013) Responsiveness to change for the Brazilian Scale of Oral Health Outcomes for 5-year-old children (SOHO-5). *Health and Quality of Life Outcomes,* 11, 137.
23. Cohen, J. (1988) *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
24. Masood, M., Masood, Y., Saub, R. and Newton, J.T. (2014) Need of minimal important difference for oral health-related quality of life measures. *Journal of Public Health Dentistry,* 74, 13–20.
25. Deyo, R.A. and Centor, R.M. (1986) Assessing the responsiveness of functional scales to clinical change: An analogy to diagnostic test performance. *Journal of Chronic Disorders*, 39, 897–906.
26. Deyo, R.A., Diehr, P.H. and Patrick, D.L. (1991) Reproducibility and responsiveness of health status measures. Statistics and strategies for evaluation. *Controlled Clinical Trials,* 12, 142S-158S
27. Zamora-Martínez, N., Paredes-Gallardo, V., García-Sanz, V., *et al.* (2021) Comparative Study of Oral Health-Related Quality of Life (OHRQL) between Different Types of Orthodontic Treatment. *Medicinia (Kaunas),* 57, 683.
28. Silvola, A.S., Rusanen, J., Tolvanen, M., *et al.* (2011) Occlusal characteristics and quality of life before and after treatment of severe malocclusion. *European Journal of Orthodontics*, 34, 704–709.
29. Silvola, A.S., Närhi, L., Tolvanen, M. and Pirttiniemi, P. (2020) Gender-specific associations of malocclusion traits with oral health-related quality of life in a Finnish adult population. *European Journal of Orthodontics*, 42, 242-249.
30. Kang, J.M. and Kang, K.H. (2014) Effect of malocclusion or orthodontic treatment on oral health-related quality of life in adults. *Korean Journal of Orthodontics*, 44, 304-311.
31. Garg, K., Tripathi, T., Rai, P., Sharma, N. and Kanase, A. (2017) Prospective evaluation of psychosocial impact after one year of orthodontic treatment using PIDAQ adapted for Indian population. *Journal of Clinical and Diagnostic Research,* 11, ZC44-ZC48.
32. Vedovello, S.A., Ambrosano, G.M., Pereira, A.C., Valdrighi, H.C., Filho, M.V. and Meneghim Mde. C. (2016) Association between malocclusion and the contextual factors of quality of life and socioeconomic status. *American Journal of Orthodontics and Dentofacial Orthopedics*, 150, 58-63.
33. Knorst, J.K., Sfreddo, C.S., de F Meira, G., Zanatta, F.B., Vettore, M.V. and Ardenghi, T.M. (2021) Socioeconomic status and oral health-related quality of life: A systematic review and meta-analysis. *Community Dentistry and Oral Epidemiology*, 49, 95-102.
34. Birkeland, K., Boe, O. and Wisth, P. (1997) Subjective assessment of dental and psychosocial effects of orthodontic treatment. *Journal of Orofacial Orthopedics,* 58, 44-61.

35. Kragt, L., Dhamo, B., Wolvius, E. and Ongkosuwito, E. (2016) The impact of malocclusions on -oral health-related quality of life in children—a systematic review and meta-analysis. *Clinical Oral Investigations,* 20, 1881-1894.
36. Pithon, M.M., Magno, M.B., Coqueiro, R. da S., *et al.* (2019) Oral health–related quality of life of children before, during, and after anterior open bite correction: A single-blinded randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, 156, 303–311.
37. Pithon, M.M., Maranon-Vasquez, G.A., Silva, L.P. da., *et al.* (2022) Effect of treatment of transverse maxillary deficiency using rapid palatal expansion on oral health-related quality of life in children: A randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, 161, 172–181.
38. Locker, D. and Allen, F. (2007) What do measures of 'oral health-related quality of life' measure? *Community Dentistry and Oral Epidemiology*, 35, 401–411.
39. Kolawole, K.A. and Ayodele-Oja, M.M. (2021) Oral health–related quality of life of adolescents assessed with the Malocclusion Impact and Child Perceptions questionnaires. *American Journal of Orthodontics and Dentofacial Orthopedics*, 159, e149–e156.
40. Machuca. C., Vettore, M.V. and Robinson, P.G. (2020) How peoples' ratings of dental implant treatment change over time? *Quality of Life Research,* 29, 1323–1334.
41. Revicki, D., Hays, R.D., Cella, D. and Sloan, J. (2008) Recommended methods for determining responsiveness and minimally important differences for patient-reported outcomes. *Journal of Clinical Epidemiology,* 61, 102–109.
42. Locker, D., Jokovic, A. and Clarke, M. (2004) Assessing the responsiveness of measures of oral health-related quality of life. *Community Dentistry and Oral Epidemiology,* 32, 10–18.
43. Alantali, K., Halabi, M., Hussein, I., *et al.* (2020) Changes in preschool children's oral health-related quality of life following restorative dental general anaesthesia. *British Dental Journal,* 229, 670–676.
44. Ostendorf, M., van Stel, H.F., Buskens. E., *et al.* (2004) Patient-reported outcome in total hip replacement. *The Journal of Bone and Joint Surgery.* British volume, 86-B, 801–808.
45. Kristman, V., Manno, M. and Cote, P. (2004) Loss to Follow-Up in Cohort Studies: How Much is Too Much? *European Journal of Epidemiology,* 19, 751–760.
46. Li, S., Malkinson, S., Veronneau, J. and Allison, P. (2008) Testing responsiveness to change for the early childhood oral health impact scale (ECOHIS). *Community Dentistry and Oral Epidemiology,* 36, 542–548.
47. Lee, G., McGrath, C., Yiu, C. and King, N. (2011) Sensitivity and responsiveness of the Chinese ECOHIS to dental treatment under general anaesthesia. *Community Dentistry and Oral Epidemiology,* 39, 372–377.
48. Benson, P.E., Da'as, T., Johal A, *et al.* (2014) Relationships between dental appearance, self-esteem, socio-economic status, and oral health-related quality of life in UK schoolchildren: A 3-year cohort study. *European Journal of Orthodontics*, 37, 481-490.

Table and Figure Legends

Tables

Figures

Table 1. Socio-demographic and clinical characteristics of the participants

Demographics	Followed-up (162) n (%)	Lost-to-follow (48) n (%)	All (210) n (%)
Age in years			
Mean (SD)	16.1 (1.5)	15.7 (1.8)	16 (1.9)
Gender			
Male	73 (45.1)	26 (54.2)	99 (47.1)
Female	89 (54.9)	22 (45.8)	111 (52.9)
Socio-economic status			
BPL*	109 (67.3)	32 (66.7)	141 (67.1)
APL*	53 (32.7)	16 (33.3)	69 (32.9)
Incisor relation			
Class I	96 (59.2)	32 (66.6)	128 (70)
Class II	52 (32)	10 (20.8)	62 (29.5)
Class III	14 (8.6)	6 (12.5)	20 (9.5)
Molar relation			
Class I	77 (47.6)	27 (56.2)	104 (49.5)
Class II	79 (48.7)	19 (39.6)	98 (46.7)
Class III	6 (3.7)	2 (4.2)	8 (3.8)
Intra-arch characteristics			
Crowding (Mild)	21 (13)	5 (10.4)	26 (12.4)
Crowding (Moderate)	33 (20.4)	11 (23)	44 (21)
Crowding (Severe)	94 (58)	27 (56.2)	121 (57.6)
Spacing	14 (8.6)	5 (10.4)	19 (9)
IOTN-DHC grades			
Little need for treatment (grades 1-2)	29 (17.9)	9 (18.7)	38 (18.1)
Moderate need (grade 3)	37 (22.8)	13 (27.1)	50 (23.8)
Definite need (grades 4-5)	96 (59.3)	26 (54.2)	122 (58.1)
Patient reported IOTN-AC grades			
Little need for treatment (grades 1-4)	32 (19.8)	10 (20.8)	42 (20)
Moderate need (grades 5-7)	55 (34)	17 (35.4)	72 (34.3)
Definite need (grades 8-10)	75 (46.2)	21 (43.8)	96 (45.7)

*Government criteria for socio-economic status in the study region

APL, above poverty line; BPL, below poverty line; IOTN-AC, Aesthetic Component of the Index of Orthodontic Treatment Need, IOTN- DHC, Dental Health Component of the Index of Orthodontic Treatment Need; SD, standard deviation

Table 2. Participants categorized according to the Global Transition Judgement category

Global Transition Judgement category	Followed-up (162) n (%)
Worsened a lot	0
Worsened a little	0
No change	24 (14.8)
Improved a little	52 (32.1)
Improved a lot	86 (53.1)

Table 3. Responsiveness of the scale: Standardized Effect Size and Standardized Response Mean for the different Global Transition Judgement categories

GTJ category	Baseline MIQ scores Mean (SD)		Post-treatment MIQ scores Mean (SD)		*P* value*	Change scores Mean (SD)		SES#	SRM#
	Raw score	*Interval score*	*Raw score*	*Interval score*		*Raw score*	*Interval score*		
Overall n= 162	28.1 (6.1)	26.6 (4.8)	3.7 (2.6)	7.3 (3.3)		24.3 (7.1)	19.2 (6.7)	4.0	2.9
No change n= 24, 14.8%	21.7 (7.0)	21.8 (5.3)	6.0 (3.3)	10.2 (2.8)	<0.001	15.8 (6.6)	11.6 (4.4)	2.2	2.6
Improved a little n= 52, 32.1%	29.3 (4.4)	27.0 (3.8)	3.9 (1.9)	7.8 (2.5)		25.5 (4.8)	19.3 (4.5)	5.0	4.3
Improved a lot n= 86, 53.1%	31.7 (3.8)	29.5 (2.5)	2.0 (1.3)	4.7 (2.8)		29.7 (2.5)	24.7 (4.1)	9.9	6.0
P value**					<0.001				

**P* value derived from paired t-test; ***P* value derived from one-way ANOVA; # Based on Interval score

GTJ, Global Transition Judgement; MIQ, Malocclusion Impact Questionnaire; SD, standard deviation; SES, Standardized Effect Size; SRM, Standardized Response Mean.

Table 4. Sensitivities and False-Positive rates (1-specificities) for different MIQ change scores

Change score (cut-off point)	Sensitivity (%)	False-Positive rate (1-specificity) (%)
15.5	96	40
16.5	94	35.6
17.5	94	33.3
18.5	93.3	31.1
19.5	91.3	28.9
20.5	90.7	26.7
21.5	87.3	17.8
22.5	84.7	11.1
23.5	83.3	11.1
24.5	79.3	11.1
25.5	75.3	11.1

Table 5. Bivariate and Multivariate Linear Regression for change in total MIQ score

Variables	Bivariate	Multivariate	
	P value	***B (Standard Error)***	***P value***
Age	0.537		
Gender	0.573		
Socio-economic status	0.723		
Total treatment time	<0.001*	-0.039 (0.134)	0.773
Pre-treatment IOTN-DHC	<0.001*	3.746 (0.993)	<0.001*
Pre-treatment IOTN-AC	<0.001*	2.102 (0.656)	0.062
Change in weighted PAR score	<0.001*	2.373 (0.654)	<0.001*

*statistical significance

Figure 1: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) flow diagram

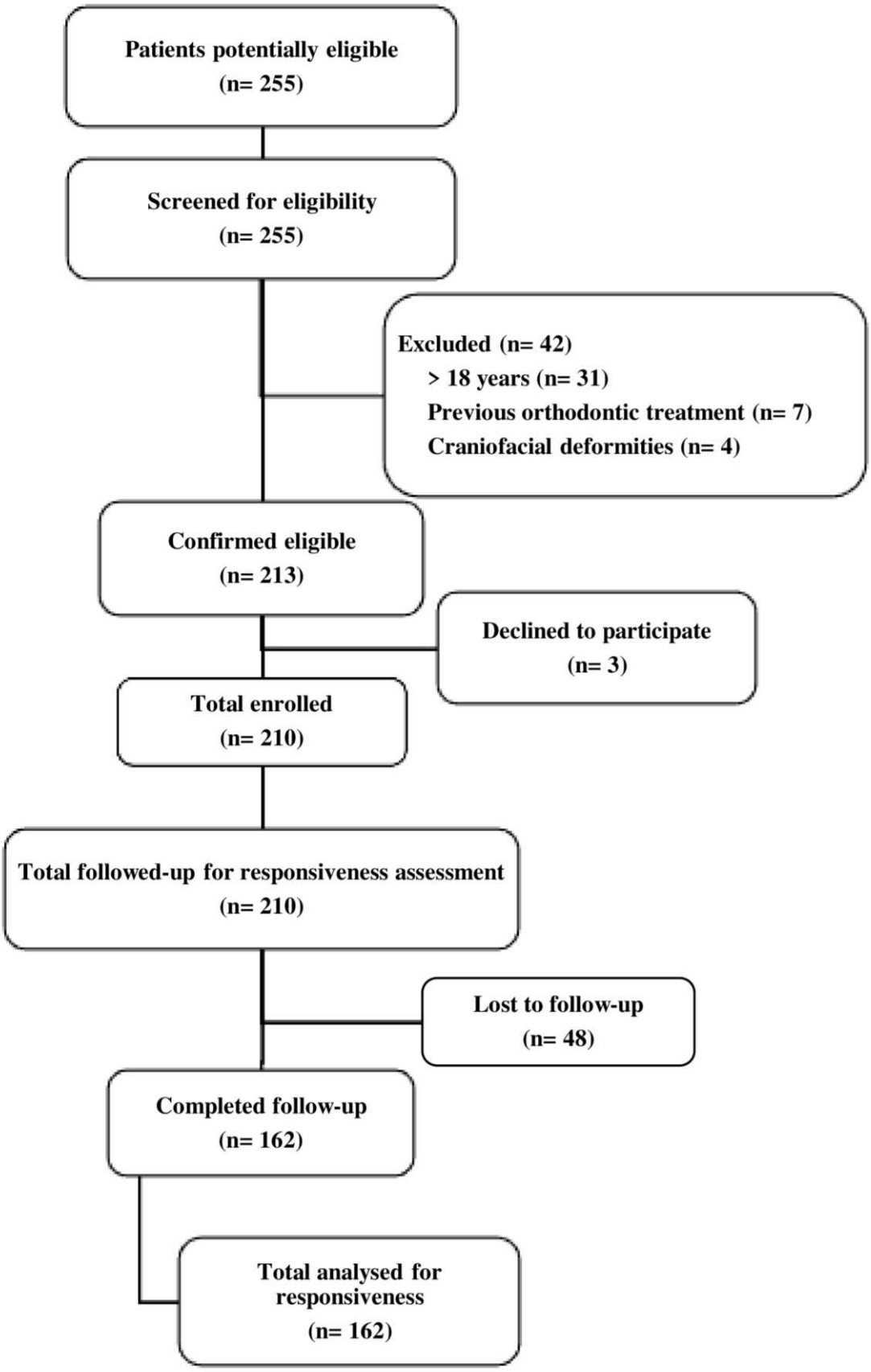

Figure 2: Receiver Operating Characteristic (ROC) curve