Index of Orthodontic Treatment Need (IOTN) and distribution of malocclusion traits in a population of growing patients attending a public orthodontic service in Perugia (Italy)

P. Negri[1], F. Vena[1,2], G. Lomurno[3], M. Coniglio[1], S. Cianetti[1], R. Gatto[4], M. Severino[4]

[1]School of Medicine, Department of Medicine, Odontostomatological University Centre: Chair Prof. Stefano Cianetti, University of Perugia, S. Andrea delle Fratte, Perugia, Italy
[2]Fondazione Policlinico Universitario A. Gemelli IRCCS, Università Cattolica del Sacro Cuore, Postgraduate School of Orthodontics, Head: Prof. Massimo Cordaro, Rome, Italy
[3]S.S.D. of Oral Surgery and Ambulatory, S. Maria della Misericordia Hospital; Department of Medicine, University of Perugia, S. Andrea delle Fratte, Perugia, Italy
[4]Department of Life, Health and Environmental Sciences, School of Dentistry, University of L'Aquila, L'Aquila, Italy

E-mail: roberto.gatto@univaq.it

Abstract

Aim Malocclusions are widespread all over the world with high prevalence values and represent a social vulnerability and health problem because of the important burden of orthodontic treatment for both families and the public health service. The Italian Ministry of Health identified the principles for priority setting in dental care, i.e. patients with IOTN (Index of Orthodontic Treatment Need) 4-5 and those in particular conditions of health or social vulnerability.

Methods A retrospective study was carried out to assess the IOTN and malocclusion in a population attending the public Orthodontic Health Service of Perugia (Italy) from September 2018 to February 2020. Medical charts, social income information, study models, photos and lateral cephalograms were examined to assess the orthodontic treatment need.

Results A total of 504 pre-orthodontic records were collected and examined. IOTN DHC (Dental Health Component of the IOTN) grade 4-5 was 27.55% and most patients belonged to lowe social classes (71.60%).

Conclusion Orthodontic health servicein Italy tends to have many patients on the waiting list, while the 72% of subject under orthodontic treatment are not part of the orthodontic priority (IOTN grade 4-5). This study suggests the heath system to guarantee a priority of need for orthodontic treatment for patients with health vulnerabilities.

Introduction

Patient demand for orthodontic treatment has dramatically increased over the past few decades in order to satisfy both functional efficiency and aesthetic harmony. The request for aesthetics plays an important role on improving self-esteem and social acceptance [Bellot-Arcìs et al., 2013; Masood et al., 2013]. Malocclusions are widespread all over the world with high prevalence and represent an important burden for both families and public health service [Lombardo et al., 2020]. Orthodontic problems are various and can affect patients already from early childhood with different severity grades which can be assessed through different indexes. An orthodontic index is defined as a numerical value used for measuring, assessing and scoring malocclusion conditions of individuals and groups of people. It is designed for aepidemiological purposes in order to provide numerous data about social need for orthodontic treatment and to make comparisons between different populations all over the world classified by the same criteria [Pradeep et al., 2017; Caruso S., 2019]. One of the most frequently used indices is the Index of Orthodontic Treatment Need (IOTN), designed and tested by Brook and Shaw and validated by other authors [Brook and Shaw, 1989; Richmond et al.,1995]; it is employed by the Italian Ministry of Health as the only clinical index that must be used in public health facilities to determine the orthodontic priority of treatment.

The IOTN comprises two parts. The first one, Dental Health Component (IOTN-DHC), registers the occlusal characteristics of a malocclusion, but is not cumulative: it takes into account only the most severe occlusal feature to classify the patient directly from grade 1 (no need of treatment) to 5 (severe need of orthodontic treatment) as shown in Table 1. In order to improve its reliability, the number of IOTN DHC grades were reduced to three: DHC 1-2 little or no need for treatment, DHC 3 moderate need for treatment, and DHC 4-5 great need for treatment. The AC (Aesthetic Component) of the IOTN has 10 grades, which correspond to 10 color photographs showing different levels of dental orthodontic attractiveness, starting with 1 (best appearance) to 10 (worst appearance) [Lunn et al., 1993; Fox et al., 2002, Caruso S., 2021]. The clinicians match one of the images to the patient's malocclusion. To make this analysis more reliable, Lunn proposed the evaluation of only 3 grades: score 1–4 indicates no need or slight need of orthodontic treatment; score 5–7 represents moderate need; while score 8–10 shows great need for treatment. Data are generally

Grade 1	Other variation in occlusion including displacement less than or equal to 1 mm
Grade 2	Increased overjet greater than 3.5 mm but less than or equal to 6 mm with competent lips at rest; reverse overjet greater than 0 mm but less than or equal to 1 mm; increased overbite greater than 3.5 mm with no gingival contact; anterior or posterior crossbite with less than or equal to 1 mm displacement between retruded contact position and intercuspal position; small lateral or anterior open bites greater than 1 mm but less than or equal to 2 mm; pre-normal or post-normal occlusion with no other anomalies; mild displacement of teeth greater than 1 mm but less than or equal to 2 mm
Grade 3	Increased overjet greater than 3.5 mm but less than or equal to 6 mm with incompetent lips at rest; reverse overjet greater than 1 mm but less than or equal to 3.5 mm; increased and complete overbite with gingival contact but without indentations or signs of trauma; anterior or posterior crossbite with less than or equal to 2 mm but greater than 1 mm displacement between retruded contact position and intercuspal position; moderate lateral or anterior open bite greater than 2 mm but less than or equal to 4 mm; moderate displacement of teeth greater than 2 mm but less than or equal to 4 mm
Grade 4	Increased overjet greater than 6 mm but less than or equal to 9 mm; reverse overjet greater than 3.5 mm with no reported masticatory or speech difficulties; reverse overjet greater than 1 mm but less than or equal to 3.5 mm with reported masticatory or speech difficulties; anterior or posterior crossbite with greater than 2 mm displacement between retruded contact position and intercuspal position; posterior lingual crossbite with no occlusal contact in one or both buccal segments; severe displacement or teeth greater than 4 mm; extreme lateral or anterior open bite greater than 4 mm; increased and complete overbite causing notable indentation on the palate or labial gingivae; patient referred by colleague for collaborative care, e.g. periodontal, restorative or TMJ considerations; less extensive hypodontia requiring pre-restorative orthodontics or orthodontic space closure to obviate the need for a prosthesis (not more than one tooth missing in any quadrant)
Grade 5	Defects of cleft lip and/or palate; increased overjet greater than 9 mm; reverse overjet greater than 3.5 mm with reported masticatory or speech difficulties; impeded eruption of teeth (with the exception of third molars) due to crowding, displacement, the presence of supernumerary teeth, retained primary teeth and any other pathological cause; extensive hypodontia with restorative implication (more than one tooth missing in any quadrant) requiring pre-restorative orthodontics

TABLE 1 The Dental Health Component of the Index of Orthodontic Treatment Need (IOTN).

collected anonymously in Microsoft Office Excel through an epidemiological dictionary (each malocclusion trait corresponds to a code).

In Italy, the vast majority of dental treatments, including orthodontic ones, are mainly provided by private practitioners, for about 80% of the total, while only the remaining 20% is provided by the National Health System (NHS). Orthodontic therapy, which is mostly addressed to individuals in developmental age, represents one of the high-cost treatments that burden family budgets. Moreover in Italy the NHS does not provide the orthodontic device to citizens, therefore all costs of orthodontic products (laboratory costs) are incurred by the patient; only the copayment can be subject to reductions, up to complete exemption, based on the patient's incomes. However, it should be noted that the total cost of orthodontic therapy provided by public health services remains well below the costs of private clinics. For this reason, there is a considerable demand to access the public services dedicated to orthodontic therapies. The guidelines of the Italian Ministry of Health specifies that the IOTN index should be applied in the diagnostic workflow of the public health systems to prioritise the treatment of patients with severe malocclusion. The ministerial guidelines on the prescriptive appropriateness of public health services have identified specific categories of patients with the right to a priority of treatment (LEA - Essential Levels of Assistance); in particular, only those with IOTN 4-5 severity index (age 0–14) should be treated as a priority, or only those with conditions of health (pathology) or social vulnerability.

Considering that the public service cannot satisfy all the treatment requests, the aim of this retrospective study is to appraise the number of patients affected by IOTN grade 4-5 malocclusion attending the public orthodontic service of the University Orthodontic Department of USL Umbria 1 (Perugia, Italy) from September 2018 to February 2019. The secondary aim is to investigate common malocclusion traits associated with IOTN grade 4-5. These data could represent an aepidemiological support for public intervention policies and new regional government programmes and finally could give an answer to this question: Does the access to public orthodontic service respect the principle of equity in health care?

Methods

This study was carried out following the experience derived from a project entrusted to our team by the National Center for Disease Control and Prevention (CCM2019) of the Italian Ministry of Health regarding the systemic complications deriving from oral pathologies in socially vulnerable subjects.

Study design

The present study was an observational retrospective study. The protocol was drawn following a modified six-criteria analysis selected from the STROBE statement: setting, participants, sample size, wideness, dependent and independent variables, outcome data and statistical analyses [Von Elm et al., 2008].

The present protocol was approved by the Ethics Committee of Umbria, number 18686/20/ON, on 05/28/2020.

Eligibility criteria

Participants were consecutively enrolled from the clinic of the University Orthodontic Department - USL Umbria 1. The age of the participants was set in agreement with local regulations, that provide orthodontic care only for children and adolescents up to 16 years of age. Only patients scheduled through the regional booking center, who consequently had attended this Orthodontic Service from September 2018 to February 2020.

Sample size

The necessary sample size was calculated to be at least 385 considering a 50% prevalence ratio for any characteristics to be estimated, a power of 0,95% and alpha of 0.03 [Perillo et al., 2010]. We considered 30% more people than the calculated sample size to ensure the validity of the study for possible data loss during extraction.

Criteria of selection

The inclusion criteria were as follows: Patients residing in Italy without any provenience limitation, patients aged up to 16 years, patients whose parents/guardians gave the consent to use medical and personal data for the study aim.

Exclusion criteria were patients with history of orthodontic treatment, patients affected by systemic health conditions.

Study selection and data extraction

Two researchers conducted a retrospective study analysing diagnostic information of the selected patients, such as: medical records, study models in the habitual occlusion, lateral cephalograms, panoramic radiographs, clinical photos and accurate measurements of the malocclusion traits. Personal and orthodontic data were stored on a password-protected software. In addition, all these records were collected by the University Orthodontic Department - USL Umbria 1, where two researchers work with students of the Faculty of Dentistry. Medical charts, study models, photos and lateral cephalograms were examined to assess the malocclusion traits and orthodontic treatment need (IOTN). Firstly, one researcher (PN) studied the medical charts of all patients in order to gain information about oral habits and socio-economic status. Oral habit was classified in 5 subgroups: oral breathing, pacifier and thumb sucking, lower lip interposition, atypical swallowing, clenching of teeth and bruxism. We used data of the economic status collected by the Regional Health System. In agreement with the Regional health System, the socio-economic status was classified into three categories (low, medium, high) based on family income.

A second examiner (FV) analysed the study models and the photos by measuring different malocclusion traits through a 3-dimensional analysis as follows.
1. Sagittal plane: Angle's molar relationship, overjet (OJ), sagittal symmetry of the arches was evaluated.
2. Transverse plane: midline shift and presence of cross-bite.
3. Vertical plane: overbite, open bite and the curve of Spee; moreover, a space analyses was performed in order to detect crowding and diastema (>2 mm).

The study models in the habitual occlusion allowed to measure – by means of a millimetric rule – the malocclusion traits in order to assess the real treatment need according to IOTN. In addition, tele-radiography, panoramic x-ray and photos were examined to confirm the occlusal traits, the presence of hypodontia, and the presence of supernumerary and impacted teeth.

Statistical analysis

Sample distribution was calculated according to the dental health component (DHC) of the IOTN and several demographic and clinical characteristics: gender, age, socio-economic status (parental income), type of dentition, malocclusion, Angle class, overjet, overbite, Bolton analysis, midline shift, crossbite, scissor bite and oral habits. Descriptive statistics were reported on all variables. Categorical data were presented as counts and percentages, while continuous data as means and standard deviations. Association between DHC IOTN and demographic and malocclusion type variables were assessed using Pearson's chi-squared test. Data were analysed using STATA 13/SE (StataCorp, College Station, Texas, USA). Statistical significance was set at $P < 0.05$.

Result

The IOTN

A total of 504 pre-orthodontic records were collected and examined, 56.12% of males and 43.88% of females. Of this total sample 86.60% of the patients were in a mixed dentition, 12.37% in permanent dentition and 1.03% in deciduous dentition stage. Regarding IOTN DHC, grade 3 was more frequent (36.73%) than grade 1-2 (35.71%) and grade 4-5 (27.55%). The IOTN AC distribution showed grade 5-7 as the most frequent (36.08%) condition, followed by grade 1-4 (32.65%) and grade 8-10 (31.27%).

Relation between IOTN DHC and socio-economic status

Table 2 shows the socio-economic status distribution according to the IOTN DHC. Most patients belonged to the lower class (71.60%), less from middle class (25.61%) and a few from the higher class (2.78%).

Relationship between IOTN DHC and malocclusion on the three axis

As shown in Table 3, Angle Class II was much more frequent (57.14%) than Class I (27,55%) and Class III (15.31%) malocclusions. Distribution of IOTN DHC related to Angle Class of malocclusion shows that most of IOTN 4-5 are Class III malocclusion (11.22%). On the sagittal plane increased overjet was the most frequent anomaly (60.20%), followed by reduced overjet (11.22%) and normal overjet (28.57%).

IOTN-DHC	Socio-economic status			Tot.
	1	2	3	
1-2	25.99%	6.94%	2.78%	35.71%
3	30.56%	6.17%	0%	36.73%
4-5	15.05%	12.50%	0%	27.55%
Total(n=504)	71.6%	25.61%	2.78%	100%

Pearson chi²(4) = 9.4217   Pr = 0.051

TABLE 2 The relation between the IOTN and socio-economic status.

IOTN-DHC	Angle Class of Malocclusion				Tot.
	Class I	Class II.1	Class II.2	Class III	
1-2	10.20%	21.43%	4.08%	0%	35.71%
3	11.22%	18.37%	3.06%	4.08%	36.73%
4-5	6.12%	8.16%	2.04%	11.22%	27.55%
Total(n=504)	27.55%	47.96%	9.18%	15.31%	100%

Pearson chi²(6) = 20.8861   Pr = 0.002

TABLE 3 The relationship between IOTN and Angle class of malocclusion.

For the variables in the transverse plane (Table 4) prevalence of unilateral posterior crossbite (20.41%) was higher than bilateral (6.12%) and anterior crossbite (7.14%). About this last trait most patients (6.12%) show IOTN DHC grade 4-5.

Midline shift was reported in the 67.35% of all patients.

The main anomaly on the vertical plane was increased overbite (41.84%), followed by normal (37.76%) and reduced overbite (20.41%). As shown in Table 5, most of reduced overbite reported in the sample was related to IOTN DHC 4-5.

Space analysis

The space analysis (Table 6) shows that crowding is really common: mandibular crowding was found in the 33.75% of the total sample, while the coexistence of lower and upper crowding was seen in 32.05% of the sample. Table 6 also shows the prevalence of cases where mandibular or maxillary crowding is associated with inferior or superior diastema. In general, 78.48% of the total sample were affected by crowding and 28.91% by diastema. Midline shift was reported in 67.35% of all patients.

Oral habits

Analysing the medical charts, we found different oral habits (Table 7): the most common was atypical swallowing (25.51%), followed by lower lip interposition (19.38%), thumb and pacifier sucking (16.32%), oral breathing (8.16%), clenching and bruxism (2.04%).

Discussion

One of the strengths of the IOTN is that researchers can easily compare between published international studies with similar samples.

The aim of our study was to quantify the number of IOTN DHC 4-5 and vulnerable patients in a sample of growing patients (504 subjects aged 4–16 years) from the orthodontic public service of Perugia, the largest city in the Umbria region (Central Italy) [Di Stadio et al., 2019].

About one third of the total sample presented malocclusion with IOTN DHC grade 4-5.

Perillo et al. [2010], after evaluating a sample of 703 southern

IOTN-DHC	Trasverse malocclusion					Tot.
	Normal	Unilateral crossbite	Bilateral crossbite	Anteriorcrossbite	Brodie	
1-2	28.57%	6.12%	1.02%	0%	0	35.71%
3	25.51%	9.18%	0%	1.02%	0	36.73%
4-5	5.10%	5.10%	5.10%	6.12%	0	27.55%
Total(n=504)	59.18%	20.41%	6.12%	7.14%	0	100%

Pearson chi²(12) = 50.4948   Pr< 0.001.

A

TABLE 4 The relationship between the IOTN and transverse malocclusion (A) and midline symmetry (B).

IOTN-DHC	Midline		Tot.
	Normal	Shift	
1-2	13.27%	22.45%	35.71%
3	15.31%	21.43%	36.73%
4-5	4.08%	23.47%	27.55%
Total (n=504)	32.65%	67.35%	100%

Pearson chi²(2) = 5.5577Pr =0.062.

B

IOTN-DHC	Overbite			Tot.
	Normal overbite	Increased overbite	Reduced overbite	
1-2	17.35%	16.33%	2.04%	35.71%
3	13.27%	19.39%	4.08%	36.73%
4-5	7.14%	6.12%	14.29%	27.55%
Total (n=504)	37.76%	41.84%	20.41%	100%

Pearson chi²(4) = 24.0579 Pr < 0.001.

A

TABLE 5 The relationship between the IOTN and overbite (A) and overjet (B).

IOTN-DHC	Overjet			Tot.
	Normal overjet	Increased overjet	Reduced overjet	
1-2	12.24%	23.47%	0%	35.71%
3	10.20%	24.49%	2.04%	36.73%
4-5	6.12%	12.24%	9.18%	27.55%
Total(n=504)	28.57%	60.20%	11.22%	100%

Pearson chi²(4) = 19.0462 Pr =0.001.

B

IOTN-DHC	Space Analysis								Tot.
	N0	Inferiorcrowding	Inferior crowding + superior crowding	Inferiordiastemas	Superior diastema	Superior crowding + inferior diastema	Inferior diastema + superior diastema	Inferior crowding + superior diastema	
1-2	3.09%	9.38%	14.43%	0%	1.03%	0%	4.12%	3.09%	35.14%
3	1.03%	13.4%	9.28%	2.06%	1.03%	1.03%	3.09%	6.19%	37.11%
4-5	1.06%	11.17%	8.34%	0%	1.03%	2.06%	3.15%	1.03%	27.84%
Total (n=504)	5.18%	33.95%	32.05%	2.06%	3.09%	3.09%	10.36%	10.31%	100%

Pearson chi2(20) = 20.9235 Pr =0.402.

TABLE 6 IOTN-DHC and space analysis. The table shows the relationship between IOTN and space issues.

IOTN-DHC	Oral Habits						Tot.
	No habits	Oral breathing	Thumb/ pacifier sucking	Lower lip interposition	Atypical swallowing	Window frame/ bruxism	
1-2	15.31%	3.06%	4.08%	3.06%	9.18%	1.02%	35,71%
3	11.23%	0%	5.10%	13.26%	6.12%	1.02%	36,73%
4-5	2.23%	5.1%	7.14%	3.06%	10.02%	0%	27,55%
Total(n=504)	28.77%	8.16%	16.32%	19.38%	25.51%	2.04%	100%

Pearson chi2(24)= 40.7663   Pr =0,018.

TABLE 7 IOTN-DHC and oral habits. The table shows the relationship between IOTN and the oral habits problems.

Italian 12-year-old schoolchildren, found a prevalence of treatment need of about 27%; a larger sample of Italian patients resulted in strong need in 26.44% of cases [Giordano et al., 2019]. Conversely, Ferro et al. [2016] reported a higher prevalence of IOTN in a sample of schoolchildren in Northern Italy (36%).

As for other European countries, a study on Spanish schoolchildren reported a IOTN prevalence of 22%, similarly to a study on a French sample of 9–12-year-old schoolchildren (21.3%) [Manzanera et al., 2009; Souames et al., 2006]; also a similar percentage was found in Turkey (28.7%) [Bilgic et al., 2015]. Higher prevalence (39.5%) was reported in Swedish children; British studies reported high prevalences: 32.7%, 33%, and 35% [Burden and Holmes, 1994; Hamdan, 2004]. Hence, we could find similarities between our study outcomes and that of studies conducted in the central and southern parts of Italy. On the contrary, northern Italy showed higher percentage of treatment need [Ferro et al., 2016].

Southern European studied reported values very similar to those of the present study; on the other hand, higher prevalence was found in Northern Europe.

Our study highlights that low-class patients represent more than half (68.06%) of the total sample of patients, and that approximately one sixth of the sample (15.05%) has a IOTN grade 4-5. Nevertheless, there was not a trend for assessed need as the most frequently present among the lower and middle classes because most of lower-class children have IOTN < 4.

Considering only the patients with high treatment need (one third of the total sample), i.e. with IOTN DHC 4-5, they were mostly in mixed dentition (93%) and their malocclusion traits varied. Almost all of them presented crowding (93.4%) and midline shift (85.19%). Further common malocclusion traits were: reduced overbite (51.8%), increased overjet (44.4%) and Angle Class III (40.7%). The most common oral habit of these patients was atypical swallowing, exhibited in about one third of cases (36.3%). Although the result of IOTN AC 8-10 was similar to IOTN DHC 4-5 across one third of the total sample, the scale used, a subjectively-rated scale, has demonstrated lack of robustness over time [Burden and Holmes, 1994]. In fact, different specialists could have a different subjective opinion on a subject's dental attractiveness and 10 photos can not represent at all the endless types of possible malocclusions.

Correct timing for orthodontic treatment is crucial to correct malocclusion during the developmental age; therefore, it was demonstrated that the physiologic growth alone, in the majority of cases, is not able to correct this type of problem. Generally, the aim of the orthodontic treatment is to satisfy the need for efficiency and aesthetic harmony of the oral cavity [Patini et al., 2019; Staderini et al., 2019; Staderini and Patini, 2020].

Beauty and appearance have became more and more part of society and culture; although smile patterns have changed frequently in relation to the concept of beauty, straight teeth are the main request of patients and the first thing that people see in a smile. Indeed, public orthodontic services have been created by the National Health Service to benefit oral health of patients first, and not only for aesthetic reasons. In addition, many studies have considered the possibility that patients self-perception of treatment need is often overestimated than that of the specialist [Hassan, 2006; Klocke et al., 2002; Stahl et al.,

2008, Baldini 2018]. Orthodontic assessment is the only way to select those children who will benefit most from an orthodontic treatment.

Clinical impact

IOTN proved to be a reliable and reproducible way to assess the real need of treatment of patients. According with these strengths, the Italian Ministry of Health chose this index to prioritise the limited resources of public services; in particular only patients with IOTN 4-5 or health or economic vulnerability could access the so-called "essential levels of care" for orthodontic treatment.

Only one third of our study sample was found to be in need for orthodontic treatment according to the above mentioned criteria.

No criteria were followed regarding the priority of treatment based on economic vulnerability.

Orthodontic health service tends to have a long waiting list, However, 72% of the subjects under orthodontic treatment are not part of the orthodontic priority. Of this non-priority subjects, more than two third were in no need for treatment. One of the possible explanation is that many of these requests were made only for aesthetic reasons and, therefore, early prevention and treatment could be the only possible way to reduce the incidence of malocclusion in childhood. In fact, investing in prevention is necessary to reduce prevalence of malocclusion in mixed and permanent dentition, as well as the burden of treatment and to maintain a sustainable public health service [Staderini et al., 2020; Marradi et al., 2020; Frezza, 2021].

Study limits

The present study has some limitations to be considered: the diagnostic criteria of IOTN 4-5 patients, comprises just a small sample of patients. Therefore, many patients with IOTN 3 are excluded from public health care, even if an orthodontic treatment should be highly recommended for some categories of IOTN 3 (open bite less than 4 mm, crossbite) both for functional and aesthetic reasons.

Conclusions

This epidemiological study aims to focus on Italian healthcare system ability to manage orthodontic priority in order to grant more and more people with an orthodontic emergency (IOTN DHC 4-5) the access to the public service. Other type of malocclusions could be addressed through orthodontic prevention and early treatment by the public paediatric dentistry service. For this reason, it is important to plan public-funded orthodontic health programmes specifically targeting children before tooth shedding in order to guarantee everyone an orthodontic evaluation. Therefore, we suggest the regional health system to create a fast-track dental care in order to guarantee a priority of need for orthodontic treatment for patients with IOTN 4-5 and to give precedence to those who are in a condition of economic vulnerability for equal needs.

References

› Baldini A, Nota A, Caruso S, Tecco S. Correlations between the visual apparatus and dental occlusion: a literature review. Bio Med Research International 2018;2018, 2694517.

› Bellot-Arcís C, Montiel-Company JM, Almerich-Silla JM. Psychosocial impact of malocclusion in Spanish adolescents. Korean J Orthod 2013;43(4):193- 200.

› Bilgic F, Gelgor IE, Celebi AA. Malocclusion prevalence and orthodontic treatment need in central Anatolian adolescents compared to European and other nations' adolescents. Dental Press J Orthod 2015;20(6):75-81.

› Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. Eur J Orthod 1989;11(3):309-20.

› Burden DJ, Holmes A. The need for orthodontic treatment in the child population of the United Kingdom. Eur J Orthod 1994;16(5):395-9.

› Caruso S, Nota A, Caruso S, Severino M, Gatto R, Meuli S, Mattei A, Tecco S. Mandibular advancement with clear aligners in the treatment of skeletal Class II. A retrospective controlled study. Eur J Paediatr Dent 2021; 22(1):26-30.

› Caruso S, Nota A, Ehsani S, Ojima K, Tecco S. Impact of molar teeth distalization with clear aligners on occlusal vertical dimension: A retrospective study BMC Oral Health, 2019;19(1):182.

› Di Stadio A, Gambacorta V, Cristi MC, Ralli M, Pindozzi S, Tassi L, Greco A, Lomurno G, Giampietro R. The use of povidone-iodine and sugar solution in surgical wound dehiscence in the head and neck following radio-chemotherapy. Int Wound J 2019;16(4):909-915.

› Ferro R, Besostri A, Olivieri A, Stellini E. Prevalence of occlusal traits and orthodontic treatment need in 14 year-old adolescents in Northeast Italy. Eur J Paediatr Dent. 2016 Mar;17(1):36-42.

› Frezza A, De Stefani A, Baciliero U, Rosa M, Lucchi P, Bruno G, Gracco A. Evaluation of tooth size in non-syndromic cleft lip and palate patients: A retrospective Italian study. Eur J Paediatr Dent 2021;22(1): 31-34.

› Fox NA, Daniels C, Gilgrass T. A comparison of the index of complexity outcome and need (ICON) with the peer assessment rating (PAR) and the index of orthodontic treatment need (IOTN). Br Dent J 2002;193(4):225-30.

› Giordano A, Guarnieri R, Galluccio G, Cassetta M, Di Giorgio R, Polimeni A, Barbato E. Epidemiology of malocclusion in 3,491 subjects attending public dental service in Rome (Italy): Evaluation of the Orthodontic Treatment Need Index. J Contemp Dent Pract 2019; 20(5):631-638.

› Hamdan AM. The relationship between patient, parent and clinician perceived need and normative orthodontic treatment need. Eur J Orthod 2004;26(3):265-71.

› Hassan AH. Orthodontic treatment needs in the western region of Saudi Arabia: a research report. Head Face Med 2006;18(2):2.

› Josefsson E, Bjerklin K, Lindsten R. Malocclusion frequency in Swedish and immigrant adolescents--influence of origin on orthodontic treatment need. Eur J Orthod 2007, 29(1):79-87.

› Klocke A, Nanda RS, Kahl-Nieke B. Anterior open bite in the deciduous dentition: longitudinal follow-up and craniofacial growth considerations. Am J Orthod Dentofacial Orthop 2002;122(4):353-8.

› Lombardo G, Vena F, Negri P, Pagano S, Barilotti C, Paglia L, Colombo S, Orso M, Cianetti S. Worldwide prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis. Eur J Paediatr Dent 2020;21(2):115-122.

› Lunn H, Richmond S, Mitropoulos C. The use of the index of orthodontic treatment need (IOTN) as a public health tool: a pilot study. Community Dent Health 1993;10(2):111-21.

› Manzanera D, Montiel-Company JM, Almerich-Silla JM, Gandía, JL. Orthodontic treatment need in Spanish schoolchildren: an epidemiological study using the Index of Orthodontic Treatment Need. Eur J Orthod 2009;31(2):180-3.

› Marradi F, Staderini E, Zimbalatti MA, Rossi A, Grippaudo C, Gallenzi P. How to obtain an orthodontic virtual patient through superimposition of three-dimensional data: A systematic review. Applied Sciences (Switzerland) 2020;10, doi:10.3390/APP10155354.

› Masood Y, Masood M, Zainul NN, Araby NB, Hussain SF, Newton T. Impact of malocclusion on oral health related quality of life in young people. Health Qual Life Outcomes 2013;26;11-25.

› Patini R, Staderini E, Camodeca A, Guglielmi F, Gallenzi P. Case reports in pediatric dentistry journals: A systematic review about their effect on impact factor and future investigations. Dent J 2019;7 doi:10.3390/dj7040103.

› Perillo L, Masucci C, Ferro F, Apicella D, Baccetti T. Prevalence of orthodontic treatment need in southern Italian schoolchildren. Eur J Orthod 2010;32(1):49-53.

› Pradeep S, Dhakshahini MR, Anitha SR. An introduction to indices in orthodontics. Int J Adv Res 2017;5(4):1395-1403.

› Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Stephens CD, Andrews M, Roberts CT. The relationship between the index of orthodontic treatment need and consensus opinion of a panel of 74 dentists. Br Dent J 1995; 178(10):370-4.

› Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61(4):344-9.

› Souames M, Bassigny F, Zenati N, Riordan PJ, Boy-Lefevre ML. Orthodontic treatment need in French schoolchildren: an epidemiological study using the Index of Orthodontic Treatment Need. Eur J Orthod 2006;28(6):605-9.

› Staderini E, Meuli S, Gallenzi P. Orthodontic treatment of class three malocclusion using clear aligners: A case report. J Oral Biol Craniofacial Res 2019;9:360-362, doi:10.1016/j.jobcr.2019.09.004.

› Staderini E, Patini R. Indication of clear aligners in the early treatment of anterior crossbite: a case series. 2020;25:33-43. doi:10.1590/2177-6709.25.4.033-043.oar.

› Staderini E, Patini R, Tepedino M, Gasparini G, Zimbalatti MA, Marradi F, Gallenzi P. Radiographic assessment of pediatric condylar fractures after conservative treatment with functional appliances. A systematic review. Int J Environ Res Public Health 2020;17: doi:10.3390/ijerph17249204.

› Stahl F, Baccetti T, Franchi L, McNamara Jr JA. Longitudinal growth changes in untreated subjects with Class II Division 1 malocclusion. Am J Orthod Dentofacial Orthop 2008;134:125–37.

› Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008, 61(4):344-9.