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Original Research Article

The distribution of malocclusion using the index of orthodontic treatment needs at a university dental hospital in and around Pretoria, South Africa

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ABSTRACT

Background: The study described the patterns of malocclusion traits and the orthodontic treatment needs at a Dental Hospital using the Index of Orthodontic Treatment Needs (IOTN), Dental Health Component (DHC).

Materials and Methods: We evaluated 2079 pre-treatment study models and clinical records of orthodontic patients from the Department of Orthodontics waiting list. The assessment of malocclusion was measured according to the molar relationship using Angle's classification.

The DHC was further used to assess the five malocclusion traits: - missing teeth, overjet, crossbite, displacement of contact point, and overbite, including open bite (MOCDO). The MOCDO score was calculated to determine the orthodontic treatment needed based on the DHC grades 1–5. The data was analysed using SPSS version 28 and the level of significance was set at $p \leq 0.05$.

Results: The sample consisted of 59.3% (n=1232) females and 40.7% (n= 847) males. The mean age of the study sample was 14 years (SD±2.3) and ranged between 12 to 20 years. Angle's Class I malocclusion was found in 57.7% of the sample, followed by Class II (35.4%) and Class III (6.9%).

The orthodontic treatment needs DHC grade were: 53% grade 4 (need for orthodontic treatment), 21% grade 5 (great need for orthodontic treatment), 17% grade 3 (borderline need for orthodontic treatment), 6% grade 2 (little need for orthodontic treatment), and 3% grade 1 (no orthodontic treatment need).

A statistically significant difference was found in Angle Class I malocclusion and the DHC grades (p=0.001), as well as MOCDO variables and DHC grades (p=0.001).

Conclusion: Angle's Class I malocclusion was the most predominant in our study sample compared to Class II and Class III malocclusions. The DHC of IOTN was successfully used to evaluate the severity of malocclusion with the majority of the sample in Grades 4 and 5, requiring mandatory orthodontic treatment. A high frequency of the occlusal traits included missing teeth, overjet, crossbite, displaced contacts and overbite. The results of our study showed that most patients on the orthodontic waiting list require mandatory orthodontic treatment. Therefore, it is recommended that DHC be used to place patients on the waiting list to prioritise orthodontic treatment.

1. Introduction

Malocclusion is a developmental condition with a deflection from the normal relation or alignment of the teeth to other teeth in the same and opposing arch.[1] Malocclusion is

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ranked third among worldwide public health dental disease priorities after dental caries and periodontal disease.[2]

The prevalence of malocclusion varies from one country to another, between different gender and race, and with age.[3–5] The worldwide prevalence of malocclusion among children and adolescents is 56% without relevant sex differences.[6] The epidemiology of malocclusion among the continents has shown that Africa had the highest prevalence (81%), followed by Europe (71%), America (53%), and Asia (48%).[6] The 2022 systemic review study reported a prevalence of 76.1% in Africa, however, South Africa was not included among the African countries.[7]

Epidemiology of malocclusion and assessment of orthodontic treatment needs are of national importance in many countries, and South Africa has included malocclusion epidemiology in the oral health national survey.[8] The prevalence of malocclusion in South Africa has been reported to range from 32% to 52.3%.[8–11]

An orthodontic treatment need index is an occlusal index originally developed to prioritize the need for orthodontic treatment. It classifies malocclusion and identifies patients in accordance with their treatment.[12,13] Several indices for assessing malocclusions have been developed in the past,[14–20] and the Index of Orthodontic Treatment Need (IOTN) has gained popularity.[19] The IOTN is an epidemiological index used to estimate the need for orthodontic treatment and a screening instrument for determining treatment priority in government institutions with limited financial resources.[21] The validity of the index has been assessed and confirmed by some researchers.[22,23] It has also shown to be applicable in diverse ethnic groups without the need for modification,[24,25] and was deemed to be trustworthy and easy to use.[21]

The IOTN was developed to grade malocclusion based on the significance of various occlusal traits for dental health and aesthetic impairment.[19] The Dental Health Component (DHC) evaluates malocclusion utilising five occlusal traits: missing teeth, overjet, crossbite, displacement of the contact point, and overbite/open bite (MOCDO).[26] There are five grades of the DHC indicating orthodontic treatment need, grade 1 representing little or no need for treatment and grade 5 representing great need for treatment.[19] The DHC malocclusion traits are further explained using alphabets to describe the severity of each malocclusion in the DHC grades (Table 1).[27]

In South Africa's nine provinces, orthodontic treatment is performed mainly in private practice and the four dental teaching hospitals.[28] It has been reported that 80% of the population in South Africa depends on the government for health services, while only 20% can afford private care.[29] Thus the four dental teaching hospitals are inundated with orthodontic waiting lists for individuals with malocclusion. The treatment of malocclusion can be classified as interceptive orthodontic treatment; by contrast, extensive care is performed in cases of moderate to severe malocclusion. Given this background of malocclusion in South Africa, it is necessary to evaluate the orthodontic treatment needs in relation to the severity of malocclusion. However, the prevalence of malocclusion and orthodontic treatment needs for patients on the orthodontic waiting list at a University Dental Hospital had not yet been reported in the indexed literature over the past 50 years. Therefore, this study assessed the orthodontic treatment needs based on the severity of malocclusion using the DHC of the IOTN. The results of the study may be used in future to plan sufficient treatment facilities and the development of adequate training programs for the prioritisation of orthodontic services and orthodontic waiting list reduction.

2. Materials and Methods

A cross-sectional retrospective study was undertaken utilising records of patients on the orthodontic waiting list at a University Dental Hospital. The study period was from 1 January 2012 to 31 December 2021. The dental hospital Ethical approval was obtained from the Research Ethics Committee (Reference: 22/2022) to conduct the study.

The study setting consisted of a University Dental Hospital situated in the city of Pretoria, in Gauteng Province, one of South Africa's nine provinces (Figure 1). Pretoria is the capital city of South Africa and was selected because the dental hospital provides oral health care, including orthodontic treatment, to most individuals in the South Africa's public health sector. Furthermore, the results of the study will generate new knowledge that will contribute to improvements in health care in the public health sector of South Africa.

In Gauteng Province, three university dental hospitals are available, separated by a radius of approximately 50 km. The fourth university dental hospital is situated in the Western Cape Province, about 1500 km away from Pretoria. All other seven provinces of South Africa do not have dental schools, and they rely on these four for public tertiary dental care including orthodontic treatment. Therefore, the University of Pretoria Dental Hospital location in the capital city of South Africa is easily accessible to the public and also serve as the referral centre for surrounding provinces and neighbouring countries.

The following inclusion and exclusion criteria were applied to the models to obtain the sample of the study:

2.1. Inclusion criteria

1. Patients in permanent dentition,
2. Age of 12 to 20 -years old,
3. Ideal orthodontics study models (correctly trimmed models with accurate reproducibility of the soft and hard tissue).

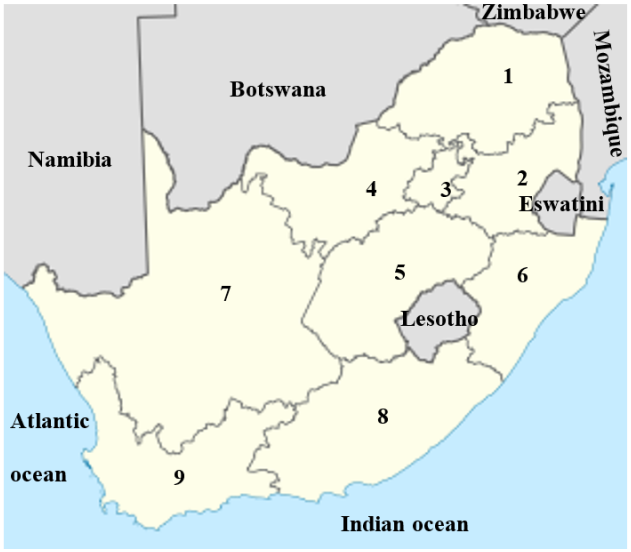

Figure 1: Map of South Africa with provinces and neighbouring countries 1- Limpoopo Provine, 2- Mpumalanga Province, 3- Gauteng Province, 4- North West Province, 5- Free State Province, 6- KwaZulu Natal Province, 7- Northern Cape Province, 8- Eastern Cape Province, 9- Western Cape Province
Source - https://en.wikipedia.org/wiki/Provinces_of_South_Africa

2.2. *Exclusion criteria*

1. Clefts and other craniofacial deformities.
2. Fractured models, restored teeth, and attrition.
3. Mixed dentition and primary dentition.
4. Models with no wax bite.
5. Significant periodontal disease.
6. Missing data, including age, biological sex and incomplete information.

2.3. *Data collection*

The assessment of dental classification of malocclusion was evaluated according to the molar relationship using Angle's classification.[30] Furthermore, the severity of malocclusion was scored according to the DHC of the IOTN. The malocclusion measurement included the acronym MOCDO (Missing teeth; Overjet; Crossbites; Displacement of contact points; Overbite) to score the worst deviant occlusal trait of the malocclusion (Table 2). Missing teeth were counted, while other measurements were done using a transparent plastic ruler with a tip of 0 mm. The most severe measurement was used as the DHC score, which classified orthodontic treatment needs.

The principal investigator (TN) and one of the authors (MALM) were calibrated prior to the commencement of the study until the level of agreement (Kappa value = 0.9) was attained.

Repeated measurements of the 10% of the study sample were re-examined two weeks after the initial measurements to test for intra-examiner and inter-examiner reliability. The level of agreement attained for intra-examiner reliability was Kappa score = 0.8, and inter-examiner reliability Kappa score = 0.9.

The data was analysed using SPSS version 28, Chi-square test was used to test for association between Angle's classification, MOCDO and DHC grades and the level of significance was set at $p \leq 0.05$.

3. Results

We measured 2079 records, which consisted of 59% (1232) females and 41% (847) males. The mean age of the study sample was 14 years (SD ±2.3) and ranged between 12 to 20 years. Class I malocclusion was found in 58% of the sample, followed by Class II (35%) and Class III (7%). The majority of the sample (53%) had a great need for orthodontic treatment, indicated by the DHC grade 4, followed by grade 5 (21%) having the greatest need and grade 1 had the lowest proportion (3.2%) with no need for treatment as shown in Table 3.

Figure 2 illustrates the distribution of different malocclusion traits within the DHC grades according to the MOCDO acronym. The missing/unerupted permanent teeth within the study sample were observed in DHC 4h (n=121;5.8%) followed by DHC 5h (n=66;3.1%). The most predominant occlusal trait was the displacement of contacts found in DHC 4c (n=561;27%), followed by DHC 4t (451;21.7%). Overjet was mostly found in DHC 4a (n=275;13.2%), followed by DHC 5a (n=231;11.1%), with the least being DHC 2b (n=99;4.8%). Most anterior and posterior crossbites were in the DHC 3c (n=451; 21,7%), followed by DHC 4c (407;19%). Overbite was predominantly found in DHC 2f (297;14.3%) and DHC 3f (198;5%).

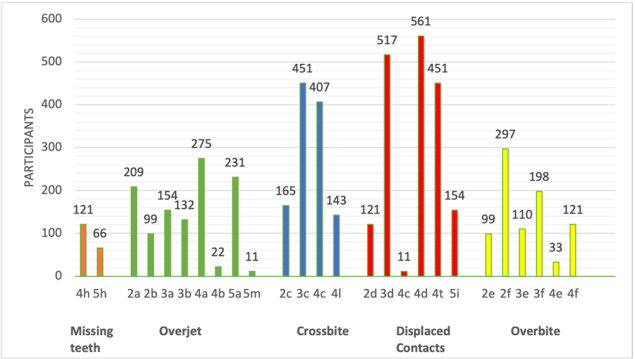

Figure 2: Distribution of malocclusion traits within the DHC scores

Table 4 presents the association between Angle's classification, MOCDO and DHC grades. More patients

with Angle Class I malocclusion presented with a great need of treatment (grade 4) compared to Angle Class II and Class III, and the Chi-square test showed statistically significant differences (p=0.001). The missing teeth component of MOCDO also showed a Chi-square statistically significant difference (p=0.001), with most of the sample in grade 4 compared to grade 5. Overjet was found more in grade 4 compared to grade 5 and 3 with a Chi-square statistically significant difference (p=0.001). Most of the sample with crossbites, displaced contacts and overbites were in grade 4 compared to grade 5, 3 and 2, and the Chi-square showed a statistically significant difference (p=0.001).

Table 1: Alphabet representation of malocclusion in the DHC grades

Alphabets	Malocclusion description
a	Overjet – recorded to the most prominent part of the most prominent incisor
b	Reverse overjet with no masticatory or speech problems
c	Crossbite
d	Displacement of contact points where teeth deviate from the line of the arch, worst displacement recorded, spacing inline of the arch not included
e	Open bite
f	Deep bite
g	Good occlusion
h	Hypodontia
i	Impacted due to lack of space ≤4 mm
l	Posterior lingual crossbite
m	Reverse overjet with masticatory or speech problems
p	Defects of the cleft lip and palate
s	Submerged deciduous teeth
t	Partially erupted teeth, tipped and impacted against adjacent teeth
x	Presence of supernumerary teeth

4. Discussion

Our study has evaluated the prevalence of malocclusion from patients on a university dental hospital orthodontic waiting list and found a very high number with the greatest need for orthodontic treatment. The results were expected because the dental hospital is a referral centre for specialized orthodontic care from general dental practitioners and neighbouring clinics, provinces, and countries. Our study results showed that most of the sample were female (59%), similar to the results reported by Nugroho et al., who found that most of the recipients for orthodontic treatment were women.[31] A study by Buthelezi et al. also revealed that most of the patients consulting at their institution were female.[32] This could be explained by the fact that most females are conscious of their appearance.[33]

The findings of our study showed that Angle Class I malocclusion (58%) was predominant compared to Class II and III. Similar results have been reported previously, showing Class I malocclusion predominancy followed by Class II and III, respectively.[34] The difference in the frequency of the various Angle's classes in most studies could be due to different geographic locations and ethnicity of the study sample. A 2020 systematic review and meta-analysis report on worldwide prevalence of malocclusion was only on four studies conducted in the continent of Africa (Tanzania 2009, Nigeria 2010, Morocco 2012 and Libya 2013). The results of the review were similar to our findings with that Angle Class I was predominant (61%), followed by Class II and Class III.[6] Similarly, Yemitan and Oyapero reported that Class I malocclusion was the highest (76.7%), in their systematic review study in Africa, followed by Class II and Class III was the lowest among all Angle's classes of malocclusion.[7] However, these systematic review studies were conducted in the Northern part of the continent of Africa and the countries reported are not a representation of the 54 countries in the continent, world's second-largest and second-most populous continent. Consequently, comparative studies in other African continent are still lacking especially, no studies from the Southern part of the continent were reported in these reviews.

Our study findings showed that most of the patients requiring orthodontic treatment needs were in DHC grade 4 (53%) with great need for treatment and grade 5 (21%) with the greatest need for orthodontic treatment. Similarly, to our findings, Maumela and Hlongwa reported that 21.7% of their sample had a severe need for orthodontic treatment, while 41.7% required mandatory orthodontic treatment.[35] The distribution of malocclusion severity in our study was similar to the findings of Shue-Te Yeh et al., who reported that the majority of their patient presented with DHC grade 4.[36] Our results found 17% of patients with a moderate need for treatment (grade 3) and 6% with little need for treatment (grade 2) while 3%, had no need for treatment (grade 1). The inability of these grades to allocate the patients for orthodontic treatment does not mean that they do not present with malocclusion, but their malocclusion fell below the category of treatment deemed by the DHC treatment needs.

The missing/unerupted component of the MOCDO in our study was 9% (n=187). Similar findings have been reported on missing teeth ranging from 2.6% to 11.3%.[37] Contrary to our findings, Mani et al. reported a lower percentage of 3.2% of missing teeth in their study.[38] Our study did not explore the reasons for the missing teeth in our sample, but these could include; early tooth loss due to extraction, dental caries or congenitally missing.

The presence of overjet in our study sample was 55%. This is a very important factor to consider, as patients with an increased overjet are said to have an increased risk of trauma to the anterior teeth.[39] Lower prevalence

Table 2: DHC components, using the MOCDO acronym

IOTN Dental Health Component	Grade 5	Grade 4	Grade 3	Grade 2	Grade 1
Missing teeth	**5h** = extensive hypodontia + restorative implications >1 tooth missing per quadrant requiring pre-restorative orthodontic treatment **5s** = submerging primary teeth **5i** = impeded eruption/impaction	**4h** = less extensive hypodontia requiring orthodontic treatment for pre-restorative or space closure			
Overjet		**4a** = OJ 6.1-9 mm **4b** = ROJ >3.5 mm with no masticatory and speech difficulties	**3a** = OJ 3.6-6 mm + incompetent lips **3b** = ROJ 1.1-3.5 mm	**2a** = OJ 3.6-6 mm + competent lips **2b** = ROJ 0.1-1 mm	
Crossbite		**4c** = x-bites + >2 mm discrepancy between RCP and ICP **4l** = posterior lingual x-bite	**3c** = x-bite + 1.1-2 mm discrepancy between RCP and ICP	**2c** = x-bite with up to 1 mm discrepancy between ICP and RCP	
Displacement of contact point		**4d** = contact point displacement >4 mm 4t = partially erupted teeth, tipped and impacted against adjacent teeth **4x** = supplemental teeth	**3d** = contact point displacement 2.1-4 mm	**2d** = contact point displacement 1.1-2 mm	Minor irregularity
Overbite		**4e** = lateral or anterior open bite >4 mm **4f** = increased + complete OB + gingival or palatal trauma	**3e** = lateral or anterior open bite 2.1-4 mm **3f** = increased + complete OB with no gingival trauma	**2e** = lateral or anterior open bite 1.1-2 mm **2f** = increased OB >3.5 mm and no gingival contact	

Source [27]

Table 3: Demographics characteristics of the study sample

Variables	Frequency
Mean age in years (SD)	14(±2.34)
Age range in years	12 - 20
Gender	n (%)
Male	847 (41%)
Female	1232 (59%)
Angle's Classification	
Class 1	1199 (58%)
Class 2	737 (35%)
Class 3	143 (7%)
DHC	
Grade 1	66 (3%)
Grade 2	132 (6%)
Grade 3	341 (17%)
Grade 4	1100 (53%)
Grade 5	440 (21%)

Table 4: Association between Angle's Classification, DHC malocclusion traits and DHC categories

	DHC Grades					p-value
	1	2	3	4	5	
Angle Class I	55(2.6%)	99(4.8%)	264(12.7%)	583(28%)	198(9.5%)	
Angle Class II	11(0.5%)	22(1%)	55(2.6%)	462(22.2)	187(8.9)	0.001
Angle Class III	0(0%)	11(0.5%)	22(1%)	55(2.6%)	55(2.6%)	
Missing Teeth	0(0%)	0(0%)	0(0%)	121(5.8%)	66(3.2%)	0.001
Overjet	0(0%)	0(0%)	154(7.3%)	649(31%)	330(15.9%)	0.001
Crossbite	0(0%)	55(2.6%)	143(6.9%)	704(33.9)	264(12.7%)	0.001
Displaced contacts	0(0%)	99(4.8%)	319(15.3%)	1001(48.1%)	396(19%)	0.000
Overbite	0(0%)	22(1.1%)	132(6.3%)	484(23.3%)	220(10.5%)	0.001

of overjet compared to our study have been reported by Singh et al. with a finding of 17.5%.[40] A study on Nigerian subjects also showed a lower prevalence of 43% overjet, compared to our study findings.[41] Research conducted on the female population of Saudi Arabia seeking orthodontic treatment found 76% overjet in adolescents which was higher compared to our results.[42]

The anterior and posterior crossbite in our sample was found to be 56.1%, similarly to the study reported by Albarakari et al. who also found a similar prevalence of crossbites in 60.5% of their study.[42] Higher prevalence of crossbite compared to our study was reported by Gungor et al. in 64.3% of their patients[43] However, Shrestha et al.[44] reported a lower prevalence of 23.3% in their study compared to our findings. In our study, anterior crossbites (49.2%) were more common than posterior crossbites (6.9%). Our results were similar to a study by Ajayi et al. findings of 21.4% for the anterior crossbite and 12.2% for the posterior crossbite.43 The reported prevalence for the posterior crossbite is low because patients do not seek orthodontic treatment for the correction of posterior teeth since they do not see or recognize it as a problem. However, it is important to diagnose and manage posterior crossbites as they may be associated with symptoms of the temporomandibular joint dysfunction.[45]

Measurement of contact point displacement as the DHC component of IOTN was performed on the greatest displacement of point of contact. Clinically, displacement of contact points is also called crowded teeth. In our study, displacement of points of contact of 87% (n= 1815) was the most predominant malocclusion trait. Similar results have been reported on crowding as the common type of malocclusion.[40,46]

The measurement of overbite was found to range from 3.5mm to overbite covering the whole lower incisors, with or without palatal trauma. Our study had a prevalence of 29.6% of overbite comparable to the findings of 20.7% of Nepalese patients[41] and 25% of Nigerian patients.[41,44] Our study findings showed that 14.3% of the sample had an overbite greater than 3.5mm, with 9.5% having increased overbite without palatal contact, while 5.8% had an increased overbite with palatal trauma. Contrary to our findings, Souames et al. found an increased overbite prevalence of 15%, an overbite without palatal contact of 45%, and an overbite with palatal contact of 10% in their samples.[5]

The results of our study found that the percentage of patients with open bites was 11.7%. Previous findings have demonstrated a reduced prevalence of 8%.[41,44] In contrast, the prevalence of open bite was greater in a sample of Saudi patients (46.7%),[42] compared to our study findings. The variation between prevalence of overbite (29.6%) and open bites (11.7%) in our study sample is similar to a previous study that reported that overbite (13.23%) was more predominant than open bites (2%).[40]

5. Study Limitations

Our study experienced challenges with incomplete records, due to the nature of retrospective investigations. The study records that were evaluated are not collected for research, however, the challenge was addressed by adhering to the inclusion and exclusion criteria for the sample selection. The skeletal malocclusion patterns of the samples were also not evaluated for this study because lateral cephalometric radiographs were not assessed. Furthermore, our sample had more females compared to males, and this cannot be generalized for biologic sex differences. The study findings showed the patients that had no need for treatment categorized by grade 1 of the DHC index showed that the index was not sensitive to patients with mild malocclusion. This exclusion by the index does not imply that those patients do not have malocclusion requiring treatment, but the index did not categorise them for treatment for government institutions with limited funds.

6. Conclusion

Angle's Class I malocclusion was the most prevalent in our study sample compared to Class II and Class III malocclusions. The DHC was successfully used to evaluate the severity of malocclusion with the majority of the sample in Grades 4 and 5, requiring mandatory orthodontic treatment. A high frequency of the occlusal traits included missing teeth, overjet, crossbite, displaced contacts and

overbite.

7. Recommendations

The results of our study showed that most patients on the orthodontic waiting list require mandatory orthodontic treatment. Therefore, it is recommended that DHC be used for placing patients on the waiting list in government funded institutions to ensure that patients with severe malocclusion are prioritised for treatment. Multicentre studies on the prevalence of malocclusion should be firstly conducted in the country of South Africa and also across the continent of Africa for clinicians and policy makers to develop strategies to prevent and manage this anomaly.

8. Data Availability Statement

The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

9. Ethics Approval Statement

Ethical approval was obtained from the University Research Ethics Committee (Reference: 22/2022) to conduct the study.

10. Source of Funding

None.

11. Conflict of Interest

None.

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