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Sengwayo, Nomcebo

2021

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ASSESSMENT OF MALOCCLUSION AND ORTHODONTIC TREATMENT NEEDS OF PATIENTS TREATED BY POSTGRADUATE ORTHODONTIC REGISTRARS USING THE DENTAL AESTHETIC INDEX

Dr Nomcebo Sengwayo
Student Number: 458141

Supervisor
Professor Phumzile Hlongwa, BOH; BDS; MDent (Ortho); PhD

Co-supervisor
Dr Yolanda Malele-Kolisa, BDS, MPH, MDent (Com Dent); PhD

A research report submitted for the partial fulfilment of the degree MSc (Dent), in the Department of Orthodontics, School of Oral Health Sciences, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg.

2021

Declaration

I, Nomcebo Sengwayo declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Science in Dentistry at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



22 November 2021

Dedication

Dedicated to my mother Busie Nobela, sibling Nombulelo Sengwayo and my daughter Nothando Mkhatshwa.

Abstract

Objectives: To assess the prevalence of malocclusion and orthodontic treatment needs of the patients using the Dental Aesthetic Index (DAI).

Materials and Methods: 150 pre-treatment study models were assessed. The DAI score was used to classify malocclusion severity and categorise orthodontic treatment. Stata version 14 was used to analyse the data and all statistical tests were conducted at 5% significance level.

Results: The overall mean DAI score was 54.67 ranging from 16 to 85. Handicapping malocclusion requiring mandatory treatment was 92.67% of the sample. Severe malocclusion was 2%, indicating the need for treatment and Definitive malocclusion was 2%, indicating elective treatment. Minor malocclusion requiring slight or no orthodontic treatment was in 3.33%. Incisal crowding (90%), anterior mandibular overjet (87.33%), and anterior maxillary irregularity (85.33%) were the most observed occlusal problems.

Conclusion: The DAI showed that 96.67% of the sample had malocclusion requiring orthodontic treatment. The index can be recommended for orthodontic needs and treatment prioritization in the public sector.

Acknowledgements

I would like to offer my sincere gratitude to my primary supervisor Professor Phumzile Hlongwa for her unwavering support, patience, motivation, invaluable guidance and believing in me throughout this research.

I would also like to offer my special thanks to my co- supervisor Dr Yolanda Malele-Kolisa for her support, patience and assistance with the statistics and data analysis.

My appreciation to Ms Molebogang Mofokeng, for offering her endless help and time to assist me in whatever I needed at the office.

Finally, a special thanks to all the people who have shown kindness and supported me to complete the research work.

Table of contents

Declaration ii
Dedication iii
Abstract iv
Acknowledgements v
List of Figures ix
List of Tables x
List of Abbreviations and Nomenclature xi
Chapter 1 1
Introduction and Literature Review 1
1.1 Background 1
1.2 Socio-economic status and Malocclusion 2
1.3 Sex and Malocclusion 3
1.4 Age and Malocclusion 3
1.5 Assessment of Malocclusion 3
1.6 Requirements of an ideal index 4
1.7 Qualitative methods of recording malocclusion 4
1.7.1 Angle's classification 4
1.7.2 World Health Organisation (WHO) /FDI Basic Methods 6
1.7.3 Proffit and Ackerman assessment method 6
1.7.4 Björk, Krebs and Solow malocclusion technique 7
1.7.5 Fisk assessment method 7
1.7.6 Sclare assessment method 8
1.7.7 McCall assessment method 8
1.7.8 Stallard assessment method 8
1.8 Quantitative methods of recording malocclusion 9
1.8.1 Dental Aesthetic Index (DAI) 9
1.8.2 The handicapping labio-lingual deviation index (HLDI) 10
1.8.3 Malocclusion severity estimate (MSE) 11
1.8.4 The occlusal index 11

1.8.5 The treatment priority index 12
1.8.6 The Handicapping malocclusion assessment record (HMAR) 12
1.8.7 The index for orthodontic treatment needs (IOTN) 13
1.8.8 Peer assessment rating index (PAR) 13
1.8.9 The index of complexity, outcome, and need (ICON) 14
1.9 Applications of orthodontic treatment need indices. 14
1.10 Statement of purpose 16
1.11 The aim of the study 16
1.12 The objectives of the study 16
Chapter 2 17
Materials and Methods 17
2.1 Study design 17
2.2 Inclusion criteria 17
2.3 Exclusion criteria 17
2.4 Study sample size and study setting 17
2.5 Data collection procedure. 18
2.6 Data analysis 19
2.6.1 Scoring of Dental Aesthetic Index 19
2.6.2 Classification of malocclusion according to DAI score (Table 2.1) 19
2.6.3 Classification of malocclusion using Angle's classification 19
2.6.4 Statistical analysis 20
2.7 Examiner calibrations and reliability 20
2.8 Ethical clearance 20
Chapter 3 22
Results 22
Chapter 4 27
Discussion 27
4.1 Angles classification of malocclusion 27
4.2 Distribution of malocclusion by gender 29
4.3 Distribution of malocclusion according to race 30
4.4 Distribution of the sample according the total DAI score 30
4.5 Dental Aesthetic Index (DAI) Score according to gender 32

4.6 The contribution of measured occlusal traits to DAI 33
4.6.1 Anterior missing teeth 33
4.6.2 Incisal segment crowding 34
4.6.3 Incisal segment spacing 34
4.6.4 Midline diastema 35
4.6.5 Maxillary anterior irregularity 35
4.6.6 Mandibular anterior irregularity 36
4.6.7 Anterior maxillary overjet 36
4.6.8 Anterior mandibular overjet 37
4.6.9 Anterior open bite 37
4.6.10 Antero-posterior molar relationship 38
4.7 Limitation of the Study 38
Chapter 5 39
Conclusions and Recommendations 39
Chapter 6 41
References 41
Appendices 52
Appendix A: Modified Dental Aesthetic Index (DAI) Form 52
Appendix B: Ethical clearance Certificate 53
Appendix C: Permission from the CEO 54
Appendix D: Approval letter from HOD of Orthodontics 55
Appendix E: Turn it in 57

List of Figures

Figure 2. 1: Orthodontic caliper 18
Figure 3. 1: Distribution of malocclusion based on gender……..23
Figure 3. 2: Distribution of malocclusion according to race…….....24
Figure 3. 3: Distribution of the sample according the total DAI score……25

List of Tables

Table 2. 1: DAI score categories……19
Table 3. 1: Mean age and DAI score of the sample…….....22
Table 3. 2: Angles classification of malocclusion……22
Table 3. 3: Dental Aesthetic Index (DAI) Score according to gender……..25
Table 3. 4: Malocclusion traits according to DAI component……26

List of Abbreviations and Nomenclature

AAO	American Association of Orthodontists
AC	Aesthetic Component
DAI	Dental Aesthetic Index
DHC	Dental Health Component
FDI	Federation Dentaire International
HLDI	Handicapping Labio-lingual Deviation Index
HMAR	Handicapping Malocclusion Assessment Records
ICON	Need for Orthodontic Treatment Index
IOTN	Index of Complexity, Outcome and Need
MSE	Malocclusion severity estimate
n	Frequency
NS	Nomcebo Sengwayo
OI	Occlusal Index
PAR	Peer assessment rating index
PH	Phumzile Hlongwa
SD	Standard Deviation
TPI	Treatment Priority Index
WHO	World Health Organization
WOHC	Wits Oral Health Centre

Chapter 1

Introduction and Literature Review

1.1 Background

The facial features such as the mouth, smile and the face have a major impact on judgement concerning facial attraction(Bhatia et al., 2016, Sardenberg et al., 2013). Malocclusion is neither a disease nor is it a fatal illness, but is a developmental disorder due to several factors such as irregular teeth as well as craniofacial growth abnormalities. There is a high predominance of malocclusion in children that has been reported by the world health epidemiological survey(Simões et al., 2017).

Malocclusion is a treatable and preventable condition(Sardenberg et al., 2013) and is ranked third amongst oral conditions in South Africa after periodontal disease and dental caries prevalence(Dutra et al., 2018). The temporomandibular joint problem, traumatic dental injuries, increase risk of dental caries and periodontal health also influence malocclusion(Anthony et al., 2018).

The causes of malocclusion are multifactorial and can include genetic and environmental factors together with various harmful oral habits. Class II malocclusion, excessive overjet and posterior cross bite are the most common type of malocclusion. Crowding is mostly common in adolescent and children due to space deficiency in the dental arches(Dimberg et al., 2015).

Malocclusion can affect the aesthetics and psychosocial behaviour of adolescents, thus affecting their self-confidence and the ability to socialize(Obilade et al., 2016, Simões et al., 2017).There is an increased awareness for dental appearance as the children reach maturity, as a result, their self- esteem and social interaction is affected when their dental appearance is not socially acceptable(Anthony et al., 2018).

Simoes and co-workers reported that children experience bullying and teasing from others because of the appearance of their teeth(Simões et al., 2017). The severity and

the prevalence of malocclusion is greater in permanent dentition compared to transitional dentition, epidemiological studies have reported a range from 10.0% to 90.0%(Guimarães et al., 2018).

Children with severe malocclusion experience more negative effects when comparing to those children with none or mild malocclusions(Anthony et al., 2018). Malocclusion can be treated by straightening of teeth through orthodontic treatment, which is an elective and expensive procedure that is not readily available in public healthcare except in some tertiary institution(Anthony et al., 2018, Sardenberg et al., 2013).

Some people with serious malocclusion are happy with their teeth appearance, while others tend to worry with minor irregularities(Silva et al., 2016).The majority of orthodontic patients are children, even though it has now been identified that a lot of adults are seeking orthodontic treatment for their malocclusion(Chen et al., 2015).

Orthodontic treatment is required to increase the function, oral health and aesthetics, in order to increase the quality of life in scholars with malocclusion in the anterior section(Dutra et al., 2018, Guimarães et al., 2018).Young adult patients expect orthodontic treatment to improve oral functioning and oral health plus boost their self-esteem and social life(Chen et al., 2015).

1.2 Socio-economic status and Malocclusion

The prevalence of malocclusion reported to be higher in regions with a poorer socioeconomic status(Piovesan et al., 2011, Scapini et al., 2013). The disadvantaged increased risk of harm to their oral health and being unable to seek early dental treatment. The study confirmed there is a negative impact on the dental clinical status of socioeconomically disadvantaged children(Scapini et al., 2013).

Studies done in Brazil and reported that 69.0% of the people are not able to take pleasure in the benefits of treatment because of the financial expenses involved(Guimaraes et al., 2018; Sardenberg et al., 2013). Many patients with lower socioeconomic status cannot afford private orthodontic treatment and many of the government training institution place patients on the waiting list, due to high demand for orthodontic treatment and fewer resources(Maumela & Hlongwa, 2012).

1.3 Sex and Malocclusion

The study by Dalaie and co-workers reported that females were 1.22 times more affected by malocclusion compared to males in the oral health related domains and malocclusion affect females in their everyday activities by 1.5 times more than males(Dalaie et al., 2018). Girls have been reported to show an impact on both emotional and social wellbeing but boys showed impact only on emotional wellbeing(Bhatia et al., 2016).

Therefore, sex influences perception with dental appearance as girls reacts more to social expectations of the importance of aesthetics compared to boys.

1.4 Age and Malocclusion

Malocclusion has been reported to have a greater influence on emotional and social well-being of children aged 11–14 years(Bhatia et al., 2016). In the adolescence phase, children become more aware of how they appear; their emotions become vulnerable and unstable. A young adult is a period between teenage years and adulthood when subjects transform from dependent children to independent individuals. By adulthood, individual views of inward and outward world are rather established(Dalaie et al., 2018).

Scapini and co-workers reported that the oral health of schoolchildren with malocclusion was negatively impacted by 30% more than that of those without malocclusion(Scapini et al., 2013). Therefore, different age groups and educational background do not have the same influence towards aesthetics.

1.5 Assessment of Malocclusion

Andrews in 1972 observed six characteristics from patients whose occlusion was considered ideal but had not received orthodontic treatment. These have been defined as “six keys to occlusion”(Andrews, 1972). Any deviations from the ideal occlusion will result in malocclusion. It is important to have a method that is good in assessing malocclusion for the records of severity and the frequency of malocclusion in a population. There are two types of methods for recording and measuring malocclusion(Agarwal and Mathur, 2012).

- ✓ The qualitative method, the occlusal structures are defined and a descriptive classification of the dentition is provided, but the information on the outline and need of treatment is not given. The signs of malocclusion are documented in all or none method because the process of assessing the variables is not outlined in the epidemiology studies of malocclusion(Tang and Wei, 1993).

- ✓ The quantitative method, orthodontic problems can be evaluated on a scale of severity and complexity. It prioritizes the treatment needed. The use of these tools reduces the possibility of bias when evaluating orthodontic diagnosis, complexity, and outcome(Tang and Wei, 1993).

1.6 Requirements of an ideal index(Gupta and Shrestha, 2015)

- ✓ The index has to maintain sensitivity all through the scale.
- ✓ The score has to match up closely using the clinical significance of the stage of the disease it embodies.
- ✓ The value of the index should be regulating to statistical breakdown.
- ✓ The index must be replicable and valid all the time.
- ✓ For the collection of data, the index should be precise and should yield itself to change.
- ✓ Minimum judgment is required during the examination procedure.
- ✓ To evidence a group difference, the examination required should be done rapidly

1.7 Qualitative methods of recording malocclusion

1.7.1 Angle's classification

A method of assessment was published in 1899(Angle, 1899) which was the first classification of malocclusion, based on the relationship of the mesiobuccal cusp of the maxillary first molar and the buccal groove of the mandibular first molar. Malocclusion can be classified into three categories based on their molar relationship.

- Class I malocclusion - The mesio-buccal cusp of the upper first permanent molar occludes in the mesio-buccal groove of the lower first permanent molar.

- Class II malocclusion -The mesio-buccal groove of the first permanent molar occludes after the mesio-buccal cusp of the upper first permanent molar a Class II/division 1 case has an increased overjet > 4 mm, whereas a class II/division 2 case shows a retroclined upper central incisor with an increased overbite.

- Class III malocclusion - occurs when the mesio-buccal groove of the lower first permanent molar occludes before the mesio-buccal cusp of the upper first permanent molar.

Angle's classification of malocclusion has been criticized in many ways. Modification for Angle's Class I and Class III malocclusion was reported by Dewey based on the malposition of anterior teeth in Angle's Class I and III malocclusion(Dewey, 1915). Dewey subdivided Class I malocclusion into five Types: - Class 1, Type 1 indicating crowding of the maxillary anterior teeth; Class 1, Type 2 indicating proclined maxillary incisors; Class 1, Type 3 indicating the presence of an anterior crossbite; Class 1, Type 4 describing the presence of a posterior crossbite; Class 1, Type 5 indicating mesioversion of molars.

Class III malocclusion was subdivided into three types: - Class III, Type 1 describing teeth that are well aligned and dental arches, with anterior biting of teeth at the edge of a relationship; Class III, Type 2 describing crowding of the mandibular incisors; Class III, Type 3 describing crowding of the maxillary incisors; with the maxilla that is underdeveloped and anterior crossbite being present(Dewey, 1915).

Case criticized Angle's method in that it overlooked the association of the teeth and the face, while malocclusions are three-dimensional problems; Angle's system does not consider sagittal deviations anteroposterior(Case, 1921). Nonetheless, Angle developed his system as a prescription of treatment for the classification of molar relationships.

1.7.2 World Health Organisation (WHO) /FDI Basic Methods

The process of assessing occlusal traits was established and tested in the period between 1969 to 1970(Barmes, 1970) and was adopted by Federation Dentaire' Internationale (FDI) Commission on Classification & Statistics for Oral Conditions (COCSTOC) at its 60th annual session in Mexico City in 1972 and published in the International Dental Journal(Baume, 1974). The World Health Organization (WHO) published the final version of the WHO/FDI basic method for recording malocclusions in its bulletin in 1979(Bezroukov et al., 1979). In order to plan for orthodontic services, the valuation method was used to determine the predominance of malocclusions and evaluate the need for treatment.

In 1979 Bezroukov and co-workers recorded five groups of items that are as follows(Bezroukov et al., 1979):

1. Gross anomalies.
2 Spaced condition: diastema, spacing, and crowding.
3.Dentition: supernumerary teeth, absent teeth, ectopic eruption, malformed incisors.
4. Occlusion: A. Maxillary overjet, midline shift, overbite, mandibular overjet, crossbite, open bite in the incisal segment. B. Lateral segment: anteroposterior relations, posterior crossbite, openbite.
5. In order to decide if orthodontic treatment is necessary or doubtful, it must be evaluated individually.

1.7.3 Proffit and Ackerman assessment method

The assessment method was published in 1973(Proffit and Ackerman, 1973) and to overcome Angle's system's major weakness. It also considered the influence of the problem of arch length with or without an impact on the profile.

The classification has taken into consideration the effect of the position of the tooth on facial aesthetics as it covered the vertical plane of space along with the anteroposterior plane. The skeletal and dental problems at the level of individual planes of space are also

covered. The classification is simply a description of the morphologic problems(Proffit and Ackerman, 1973).

There are five methods of measuring malocclusion(Proffit and Ackerman, 1973).

1. Profile: The profile of the lip relative to the chin and nose (concave, convex, straight), mandibular recession, and mandibular prominence.
2. Alignment: Ideal, spacing, crowding, mutilated.
3. Angle's classification: Dental arches and their relationships on the sagittal plane.
4. Crossbite: Dental arches and their relationship in a transverse plane, defined by the buccolingual relationship of posterior teeth.
5. Bite depth: Dental arches in the vertical plane can be determined by the presence or absence of posterior or anterior open bites, posterior collapsed bites, or anterior deep bites.

1.7.4 Björk, Krebs and Solow malocclusion technique

Björk, Krebs, and Solow(Björk et al., 1964)established a thorough technique to record malocclusion in 1964 with items that were clearly defined. A detailed definition of symptoms of malocclusion was registered objectively. Data analyses were obtained by computers(Björk et al., 1964).

There are three parts method of recording malocclusion which are as follows:

1. Abnormalities in the dentition: malalignment of individual teeth, abnormal eruption, tooth irregularities.

2. Abnormalities in space disorders: crowding and spacing.

3. Occlusal irregularities: It consists of an abnormal relationship between the lower and upper dental arches in the transverse, sagittal, and vertical planes(Björk et al., 1964)

1.7.5 Fisk assessment method

The assessment method was developed by Fisk in 1960(Fisk, 1960). The method was used to group patients according to their dental age.

Fisk in 1960 considered three types of planes of space(Fisk, 1960):

1. Anteroposterior relationship: Overjet(mm), angle's classification, negative overjet (mm), and anterior crossbite.
2. Vertical relationship: open bite (mm) and overbite (mm).
3. Transverse relationship: Posterior crossbite.

Labiolingual spread, mutilation postnatal defects, supernumerary teeth, spacing, therapeutic extractions, and congenital defects were included as additional measurements(Fisk, 1960).

1.7.6 Sclare assessment method

The assessment method was developed by Sclare in 1945(Sclare, 1945). There was no definition of the symptoms, just a list of all or nothing. The following specific symptoms of dental malocclusion were recorded as follows(Sclare, 1945):

- ✓ Relationship between molars according to Angle's classification,
- ✓ Constriction of the arch and crowding of the incisors,
- ✓ Constriction of the arch without crowding of the incisors,
- ✓ Crowded incisors with superior protrusion,
- ✓ Superior protrusion without crowding of the incisors,
- ✓ The canines have a prominent labial prominence,
- ✓ Open bite, rotated incisors, crossbite, and lingually positioned incisors.

1.7.7 McCall assessment method

The assessment method was developed by McCall in 1944(McCall, 1944).

The symptoms of malocclusion that were registered include posterior crossbite, molar relationship, tooth displacement, excessive overbite, anterior crowding, constriction of arches, rotated incisors. The symptoms listed above were not defined and were recorded in all or none manner(McCall, 1944).

1.7.8 Stallard assessment method

The assessment method was developed by Stallard in 1932(Stallard, 1932).

They recorded the overall dental status, including some of the symptoms of malocclusion.

Several symptoms of malocclusion were not defined(Stallard, 1932).

1.8 Quantitative methods of recording malocclusion

1.8.1 Dental Aesthetic Index (DAI)

The index was developed in the United States by Cons, Jenny and Kohout in 1986, to address the aesthetic and psychosocial components of malocclusion(Cons et al., 1986). It is an epidemiological index used to identify orthodontic treatment needs and is used as a screening tool to determine treatment priority in resource-constrained government institutions(Cons et al., 1989, Jenny and Cons, 1996, Hlongwa et al., 2004, Maumela and Hlongwa, 2012).

The DAI consist of ten occlusal traits associated with dentofacial anomalies which are: anteroposterior molar relation, anterior open bite, maxillary overjet, crowded incisal segments, spaced incisal segments, anterior maxillary irregularity, anterior mandibular irregularity, midline diastema, mandibular overjet, and missing teeth(Cons et al., 1986). However, the World Health Organization (WHO) has recommended the Dental Aesthetic Index (DAI) to be used for evaluating dentofacial abnormalities in people with permanent dentition((World Health Organization, 1987).

The reason to use DAI instead of other indices is that it is measurable, easy and simple to use, reliable, objective, valid and universally accepted and it does not need to adapt or modify to different cultural and ethnic settings(Garbin et al., 2010).

1.8.1.1 The advantages of DAI(Borzabadi-Farahani, 2011)

- ✓ The index concentrates on patient's perception regarding orthodontic treatment since the patient need to be satisfied with the enhanced aesthetics and function after receiving treatment.
- ✓ The index can be used effectively to identify orthodontic treatment need measurably.
- ✓ It can also be utilized in the mouth of the patient directly and plaster models.
- ✓ The cost and the load can be reduced by training dental auxiliaries, dentists to use the dental aesthetic index.
- ✓ To assess the treatment standard, the index can be used even if it was not developed for that purpose(Tang and Wei, 1993).

- ✓ In the beginning a cut-off point of 36 was suggested by Jenny and co-workers in order to identify handicapping malocclusions.

1.8.1.2 The limitation of DAI

- ✓ The index was developed for patients in permanent dentition and inadequate to assess mixed dentition which makes it difficult to identify cases of malocclusion in its early stages. Therefore it delays early prevention and treatment of patients(Garbin et al., 2010).
- ✓ Furthermore, the index is unable to assess the condition of the soft tissue, dental, osseous and function of stomatognathic system. It focuses on aesthetics and therefore neglects the other occlusal traits such as deep bite, open bite, buccal cross bite, diastema and in so doing limits the comprehensiveness as an assessment tool(Goyal et al., 2013).
- ✓ The index uses a millimeter gauge for measurement and minor error in precision can result in overstated numbers due to index weighting. Due to the fact that this index identifies those with severe malocclusion and those who need orthodontic treatment based on dental aesthetics, finding a cut-off score that suits a particular ethnic group is imperative(Tang and Wei, 1993).
- ✓ During the study, it was observed that the index underestimates the need of orthodontic treatment. Some of the patients that has certain malocclusion traits leading to functional and esthetic impairment are not considered by DAI. It has a strong clinical and subjective need of treatment that were categorized in no-need or elective - need" categories(Goyal et al., 2013).

1.8.2 The handicapping labio-lingual deviation index (HLDI)

Draker developed the index in 1960(Draker, 1960). The ability of the HLDI was tested by Carlos to distinguish between handicapping and nonhandicapping malocclusion. The orthodontist made a clinical judgment to make it a standard. The HLDI scores distribution showed the index was not capable to make a distinction on the so-called handicapping malocclusion because of the overlapping of the two groups(Draker, 1960). It consists of twelve features that are weighed and calculated to come up with a score. It substitutes

clinical judgment when screening subjects with handicapping anomalies. Gray and Demirjian in 1977 noted that the HLD Index tends to identify only the very worst cases (Gray and Demirjian, 1977).

1.8.3 Malocclusion severity estimate (MSE)

The index was developed by Grainger in 1960(Grainger, 1960) which can be used on both patients and study models. The validity of the index was obtained by comparing the study sample index scores with the clinical standards. These occlusions were grouped difficulty of treatment, aesthetics, and function by one public health dentist and five orthodontists. However, the MSE had limitations which are as follow(Grainger, 1960)

- ✓ MSE score does not reveal all the accumulated measurements.
- ✓ The results might not be valid for mixed and deciduous dentitions because data was derived from 12-year old patients.
- ✓ The MSE was revised and was named the treatment priority index because occlusal disorders which were not scored as zero were absent.

1.8.4 The occlusal index

Summers developed the index in 1966(Summers, 1966) and was used to measure malocclusion and occlusion for epidemiological studies. The index should be valid and reliable. The index could identify people that need treatment and the ones who do not need treatment.

The scoring scheme is different for permanent, mixed, and deciduous dentition. It consists of nine occlusal traits which are weighed and defined measurements. The occlusal traits are as follows; overjet, overbite midline relation, posterior crossbite, maxillary median diastema, posterior open bite, congenitally missing maxillary incisors, displacement molar relation(Summers, 1966).

It also consists of seven malocclusion syndromes which are as follows(Summers, 1966);

i. Open bite and overjet,
ii. Midline deviation, midline diastema, posterior crossbite, overjet, overbite, and distal molar relation,

iii. Missing congenital maxillary incisors,
iv. Tooth displacement,
v. An analysis of mixed dentition, mesial molar relation, and tooth displacement
vi. Posterior open bite
vii. Overjet, posterior crossbite, overbite, deviation of the midline, and mesial-molar relationship.

1.8.5 The treatment priority index

The index was developed by Grainger in 1967(Grainger, 1967) and was used to assess the types of malocclusion that are most common hence it provides the means of patient's status according to the degree of handicap, the severity of malocclusion, and their treatment priority. It also consists of seven malocclusion syndrome which are retrognathism, maxillary collapse syndrome, congenitally missing incisors, maxillary expansion syndrome, overbite, open bite, prognathism(Grainger, 1967).

Grainger defined the prerequisite for determining a handicap as follows(Grainger, 1967):

- ✓ Speech impairment
- ✓ Major reduction in masticatory function
- ✓ Unstable occlusion
- ✓ Unacceptable aesthetics
- ✓ Traumatic disorder affecting tissue damage
- ✓ Traumatic or gross defects

The index excluded malocclusion as slight asymmetry and midline diastema because of the less importance of public health, therefore measurements are done indirectly or from study models clinically(Grainger, 1967).

1.8.6 The Handicapping malocclusion assessment record (HMAR)

The index was developed by Salzmann in 1968(Salzmann, 1968). The purpose for the development of (HMAR) was to make means available for creating the main concern for handicapping malocclusion. Handicapping dentofacial deformity as well as handicapping

malocclusion were defined as disorders that make oral health maintenance a problem and speech and dentofacial aesthetics are affected, thus affecting the well-being of the patient(Salzmann, 1968).

The index consists of three-part of weighted measurements as follows(Salzmann, 1968):

- ✓ Deviation of the inter-arch: Overbite, overjet, mesiodistal deviation, and open bite.
- ✓ Deviation of the intra-arch: Missing teeth, rotations, crowding, and spacing.
- ✓ Six handicapping dentofacial deformities: Oral clefts and facial, occlusal interferences, facial asymmetry, speech impairment, and functional jaw limitation.

1.8.7 The index for orthodontic treatment needs (IOTN)

The index was developed by Brook & Shaw in 1989(Brook and Shaw, 1989). The IOTN has an aesthetic component as well as a dental health component.

- ✓ The **dental health component** comprises five grades of the need of treatment, which are from Grade 1-5; none, little, moderate, great and very great. Based on the cut-off points established for each occlusal trait, there is a calculable risk to the dentition(Brook and Shaw, 1989).
- ✓ The **esthetic component** assesses and records the aesthetic impairment presented by malocclusion. During a multidisciplinary survey, 1000 dental photographs of a 12-year old were collected to form the index. The photographs were graded by six non-dental judges on a visual scale and a 10-point scale were provided from 0.5 which represents the appearance of the teeth to be attractive to 5.0 which represents dental appearance to be unattractive(Brook and Shaw, 1989).

1.8.8 Peer assessment rating index (PAR)

- ✓ The index was introduced by Richmond in 1992(Richmond et al., 1992). It is a method used to determine the effectiveness of treatment for malocclusions and to evaluate the effectiveness of orthodontics. On a series of measurements, there is

one score provided that considers the degree a case's deviation from normal occlusion and alignment.

- ✓ This index is a reliable and valid instrument used to measure malocclusion on patients and dental study models. In orthodontics, the index score was reduced and used to assess improvement in an overall alignment and occlusion of a patient(Richmond et al., 1992).

1.8.9 The index of complexity, outcome, and need (ICON)

It was developed by Richmond & Daniel in 2000(Daniels and Richmond, 2000). ICON is used to evaluate the output and input of treatment with one set of occlusal traits.

Occlusal trait scores consist of impacted teeth, anterior vertical relationship, upper and lower segment alignment, missing teeth, buccal segment AP relationship, upper and lower buccal segment alignment, crossbite, buccal segment vertical relationship(Daniels and Richmond, 2000).

The index was used to compare treatment starting points at different countries and used for orthodontic quality assurance standards. An international panel of 97 orthodontists evaluated 98 treated study models and 240 different samples initially performed with respect to treatment need, improvement of treatment, and acceptability(Daniels and Richmond, 2000).

The index was intended to be used in late mixed dentition onwards because of the difficultly of evaluating aesthetics during transitional stages. The index is considered to be a reliable and highly valid method because it was easy to apply clinically and on dental casts. When it is applied, each case takes about 1 minute and as a result, is reasonably quick(Daniels and Richmond, 2000).

1.9 Applications of orthodontic treatment need indices.

Borzabadi-Farahani conducted a study in 2011 to assess the evidence on four indices of orthodontic treatment need and created a classification system that supports the orthodontic profession in many ways(Borzabadi-Farahani, 2011).

- ✓ **Increasing confidence in the orthodontic specialty.** The use of orthodontic treatment indices by dentists and dental specialists assists in identifying and referring orthodontic patients. This gives assurance to the orthodontic specialty which reduces the biases of orthodontic referrals.
- ✓ **Allocation of resources and planning of manpower**. One of the main concerns for insurance decision makers as well as public health providers is who needs to be offered the state subsidized treatment? Establishing thresholds for orthodontic treatment indices and treatment eligibility guidelines are important in addressing this issue. This guarantees that funds will be allocated appropriately, particularly to the most in need.
- ✓ **Assess the relationship between malocclusion and other medical or dental conditions.** Associated medical and dental problems with malocclusion should be assessed. For example the ICON index(Daniels and Richmond, 2000) has a scale that provide more information such as masticatory function, periodontal status, caries experience and dental trauma.
- ✓ **Analysis of orthodontic treatment outcomes and clinical performance.** The goal at the national, institutional, and individual level is to ensure high standards of orthodontic care. Hence, follow up on the treatment outcome and assess the acceptability of the outcome is crucial. It has been shown that the ICON(Daniels and Richmond, 2000) is more accurate in identifying failures of treatment than the PAR index(Richmond et al., 1992). In orthodontic lawsuits, this feature is useful.
- ✓ **Evaluation of orthodontic treatment complexity and informed consent**. This will assist in identifying individuals needing surgical intervention and those needing the hospital for treatment. General dentists can treat patients with minor problems. Orthodontic treatment need indices such as ICON(Daniels and Richmond, 2000) can be used to identify complex malocclusion. Typically, these kinds of malocclusion get a greater score and the outcome can become worse if treatment is not given by the skilled clinician in the right setting.
- ✓ **Evaluation of orthodontic treatment's cost-effectiveness.** Health care providers are mostly interested in cost effectiveness especially if funded publicly

or insurance-based services. A patient that pays for his treatment is in the interest of both the patient and the physician. An increase in practitioner profits is the result of improved cost efficiency, lower patient costs, and allows more patients to receive orthodontic treatment through public funding(Deans et al., 2009). A valid and reliable way to measure the success of orthodontic treatment is through orthodontic indices(Shaw et al., 1991) and is used to conduct cost-benefit studies(Deans et al., 2009, Richmond et al., 2005) The ICON(Daniels and Richmond, 2000) is used to compare different operators and clinics and to conduct quality assurance assessments.

1.10 Statement of purpose

The purpose of the study was to investigate the use of Dental Aesthetic Index(DAI) as a screening device to assess the severity of malocclusion and identify the need for orthodontic treatment of patients treated by orthodontic registrars Wits Oral Health Centre. Since resources are limited in our government training institutions and unable to meet the demand of the patients, therefore DAI could be used to prioritize funded orthodontic treatment in public health programs.

1.11 The aim of the study

The study aim was to assess the severity of malocclusion and the need for orthodontic treatment of patients treated by orthodontic registrars using Dental Aesthetic Index (DAI) at Wits Oral Health Centre (WOHC), University of the Witwatersrand.

1.12 The objectives of the study

1. To determine the types of malocclusion among patients at WOHC.
2. To assess the distribution of malocclusion by gender and race.
3. To assess how each measured occlusal trait contributes to the DAI.

Chapter 2

Materials and Methods

2.1 Study design

This retrospective cross-sectional study, reviewed records and study model from 1 January 2016 to 31 December 2019. This study period was chosen as it coincides with the cohort of registrars and their records were readily available and accessible at the Department of Orthodontics.

2.2 Inclusion criteria

- ✓ Pre-treatment study models with bite registration were used in the study.
- ✓ Study models of great accuracy and properly trimmed according to recognized standards and norms(Aldabagh et al., 2018) were used in the study. This was determined by the principal investigator according to the guidelines given by Aldabagh et al., 2018.

2.3 Exclusion criteria

- ✓ Patient records with severe craniofacial anomalies, such as cleft lip and palate, were not included in the study.
- ✓ Absence of wax bite, making the occlusal relationships of the models uncertain, therefore those study models were excluded.
- ✓ Models with broken teeth were also excluded in the study.

2.4 Study sample size and study setting

A minimum of 70 patients were seen by each of the four registrars at the WOHC over a period of four years. To conduct the study during the chosen period, sample-size calculations based on 95% power and an alpha .05 alpha indicated that 163 records with study models were needed(Raosoft, 1996). The study sample comprised of 150 pre-treatment study models of patients with permanent dentition which were randomly selected from the archived records of the Department of Orthodontics, Wits Oral Health Centre, University of the Witwatersrand. Each study model was allocated a number from

1 to 200 and the computer-generator random number was used to generate the unpredictable random 150 numbers.

2.5 Data collection procedure.

Each pair of study model was assigned with a unique number for anonymity of the data. The DAI form (Appendix A) was modified to incorporate demographic information including age, gender, race and the Angle's classification. Each study model was assessed and scored according to the ten components of DAI.

Each pair of study model was measured twice on a flat surface using an orthodontic caliper as shown in Figure 2.1 to measure each occlusal traits in millimeters. The two measured scores were added and the average was recorded on the Dental Aesthetic Index form (Appendix A). The DAI score was calculated by multiplying the occlusal trait measurement by the weight and the constant(Cons et al., 1986).

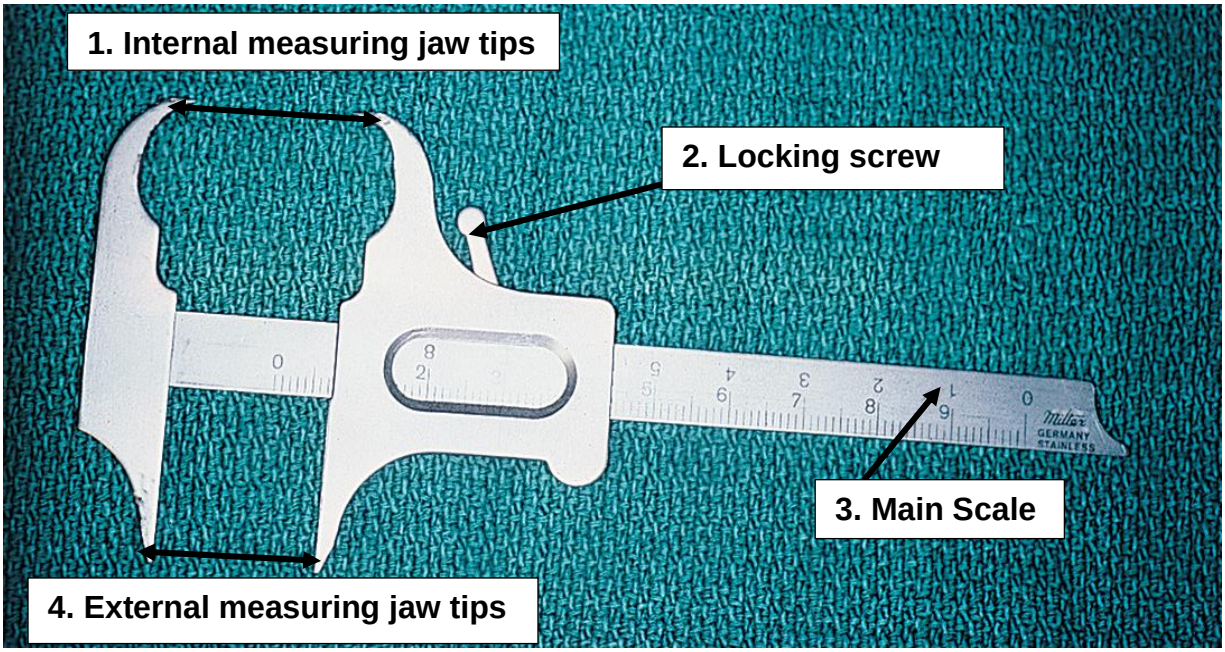


Figure 2. 1: **Orthodontic caliper**

The calliper consists of an internal and external measuring jaw tips (Numbers 1 and 4) which was used to measure the tooth size and distance of spaces. On the study models, the mesiodistal widths of teeth were measured using the external measuring jaw tips (Number 4). After the measurement was taken, the locking screw (number 2) was tightened to ensure that the external measuring jaw tip remained in place until the measurement was recorded.

2.6 Data analysis

2.6.1 Scoring of Dental Aesthetic Index

Dentofacial anomalies were measured in millimetres, multiplied by the weight and the constant is added to get the total DAI score(Cons et al., 1986). DAI recognises occlusal traits and mathematically comes a single score. The regression equation for obtaining a DAI score is DAI score (Appendix A) = **6** x Missing Visible Teeth + **1** X Crowding + **1** x Spacing + **3 x** Diastema + **1 x** Largest Upper Anterior Irregularity + **1** x Largest Lower Anterior Irregularity + **2** x Anterior Maxillary Overjet + **4** x Largest Mandibular Overjet + **4** x Vertical Anterior Open bite + **3** X Antero-Posterior Molar Relation + **13** (a constant number).

2.6.2 Classification of malocclusion according to DAI score (Table 2.1)

As shown in Table 2.1, (1) DAI ≤ 25 – indicated normal occlusion or minor malocclusion, showing that orthodontic treatment is unnecessary; (2) DAI = 26-30 – indicated definitive malocclusion, thus orthodontic treatment is elective; (3) DAI = 31-35 – indicated severe malocclusion, therefore, orthodontic treatment is needed and (4) DAI ≥ 36 – indicated severe/ handicapping malocclusion, and orthodontic treatment is mandatory.

***Table 2. 1*: DAI score categories**

DAI Score	***Malocclusion Severity***	***Orthodontic treatment needs***
≤25	Minor or no anomaly	No treatment or slight treatment
26-30	Definitive malocclusion	Elective treatment
31-35	Severe malocclusion	Need treatment
≥36	Handicapping malocclusion	Treatment mandatory

2.6.3 Classification of malocclusion using Angle's classification

Classification of malocclusion of the sample was assessed according to Angle's classification system(Angle, 1899). Malocclusion was classified into 3 classes, and

Dewey's modifications for Class I and Class III malocclusion was not used as they are incorporated in the DAI.

2.6.4 Statistical analysis

Data was captured from the DAI form (Appendix A) and entered into Microsoft excel. The clean data was summarised and all statistical analyses were done using Stata/SE 14.0 to summarise into frequencies, percentages, means and standard deviation. The data was normally distributed and the T-tests and CHI squared tests was used to calculate factors associated with malocclusion. All statistical tests were conducted at $p \leq 0.05$ and 95% CI levels to determine significance.

2.7 Examiner calibrations and reliability

Preliminary calibration exercises for the Principal Investigator (NS) was undertaken to familiarize the examiner with the DAI administrative forms and the instructions was set out in the guideline of measurement tools. Ten pre-treatment study models of orthodontic patients in the permanent dentition stage, not included in this study, were carefully chosen from the archived records of the Department of Orthodontics, University of Witwatersrand, for calibrating the examiner on the use of the DAI. The examiner was calibrated by one of the supervisors (PH) who has been calibrated in the use of DAI, until the level of agreement was attained.

Repeated measurements of the 10% of the study sample was re-examined by the PI (NS), two weeks after the initial measurements, to check for the intra-examiner reliability of the method using interclass correlation. One of the supervisors (PH) also measured the DAI scores of these records to evaluate the inter-examiner reliability. The level of agreement attained for the intra-examiner reliability was (Kappa score of 0.9) and the inter-examiner reliability score was (Kappa score of 0.8).

2.8 Ethical clearance

Ethical approval to conduct the study was obtained from the Human Research Ethics Committee, Medical (HREC) of the University of Witwatersrand, Johannesburg (approval

number: M200734 - Appendix B). The permission to access clinical records for the research was also obtained from the CEO (Appendix C) and Head of Department of Orthodontics (Appendix D) at the School of Oral Health Science. Study models of patients were used for the Dental Aesthetic Index (DAI) therefore consent was not obtained as this was a record review. However, all patient records were given unique codes, and no personal identifiable information was recorded. Security of data collected was managed and all information was stored in a password protected computer accessible to the PI.

Chapter 3

Results

The study sample comprised of 150 pre-treatment orthodontic study models which were assessed. The majority of the sample were females at 56.67% (n=85) and males were 43.33% (n= 65). The mean age was 18.22 years old (SD ± 6.05) and ranging from 9 to 46 years old. The skewness/kurtosis test and the shapiro-wilk W test was done to calculate the distribution of the sample age. The shapiro-wilk W test result was 0.83 and the skewness/kurtosis test result was 0.00. Therefore, this study sample mean age was evenly distributed. The overall mean DAI score of this sample was 54.67 (SD ±13, 06) ranging from 16 to 85 (Table 3.1).

Table 3. 1: **Mean age and DAI score of the sample**

Variable	***Observation***	***Mean***	***Standard deviation***	***Minimum***	***Maximum***
AGE	150	18.22	6.057	9	46
Total DAI Score	150	54.67	13.068	16	85

The sample's classification of malocclusion

Classification of malocclusion of the sample according to Angle's classification is shown in Table 3.2. The majority (n=112, 74.67%) of study sample had a Class I malocclusion.

Table 3. 2: **Angles classification of malocclusion**

Malocclusion classification	**Frequency (n)***	**Percentage (%)**
Class I malocclusion	112	74.67
Class II malocclusion	26	17.33
Class III malocclusion	12	8.00
Total	150	100

Distribution of malocclusion by gender.

Females had significantly higher number of Class I and II malocclusion compared to the males. However, Class III malocclusion was similar amongst the males and females as presented in Figure 3.1. The males had significantly lower number of malocclusion compared to the females. The result showed no statistically significant differences between the genders in Class II and Class III malocclusion (Pr = 0.824; p ≥ 0.05).

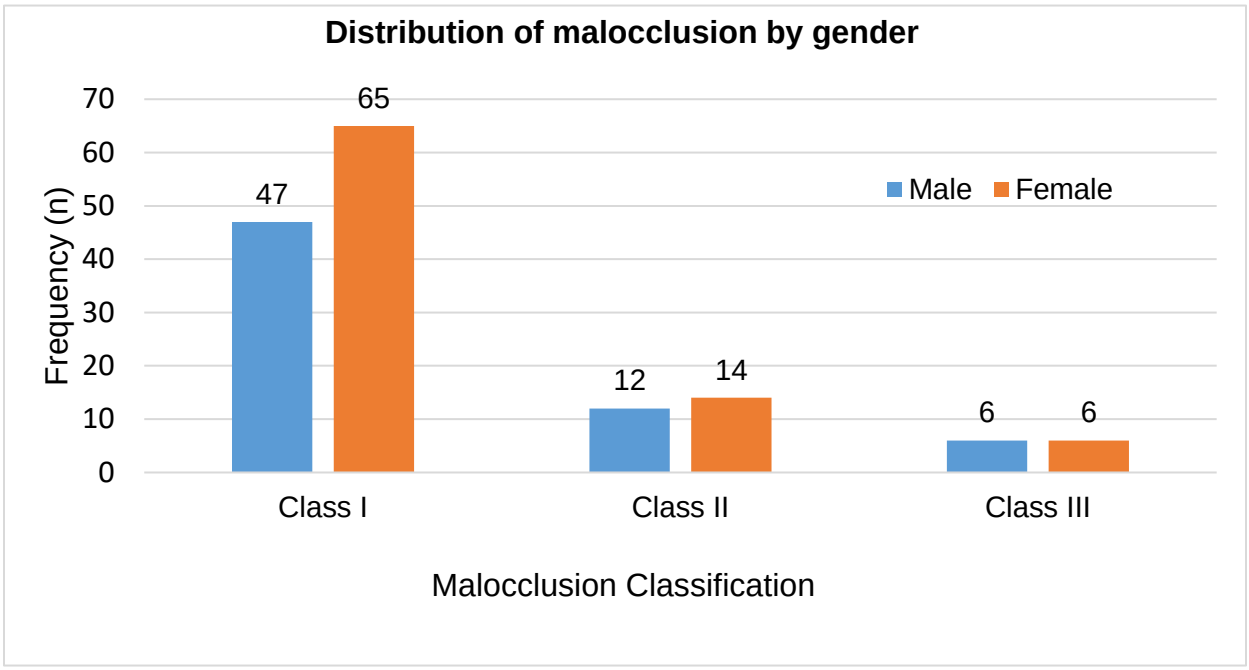


Figure 3. 1: **Distribution of malocclusion based on gender.**

Distribution of malocclusion based on race

Distribution of malocclusion according to race is shown in Figure 3.2. Africans had predominantly higher number of malocclusion compare to Whites, Indian and Coloured races. Class I malocclusion was the most commonly found amongst all the races and the distribution was higher in Africans, Coloured, Indians, and White. The result showed no statistically significant differences between the frequency of Class I malocclusion amongst the Whites, Indian and Coloured races (Pr = 0.702; p ≥ 0.05).

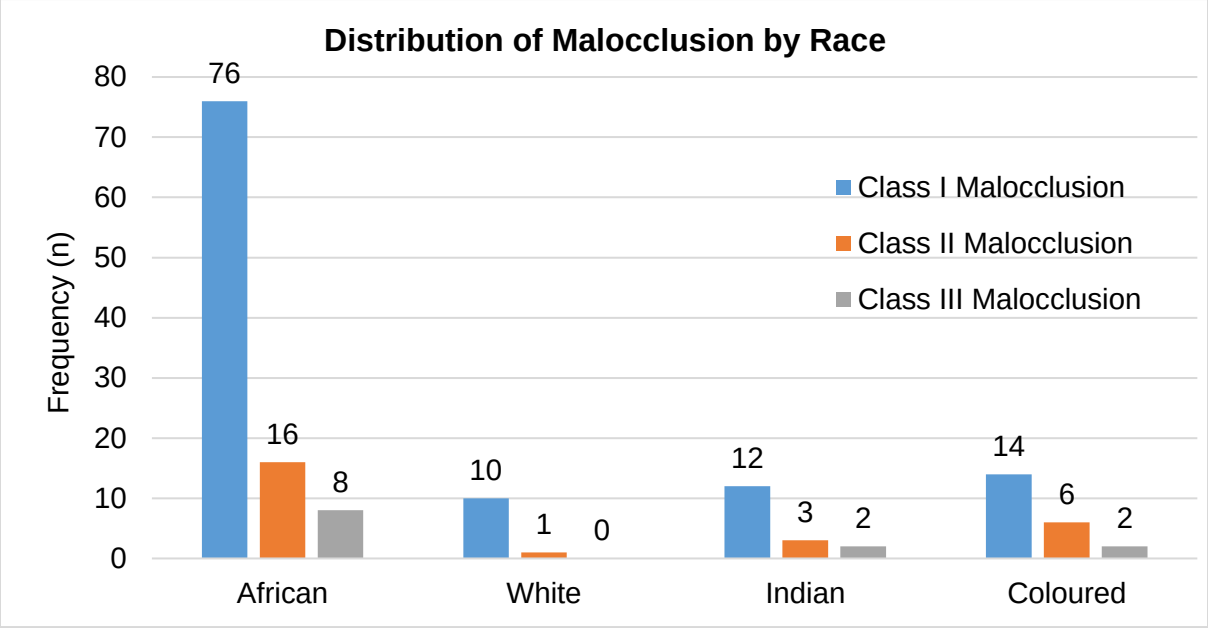


Figure 3. 2: **Distribution of malocclusion according to race**

Distribution of the sample according the total DAI score

The results presented in Figure 3.3 show that majority (n=139, 92.67%) of the study sample had handicapping malocclusion and required mandatory treatment. Only (n=5, 3.33%) of the study sample had minor malocclusion and required no or slight orthodontic treatment.

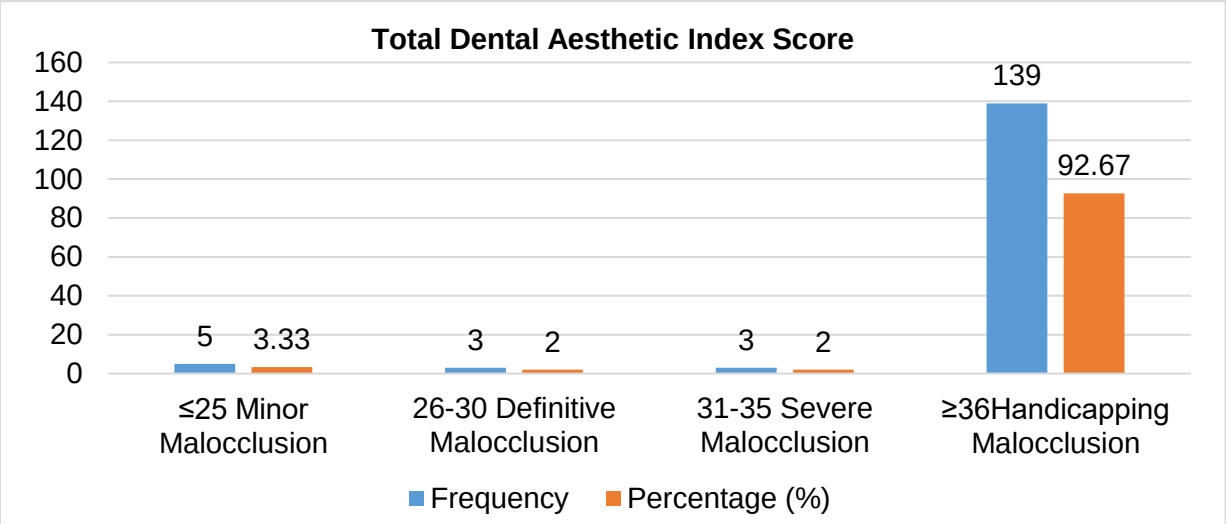


Figure 3.3: **Distribution of the sample according the total DAI score**

Dental Aesthetic Index (DAI) Score according to gender

The results presented in Table 3.3 show that there was a higher number of female that had handicapping malocclusion and required mandatory treatment compared to males. There were three female and two male patients that were not in need of any orthodontic treatment. The results also showed no statistically significant difference between the sexes in terms of treatment need (Pr = 0.139; p ≥ 0.05; Pearson chi2= 5.4880).

Table 3. 3: **Dental Aesthetic Index (DAI) Score according to gender**

Gender	***No treatment (n)***	***Elective treatment (n)***	***Need treatment (n)***	***Mandatory treatment (n)***
Male	2	0	3	59
Female	3	3	0	80
Total	5	3	3	139

Distribution of 10 occlusal traits according to DAI components

The results presented at Table 3.4 show that dental crowding was the most common occlusal traits (n=135, 90%), followed by increased anterior mandibular overjet and the least commonly found was vertical anterior open bite (n=13, 8.67%).

***Table 3. 4*: Malocclusion traits according to DAI components**

DAI Component	***Frequency(n=150)***	***Percentage (%)***
Crowding	135	90.00
Anterior mandibular overjet	131	87.33
Anterior maxillary irregularity	128	85.33
Anterior maxillary overjet	124	82.67
Molar relationship	124	82.67
Anterior mandibular irregularity	110	73.33
Spacing	37	24.67
Midline diastema	35	23.33
Number of missing visible teeth	22	14.67
Vertical anterior openbite	13	8.67

Chapter 4

Discussion

This study has evaluated the prevalence of malocclusion from patients treated by postgraduate students at a university dental hospital and found that a very high number of patients (n=139, 92.67%) had handicapping malocclusion. The results were expected because the WOHC Orthodontic Department is centre for specialised orthodontic care where patients are referred by general dental practitioners or clinics. The results corroborate the findings in literature where it was noted that orthodontic care is mostly available at tertiary institutions(Anthony et al., 2018, Sardenberg et al., 2013) and registrars also select difficult cases to benefit their training hence the high score.

The results may also highlight the selection bias(Hernán et al., 2004, Winship and Mare, 1992). An extreme and severe case of the condition will be seen in a specialised centre as opposed to community or primary health care centre. The results also show that five participants did not need orthodontic care, this might be attributed to overzealous screening procedures, it is however a very small number.

Thilander in 2001 recommended that a study on the frequency of malocclusion require a selection of a well-defined sample, without a previous past of orthodontic treatment as well as independent collection of data(Thilander, 2001). As a result, the sample in this study was collected from a well-defined sample of pre-orthodontic treatment, therefore, our sample selection was in accordance with the recommended criteria.

4.1 Angles classification of malocclusion

The most common type of malocclusion found in this study sample was Class I malocclusion with a frequency of 112 (74.67%) followed by Class II malocclusion with a frequency of 26 (17.33%) and the least common type was Class III malocclusion with frequency of 12 (8.00%). Results in this study are similar to other studies conducted in South Africa(Drummond, 2004, Hirschowitz et al., 1981) and studies conducted in other countries such as Brazil, Morocco, and Nigeria(Borzabadi-Farahani et al., 2012, Garbin

et al., 2010, Onyeaso, 2004b) which shows that indeed malocclusion is a public health problem as it is common in non-special samples.

This study finding showed a higher predominance of Class I malocclusion which is similar to previous study done by Hirschowitz and co-workers in 1981. They evaluated 12-year-old school children from Soweto to determine the dental status from a lower socio-economic group. Their findings reported that 79.5 % of the children had Class I malocclusion; 12.4% had Class II malocclusion and 9% had Class III malocclusion(Hirschowitz et al., 1981). Even though Hirschowitz and co-workers looked at 12-year-old, this study sample mean age was 18 years old, however the range was between 9 to 45 years old indicating that malocclusion affects all age groups. Furthermore, the children that were part of this study sample come from all around Gauteng Province including Soweto.

Similarly, high predominance of Class I malocclusion was also reported among 12-year-old school children in South Africa by Drummond in 2004. The author evaluated the prevalence of malocclusion and the need of orthodontic treatment using the Dental Aesthetic Index. The presence of malocclusion was recorded as Class I on 79.5 %, Class II on 12.4 % and 9 % had Class III malocclusion(Drummond, 2004). Their study sample in the 9 provinces of South Africa was similar to this study sample age ranging between 9 to 45 years old.

An epidemiological study done by Garbin et al., in 2010 assessed the prevalence of malocclusions and treatment need among 12-year-old children at São Paulo state, Brazil. The prevalence of malocclusion was 66.76 % while the normal occlusion was 33.25 %. They recorded Class I malocclusion on 55.92 % which was higher than Class II on 42.86 % and Class III was 1.22 %(Garbin et al., 2010). This study used both Angle's classification and the Dental Aesthetic Index and their results on the prevalence of malocclusion was similar to this study finding.

In a 2012 study , Bourzgui and co-authors found a prevalence of 61.4% of the children had Class I malocclusion, Class II was 24% and Class III was 10%(Bourzgui et al., 2012).These findings were similar to our study results with a predominance of Class I malocclusion. While in contrast, a Nigeria study by Onyeaso et al. in 2004 found lower malocclusion prevalence amongst 12 to 17 years old of 50% for Class I, 14% was Class II, and 12% was Class III(Onyeaso, 2004a), the high predominance of Class I malocclusion in this study was in concordance with our study findings.

4.2 Distribution of malocclusion by gender

The results presented in Figure 3.1 show that the majority of females had Class I malocclusion (n=65; 58.04%) compared to males (n= 47; 41.96%). Class III malocclusion was similar amongst the males and females (n=6; 50%). The results of the current study were expected as it has been reported that females tend to be concerned about aesthetics, their dental appearance and social acceptability compared to males(Dalaie et al., 2018). Males are reported to be less in secured about their appearance(Anthony et al., 2018, Masood et al., 2013). Furthermore, parents seem to seek orthodontic treatment for their female children more than male children(Masood et al., 2013). Therefore, females react more to social expectations on the importance of aesthetics compared to males. Similar results to this study findings have been reported(Alogaibi et al., 2020, Jacobson, 1967, Mtaya et al., 2009, Sundareswaran and Kizhakool, 2019).

A 1967 study by Jacobson at the Department of Anatomy of the University of the Witwatersrand, Johannesburg examined 460 crania and mandibles of black South African. The study sample were adults, between the ages of 16 and 108 years. Their result showed 97.4% of females and 96.4% of males to have Class I malocclusion, While Class II malocclusion was recorded in less than 3% of the sample in both sexes(Jacobson, 1967). The selected study sample of this study was from a tertiary institution which was similar to this study.

Alogaibi et al., in 2020 reported similar results to this study findings, when assessing malocclusion prevalence and orthodontic treatment in Saudi of Jeddah City among 14 to 18 years old. They reported Class I malocclusion as the most prevalent in females with 34% and males with 23%, Class II malocclusion in males 11.5% and females 5.7% and Class III in males 9.5% and females 4.5%(Alogaibi et al., 2020).

Similarly, Sundareswaran and Kizhakool in 2019 assessed the distribution of malocclusion among adolescents, aged between 13 to 15 years old of Kerala, South India. Their results showed a higher prevalence on females 76.6% with Class I malocclusion compared to males, Class II malocclusion showed males to have a higher prevalence with 5.9% and also Class III with an increased prevalence among males 8%(Sundareswaran and Kizhakool, 2019).

4.3 Distribution of malocclusion according to race

The results presented in Figure 3.2 show malocclusions and their distribution by race. Angle's Class I malocclusion in Africans (n=76; 67.86%) was higher compare to other races. Similar result to our current study findings were reported by Alhammadi et al. in 2018. They assessed the prevalence and distribution of malocclusion traits in Saudi Arabia. Their result showed Class I malocclusion to have the highest prevalence in African (89.44%). However, Class II and Class III malocclusion were lowest compared to other race(Alhammadi et al., 2018) which was similar to this study findings.

4.4 Distribution of the sample according the total DAI score

The results presented in Figure 3.3 show that our sample had a majority of the patients with handicapping malocclusion (n=139; 92.67%) and required mandatory treatment. Patients with definitive and severe malocclusion were (n= 3; 2%) and their treatment was elective or necessary. Those that requires no or slight orthodontic treatment were (n=5; 3.33%) which had minor malocclusion. The higher number of patient with handicapping malocclusion in our study was due to the fact that orthodontic treatment in this sample was provided by registrars, who are training to be orthodontic specialist. It is reported that

orthodontist specialist in private practice make treatment too costly(Thilander, 2001). In South Africa, orthodontic treatment is not available in public healthcare except in tertiary institution, but is predominantly offered in private practice.

Similar results to this study findings were reported by other studies(Goyal et al., 2013, Maumela and Hlongwa, 2012, Onyeaso, 2004a, Onyeaso and BeGole, 2006, Poonacha et al., 2010) which selected their samples from study models of patient that were attending orthodontic clinic.

A retrospective study was done in Rwanda by Goyal et al., in 2013 assessing the level of malocclusion severity and orthodontic treatment need of patients treated at the Dental Department of King Faisal Hospital Kigali. They studied 170 pairs of orthodontic study models of patients of both sexes aged 11 to 35 years before treatment. They found that 89% needed orthodontic treatment depending on the levels of severity. Handicapping malocclusion and mandatory treatment was reported in 51% , severe malocclusion and treatment greatly needed was found in 23%, while 11% of their sample needed no treatment(Goyal et al., 2013).

Similarly, a study by Poonacha et al., 2010 in India determined early detection of dental anomalies with the help of DAI and early referral of patients to the orthodontist for better comprehensive care during the growth period in children. They assessed 100 pre-treatment dental study models between the ages of 12 to 14 years old. They found that 3% had no or minor malocclusion which means no or slight treatment was needed and 97% were in need of orthodontic treatment. Out of the 97%, 55% had handicapping malocclusion and needed mandatory treatment. 27% had severe malocclusion and the treatment was desirable, whereas 15% had definitive malocclusion and the treatment required was elective(Poonacha et al., 2010).

Maumela and Hlongwa evaluated the use of the DAI index to prioritize the need for orthodontic services in a government funded institution in 2010. The sample consisted of 120 study models of patients aged between 10 and 45 years old before treatment. They found that 80% needed orthodontic treatment, with 41.7% having handicapping

malocclusion, 21.7% with severe malocclusion while 17.5% had definitive malocclusion and 19.1% had normal or minor malocclusion and need no treatment(Maumela and Hlongwa, 2012).

Similarly, a retrospective cross sectional study conducted in North America by Onyeaso and BeGole in 2006 assessed the need for orthodontic treatment of patients that were treated in an orthodontic clinic using DAI. They examined 100 pre-treatment study models of patients between the ages of 10 to 52 years old. They found that 85% of their sample needed orthodontic treatment depending on their level of malocclusion severity, with 47% having handicapping malocclusion which qualified for mandatory orthodontic treatment, and 15% of the study sample required no or slight need of treatment(Onyeaso and BeGole, 2006).

4.5 Dental Aesthetic Index (DAI) Score according to gender

The results presented in Table 3.3 show that females had a higher prevalence of handicapping malocclusion (n= 80) requiring mandatory orthodontic treatment compared to males with (n= 49). Females that required no or slight treatment were similar to males (n= 3) and (n= 2). Similar results to this study finding were reported by Bourzgui et al., in 2012 following assessing the need for orthodontic treatment among schoolchildren in Casablanca, Morocco. Their result showed that 85.5% of females had handicapping malocclusion and required orthodontic treatment and 17.1% showed minor malocclusion and requiring no or slight treatment. Among males,82.9% required mandatory orthodontic treatment and 14.5% showed no or slight treatment needed(Bourzgui et al., 2012).

Similarly, a Rwandan study by Goyal and co-workers in 2013 evaluated the need for orthodontic treatment using the Dental Aesthetic Index. The result showed that 55%f of females had handicapping malocclusion requiring mandatory treatment, those with severe malocclusion was 23% and treatment was needed, and definite malocclusion was 11% and treatment was elective. Minor malocclusion was found in 10% and they required no or slight orthodontic treatment. Among males with handicapping malocclusion 48% required mandatory treatment and 22% with severe malocclusion needed treatment.

Definite malocclusion was 20% and treatment was elective. Those with minor malocclusion were 11% and they required no or slight orthodontic treatment(Goyal et al., 2013).

A study done in Nigeria by Utomi and Onyeaso in 2015 assessed the need of orthodontic treatment of patients attending a Nigerian Teaching Hospital using Dental Aesthetic Index. Their results showed that 29% of females compared to males with 26.3% had handicapping malocclusion, requiring orthodontic treatment also requiring mandatory orthodontic treatment. Severe malocclusion with treatment extremely necessary was reported on 16.1% of females and 17.6% males. Definitive malocclusion requiring elective treatment and no or slight treatment needs was similar for both males and females(Utomi and Onyeaso, 2015).

4.6 The contribution of measured occlusal traits to DAI

4.6.1 Anterior missing teeth

The number of permanent incisors, canines, and premolars missing in the upper and lower arches in this study finding was 14.67%. The reason for the anterior missing teeth was not investigated in this study, however congenitally absence or unaffordability of treatment making people to choose the minimum expensive treatment, for example extraction in order to relieve their dental problems has been reported(Tak et al., 2013).

Similar results to this study findings were reported by Tak and co-authors with 10.5% of their study sample having one or more anterior missing teeth(Tak et al., 2013). Similarly, Cavalcanti et al., 2013 reported 13% of the missing teeth in their sample(Cavalcanti et al., 2008), whilst a study done in Peru by Bernabé and FloresMir reported 16.5% of individuals presenting at least one missing tooth(Bernabé and Flores-Mir, 2006). Esa et al., in 2001 also found that 6.9% of the Malaysian school children had a number of missing teeth(Esa et al., 2001) and Utomi & Onyeaso in 2015 showed 10% of their study sample to have missing anterior teeth(Utomi and Onyeaso, 2015). Shrestha et al., in 2015 also reported 10.66% of the sample among Nepalese patients to have number of missing teeth(Shrestha et al., 2015).

4.6.2 Incisal segment crowding

The incisal segment crowding is the insufficient space among the left and right canine teeth and is inadequate to provide space all four anterior teeth in a normal position and the teeth may be displaced or rotated out of the arch(World Health Organization, 1997). This study showed that crowding (n=135; 90%) was the most common occlusal trait in this sample. We did not explore the causes of crowding in this study, but dental caries and extraction of molars, which can cause the first permanent molar to migrate, rotate or incline has been cited as causing crowding(Brito et al., 2009). Other causes of crowding reported include size of the tooth and jaw discrepancies, dento alveolar discrepancies, genetic and racial differences of study samples(Shivakumar et al., 2010).

Similar results to this study findings regarding crowding were reported by Goyal and co-authors, with 81% of their study sample having crowding(Goyal et al., 2013). Similarly, Shrestha et al., in 2015 reported 80.9% of the study sample among Nepalese patients to have crowding(Shrestha et al., 2015). A study done by Uzuner et al in 2015 showed that 88.2% of the selected Turkish orthodontics patients had crowding(Uzuner et al., 2015). These studies had lower percentage of crowding compare to our study findings, Drummond in 2004 found that 40% of the children assessed showed sign of crowding(Drummond, 2004), whilst Thilander also recorded 52.1% of crowding to be the most common anomaly(Thilander, 2001).

4.6.3 Incisal segment spacing

Incisal segment spacing is defined as a space present between the left and right canine teeth exceed the amount of 1-2mm that is necessary to provide space for all upper anterior teeth in a normal position(World Health Organization, 1997). Examination for spacing was done on both upper and lower incisal segments. This study showed that 24.67% of the sample had incisal segment spacing in both upper or lower dental arches.

The results of this study were in accordance to the studies by Bernabé and Flores-Mir in 2006 in Peru who reported 25.1% of the study sample with incisal spacing(Bernabé and Flores-Mir, 2006).Similarly, Tak et al., in 2013 reported that 27.1% of the study population

had anterior spacing(Tak et al., 2013). However, lower frequencies of incisal spacing were reported by Uzuner et al in 2015 at 18.9 % from the selected Turkish orthodontics patients(Uzuner et al., 2015), whilst Utomi & Onyeaso in 2015 recorded higher prevalence of incisal spacing among Nigerian patients at 42.0%(Utomi and Onyeaso, 2015).

4.6.4 Midline diastema

A midline diastema is defined as a space of more than 2 millimetres between two permanent maxillary incisors during normal contact points(World Health Organization, 1997). In this present study 23.33% of the study sample had midline diastema. The causes of diastema in children have been reported to include different harmful oral practises such as mouth breathing, tongue thrusting, dilacerations of central incisor, abnormal labial frenum, microdontia and dento-alveolar discrepancies of the dental arches(Shivakumar et al., 2009). This study did not investigate the causes of midline diastema.

The results of this study are similar to other studies by(Goyal et al., 2013, Shrestha et al., 2015, Utomi and Onyeaso, 2015, Uzuner et al., 2015). Goyal et al., in 2013 reported 27% of Rwanda patients to have midline diastema(Goyal et al., 2013) and Uzuner et al in 2015 showed that 25.2 % of the selected Turkish orthodontics patients had diastema(Uzuner et al., 2015). Shrestha et al., in 2015 showed that 17.33% of the sample among Nepalese patients had midline diastema(Shrestha et al., 2015) whilst Utomi and Onyeaso in 2015 showed a higher prevalence of midline diastema among Nigerian patients at 41.3%(Utomi and Onyeaso, 2015).

4.6.5 Maxillary anterior irregularity

Maxillary anterior irregularity is when teeth are either rotated out of or displaced from their normal position and the upper incisors are assessed to find the highest irregularity(World Health Organization, 1997). This study showed that 85.33% of the sample had anterior maxillary irregularity. Results of this study are similar to other studies that reported anterior maxillary irregularity(Bernabé and Flores-Mir, 2006, Goyal et al., 2013, Shrestha et al., 2015, Uzuner et al., 2015).

A study done in Turkey by Uzuner et al., in 2015 recorded 89.9% of the study sample had anterior maxillary irregularity(Uzuner et al., 2015). Goyal et al., in 2013 also recorded 75% of their sample to have anterior maxillary irregularity(Goyal et al., 2013). Shrestha et al., in 2015 reported 98.6% of the sample among Nepalese patients to have anterior maxillary irregularity(Shrestha et al., 2015) whilst Bernabé and Flores-Mir in 2006 reported 67.1% of their sample in Peru to have anterior maxillary irregularity(Bernabé and Flores-Mir, 2006).

4.6.6 Mandibular anterior irregularity

Mandibular anterior irregularity is when teeth are either rotated out of or displaced from their normal position and the lower incisors are assessed to find the highest irregularity(World Health Organization, 1997). This study showed that 73.33% of the sample had anterior mandibular irregularity and the result was similar to other studies(Bernabé and Flores-Mir, 2006, Goyal et al., 2013, Shrestha et al., 2015) that reported anterior mandibular irregularity in their sample.

A study done in Nepal by Shrestha et al., in 2015 reported anterior mandibular irregularity at 90.6%(Shrestha et al., 2015). Similarly, Bernabé and Flores-Mir in 2006 reported 84.7% of the Peruvian young adult to have anterior mandibular irregularity(Bernabé and Flores-Mir, 2006). However, a lower frequency of anterior mandibular irregularity compared to this study findings was reported in Rwanda by Goyal et al., in 2013 at 62%(Goyal et al., 2013).

4.6.7 Anterior maxillary overjet

Anterior maxillary overjet occurs when the maxillary and mandibular teeth are positioned between each other in centric occlusion and is measured in millimetres (2-3mm). A measurement of the distance between the upper incisors' labial-incisal edge and the opposing lower incisors' anterior(World Health Organization, 1997). This study showed that 82.67% of the sample had anterior maxillary overjet. Results in this study are similar to other studies(Bernabé and Flores-Mir, 2006, Firdaus et al., 2019, Goyal et al., 2013, Utomi and Onyeaso, 2015), reporting a high prevalence of anterior maxillary overjet.

A study done in Indonesia by Firdaus et al., in 2019 reported 80.8% of the patients had an abnormal maxillary overjet(Firdaus et al., 2019). Similarly, Bernabé and Flores-Mir in 2006 reported 79.6% of their sample in Peru to have anterior maxillary overjet(Bernabé and Flores-Mir, 2006). A study done in Rwanda by Goyal et al., in 2013 reported 74% of patients had overjet(Goyal et al., 2013) and Utomi and Onyeaso in 2015 reported 75.3% of their sample in Nigeria to have anterior maxillary overjet(Utomi and Onyeaso, 2015).

4.6.8 Anterior mandibular overjet

Anterior mandibular overjet occurs when the lower anterior teeth protrude anteriorly over the opposing upper anterior teeth, which is also known as reversed or negative overbite(World Health Organization, 1997). This study showed 87.33% of the sample had overbite. Results in this study were similar to other studies(Bourzgui et al., 2012, Nainan et al., 2013) which reported anterior mandibular overjet from their sample.

A study done in Casablanca, Morocco by Bourzgui et al., in 2012 reported that 88.6% of their sample had negative overbite(Bourzgui et al., 2012). Similarly, Nainan et al., in 2013 reported 75.7% of the Indian patients in Mumbai to have negative overbite(Nainan et al., 2013).

4.6.9 Anterior open bite

Anterior open bite (AOB) occurs when the upper and the lower incisors are not overlapping in normal overjet and overbite and the condition reveals differences of space in the vertical plane(World Health Organization, 1997). In this study 8.67% of the sample had AOB. The results of this study were similar to findings in other studies which reported AOB in their sample(Goyal et al., 2013, Otuyemi et al., 1999, Thilander, 2001, Uzuner et al., 2015).

A study done in Nigeria by Otuyemi et al., in 1999 reported 10.2% of the sample to have AOB(Otuyemi et al., 1999).Similarly, Thilander in 2001 reported 10.7% of the sample in Colombia to have AOB(Thilander, 2001). However, Goyal et al., in 2013 reported 14% of AOB in Rwandese population(Goyal et al., 2013) and Uzuner et al in 2015 reported 15.3% of their Turkish orthodontic patients sample had AOB(Uzuner et al., 2015).

4.6.10 Antero-posterior molar relationship

The antero-posterior molar relation is the relationship that occurs when the mesiobuccal cusp of the upper first permanent molars occludes with the buccal groove of the lower first permanent molars(Angle, 1899). Both sides of the teeth are examine while in occlusion and only record the irregularity from the side with abnormal relationship(World Health Organization, 1997). This study found that 82.67% of the sample presented with an abnormal antero-posterior molar relationship. Similar results to this study has been reported(Firdaus et al., 2019, Shrestha et al., 2015, Uzuner et al., 2015).

Firdaus et al., in 2019 recorded 76.9% of the Indonesian patients presenting with abnormal anteroposterior molar relation(Firdaus et al., 2019). Similarly, Uzuner et al in 2015 showed that 73.3% of their Turkish orthodontic patients sample had deviation from the normal anterior posterior molar relation(Uzuner et al., 2015), whilst Shrestha et al., in 2015 reported a lower frequency of abnormal molar relation among Nepalese patients at 59.3%(Shrestha et al., 2015).

4.7 Limitation of the Study

We have estimated 170 study models to compensate for the sample size but we encountered the following limitations:

- ✓ Most of the pre-treatment study models with bite registration were missing, therefore the study sample size had to be reduced 150.
- ✓ Most study models were not in model boxes and some had no patient details on them.
- ✓ Some of the study models were not correctly trimmed or not trimmed at all according to accepted norms and standards(Aldabagh et al., 2018).
- ✓ Some of the patient's records were also missing.

However, even with the limitations, this study was able to evaluate 150 study models and reported the findings accordingly.

Chapter 5

Conclusions and Recommendations

Conclusions

Most patients treated by registrars at the WOHC presented with a high Dai score and were categorized as handicapping malocclusion. These patients were all treated by postgraduate students in the Orthodontic Department since they needed mandatory orthodontic treatment. Angle's Class I malocclusion (n=112, 74.67%) was the most prevalent compared to other types of malocclusion. This study also observed a high frequency of crowding (n=135, 90%), anterior maxillary irregularity (n=128, 85.35%), abnormal anterior mandibular overjet (n=131, 87.33%) and abnormal molar relationship (n=124, 82.67%) of the occlusal traits.

This study found that DAI was useful in evaluating the severity of malocclusion and all evaluated patients received orthodontic treatment in this resource-constrained government institution. The limitation of the DAI as reported by(Maumela and Hlongwa, 2012) did not affect the assessment of malocclusion in this study.

Recommendations

- In this study, we found a higher prevalence of malocclusion, which point out that many patients were in need of mandatory orthodontic treatment. Therefore, interceptive treatment will be beneficial in decreasing and preventing the severity of malocclusion by improving more on the school-based oral health promotion programs.
- In South African public sector, orthodontic treatment is mostly provided by government funded institutions and resources are not enough to satisfy the increasing orthodontic demands, so prioritizing of patients using DAI can assist in budgeting and resource allocation.

- Updated epidemiological studies need to be conducted on a larger population sample in South Africa to assess the prevalence of malocclusion as most of the studies predates democracy.

Chapter 6

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Appendices

Appendix A: Modified Dental Aesthetic Index (DAI) Form

Study model no: Age: Gender: M/F Race: A/C/I Malocclusion Class: I/II/III			
DAI Component	**A Measurement**	**B Weight**	**C Total Score**
1. Number of missing visible teeth (incisors, canines, and premolars in maxillary and mandibular arch)		6	
2. Crowding in incisal segment 0 = no segments crowded 1 = 1 segment crowded 2 = 2 segments crowded		1	
3. Spacing in incisal segment 0 = no spacing, 1 = 1 segment spaced 2 = 2 segments spaced		1	
4. Midline diastema, in millimetres		3	
5. Largest anterior maxillary irregularity, in millimetres		1	
6. Largest anterior mandibular irregularity, in millimetres		1	
7. Anterior maxillary overjet, in millimetres		2	
8. Anterior mandibular overjet, in millimetres		4	
9. Vertical anterior openbite, in millimetres		4	
10. Anteroposterior molar relationship, largest deviation from normal either left or right 0 = normal, 1 = ½ cusp mesial or distal, 2 = 1 full cusp or more mesial or distal		3	
11. Constant		13	
Total score			

Appendix B: Ethical clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Nomcebo Sengwayo

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200734 MED20-06-110

NAME: (Principal Investigator)	Dr Nomcebo Sengwayo
DEPARTMENT:	Orthodontics Wits Oral Health Centre
PROJECT TITLE:	Assessment of malocclusion and orthodontic treatment needs of patients treated by postgraduate orthodontic registrars using the dental Aesthetic Index
DATE CONSIDERED:	31/07/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Phumzile Hlongwa and Dr Yolanda Kolisa
APPROVED BY:	Dr C Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	14/09/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the stucy was initially reviewed July and will therefore be due in the month of July each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

27/04/2021
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Permission from the CEO

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

School of Oral Health Science

Department of Oral Biological Sciences, 7 York Road, Parktown, 2193. Tel: 011 717 2045 Fax: 086 553 3690 Email: Juliths.Molepo@wits.ac.za

26 August 2020

Dr C. Sengwayo
Orthodontics
Faculty of Health Sciences
University of the Witwatersrand
Johannesburg

RE: PERMISSION TO CONDUCT RESEARCH

REFERENCE: HRRC/August/04/2020

It is my pleasure to grant final approval to conduct your research at Wits Oral Health Centre titled "Assessment of malocclusion and orthodontic needs of patients treated by post graduate orthodontic registrars using the dental aesthetic index".

The Hospital Research and Risk Committee allocated a unique reference number to this application – Kindly quote this reference number in all future correspondence regarding this research.

Please note that the Hospital Research and Risk Committee should be informed of the estimated date the research will commence, as well as regular status reports until the research has been concluded. Within a month after conclusion of the research project, a written report must be submitted to the Head of School/CEO, summarizing the final result/outcome as well as the recommendations made based on the research concluded.

Regards,

Prof M. S Nemutandani

CEO/Head of School

Date: 2020/08/26

Appendix D: Approval letter from HOD of Orthodontics

The School of Oral Health Sciences
Wits Dental Hospital
Faculty of Health Sciences

7 York Road, Park Town, Johannesburg.
Tel: +27 11 488-4879/1
Fax: +27 11 488-4903
8th floor, Area 385, Johannesburg General Hospital, Park Town
Private Bag 3, Wits, 2050

Department of Orthodontics

25 June 2020

Professor Nemutandani
The Head of the School of Oral Health Sciences,
The CEO: Wits Oral Health Centre,
University of the Witwatersrand

Dear Professor Nemutandani

RE: PERMISSION TO ACCESS PATIENTS RECORDS FOR RESEARCH PROJECT

I, Nomcebo Sengwayo, plan to conduct a study review on the severity of malocclusion and the orthodontic treatment need in the Department of Orthodontic at Wits Oral Health Centre. The study is part of the partial fulfilment for the requirements for MSc Dent and I will be supervised by Prof P Hlongwa and Dr Y Kolisa.

The proposed title of the study: **Assessment of malocclusion and orthodontics treatment needs of patients treated by postgraduate orthodontic registrars using the dental aesthetic index.**

Student: Dr Nomcebo Sengwayo

Student Number: 458141

The aim of the study will assess the severity of malocclusion and the need for orthodontic treatment of patients. I am writing to you, as the Chief Executive Officer of Wits Oral Health Centre, to request permission to access pre-treatment orthodontics study models of patients of patients treated by orthodontics registrars, from the archived of the Department of Orthodontic at Wits Oral Health Centre. I have received permission from the HOD, Dr M Makofane, to access the study model (See attached letter).

The study models will be used onsite and will not be removed from Orthodontics Department and will be handle with care.Each study model will be assigned a unique number for anonymity of the data.
I have applied for ethical approval from the Human Research Ethics Committee (HREC) Medical of the University of Witwatersrand and awaiting ethical clearance certificate

Thank you for your time and consideration in this matter.

Yours sincerely

NSengwayo

Dr Nomcebo Sengwayo

25 June 25, 2020

Date

RECOMMENDED/NOT RECOMMENDED

COMMENTS.....
.....

Professor P Hlongwa
Supervisor

25/06/2020
Date

SUPPORTED/NOT SUPPORTED

COMMENTS.....
.....

Dr Y Kolisa
Co- Supervisor

26.06.2020
Date

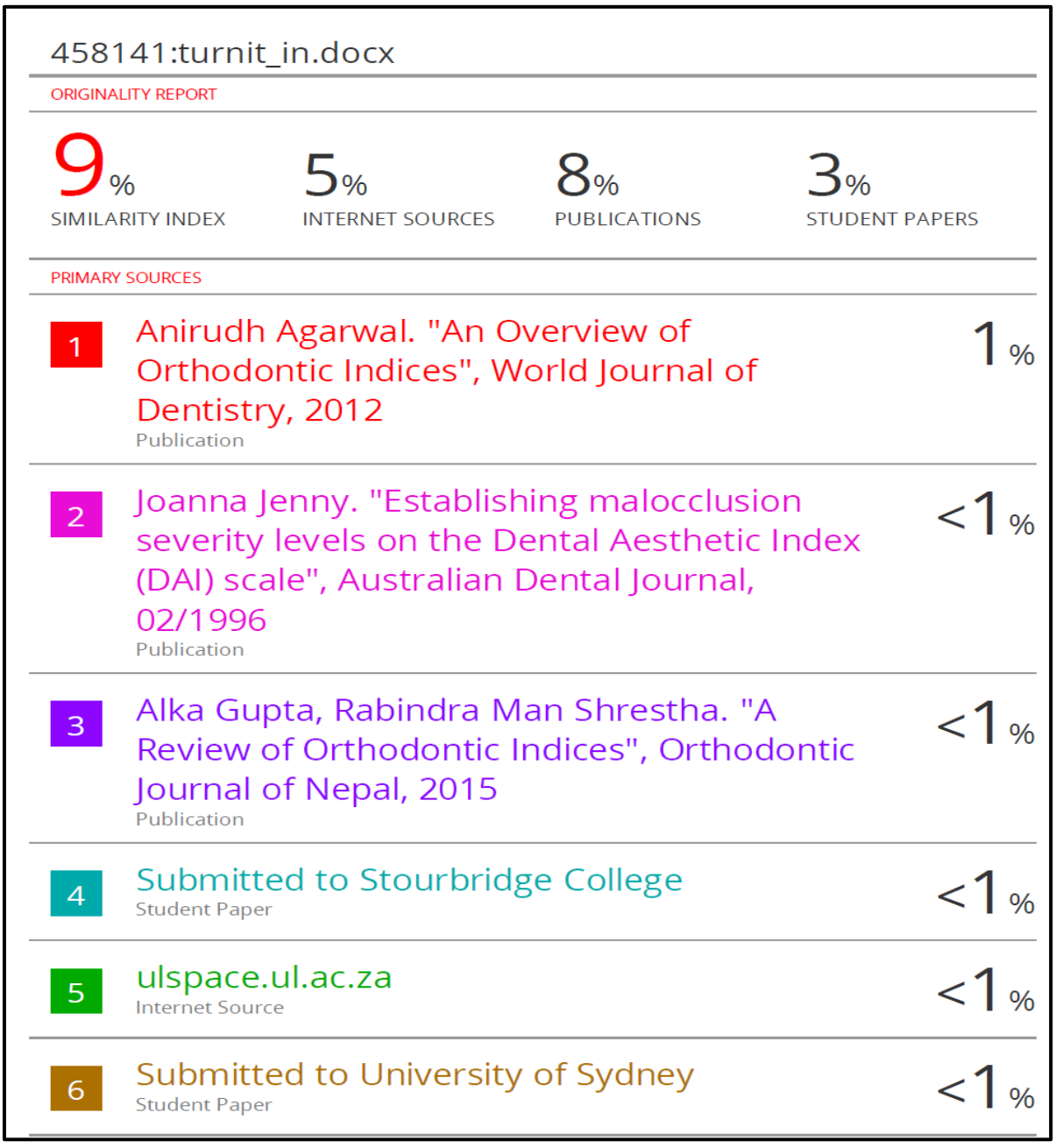
PERMISSION APPROVED/NOT APPROVED

COMMENTS.....approve.....
.....

Dr M Makofane
HOD: Department of Orthodontics
Wits School of Oral Health Sciences
University of the Witwatersrand

03/07/20.
Date

Appendix E: Turn it in



458141:turnit_in.docx

ORIGINALITY REPORT

9%	5%	8%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Anirudh Agarwal. "An Overview of Orthodontic Indices", World Journal of Dentistry, 2012 Publication	1%
2	Joanna Jenny. "Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale", Australian Dental Journal, 02/1996 Publication	<1%
3	Alka Gupta, Rabindra Man Shrestha. "A Review of Orthodontic Indices", Orthodontic Journal of Nepal, 2015 Publication	<1%
4	Submitted to Stourbridge College Student Paper	<1%
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7	C. Livas, K. Delli. "Subjective and objective perception of orthodontic treatment need: a systematic review", The European Journal of Orthodontics, 2012 Publication	<1 %
8	Shrestha, Rabindra Man, Bikash Lamichhane, Anuj Kumar Sharma, and Sujita Shrestha. "Dental Aesthetic Index among Nepalese Orthodontic Patients", Orthodontic Journal of Nepal, 2016. Publication	<1 %
9	Ali Borzabadi-Farahani. "Chapter 9 An Overview of Selected Orthodontic Treatment Need Indices", IntechOpen, 2011 Publication	<1 %
10	Lucas Duarte-Rodrigues, Joana Ramos-Jorge, Clarissa Lopes Drumond, Priscilla Barboza Diniz et al. "Correlation and comparative analysis of the CPQ8-10 and child-OIDP indexes for dental caries and malocclusion", Brazilian Oral Research, 2017 Publication	<1 %
11	Carlos Bellot-Arcs, Jos Mara, Jos Manuel. "Chapter 1 Orthodontic Treatment Need: An Epidemiological Approach", IntechOpen, 2012 Publication	<1 %

12	Luciana Freitas Gomes e Silva, Erika Bárbara Abreu Fonseca Thomaz, Heloiza Viana Freitas, Alex Luiz Pozzobon Pereira et al. "Impact of Malocclusion on the Quality of Life of Brazilian Adolescents: A Population-Based Study", PLOS ONE, 2016 Publication	<1 %
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16	Hemant Kumar Halwai, Vanita Gautam. "Distribution of Malocclusion Traits among Orthodontic Patients in a Tertiary Care Center of Western Nepal", Orthodontic Journal of Nepal, 2018 Publication	<1 %
17	Tang, E.L.K.. "Recording and measuring malocclusion: A review of the literature", American Journal of Orthodontics & Dentofacial Orthopedics, 199304 Publication	<1 %
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19	Dhanyasi Ashok Kumar, Rana K. Varghese, Shailendra Singh Chaturvedi, Anil Agrawal, Chinar Fating, Ramanpal Singh Makkad. "Prevalence of Malocclusion Among Children and Adolescents Residing in Orphanages of Bilaspur, Chattishgarh, India", Journal of Advanced Oral Research, 2018 Publication	<1 %
20	Submitted to King's College Student Paper	<1 %
21	"Abstracts of Lectures and Posters", The European Journal of Orthodontics, 2012. Publication	<1 %
22	Andre B. Krzypow, Myron A. Lieberaian, Michaela Modan. "Prevalence of Malocclusion in Young Adults of Various Ethnic Backgrounds in Israel", Journal of Dental Research, 2016 Publication	<1 %
23	Shenoy, Rekha P., Ganesh Panchmal, K. Prashanth Shenai, M. Shashidhar Kotian, Abdul Salam T. A., and Gagandeep Chadha. "Malocclusion and Orthodontic Treatment Need among High School Students in Mangalore City, India", JMED Research, 2014. Publication	<1 %
24	Submitted to Trinity College Dublin Student Paper	

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25	Submitted to University of KwaZulu-Natal Student Paper	<1 %
26	ARMANDO K. KAIEDA, IGOR F.P. LIMA, MARCO ANTÔNIO SCANAVINI, RAILDO S. COQUEIRO et al. "Perception, knowledge and attitudes of Brazilian orthodontists on the treatment of Class II malocclusions", Anais da Academia Brasileira de Ciências, 2017 Publication	<1 %
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30	"Assessment of various components of oral health status in different population groups of Meerut division of Western U.P.: A pathfinder survey", Journal of Dental Specialities, 2020 Publication	<1 %
31	Jasmin Winnier, Ullal A Nayak. "The Relationship of Dental Aesthetic Index with Dental Appearance, Smile and Desire for	<1 %

	Orthodontic Correction", International Journal of Clinical Pediatric Dentistry, 2009 Publication	
32	Kaarlye C. P. Andrade de Melo, Mario Vedovello-Filho, Vivian F. Furletti-Góis, Marcelo de C. Meneghim, Silvia A. S. Vedovello. "Is the adolescent's esthetic concern associated with anterior occlusal conditions or the malocclusion severity level?", The Angle Orthodontist, 2021 Publication	<1 %
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38	Renata França Prado, Joana Ramos-Jorge, Leandro Silva Marques, Saul Martins de Paiva et al. "Prospective evaluation of the psychosocial impact of the first 6 months of orthodontic treatment with fixed appliance among young adults", The Angle Orthodontist, 2016 Publication	<1 %
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	among young adults: a cross sectional questionnaire study", International Journal of Adolescent Medicine and Health, 2017 Publication	
45	N. Puertes-Fernandez, J. M. Montiel-Company, J. M. Almerich-Silla, D. Manzanera. "Orthodontic treatment need in a 12-year-old population in the Western Sahara", The European Journal of Orthodontics, 2010 Publication	<1 %
46	Nadejda Beleva, Nazli Idil Kacamak, Cagla Sin, Beste Kamiloglu. "Prevalence of malocclusion in north Cyprus School", Research Square, 2019 Publication	<1 %
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