THE PREVALENCE OF MALOCCLUSION AND ORTHODONTIC TREATMENT NEEDS OF PATIENTS TREATED BY STUDENTS AT WITS ORAL HEALTH CENTRE

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Declaration

I, Ameera Rawat declares that "The Prevalence of Malocclusion and Orthodontic Treatment Need of Patient's treated at Wits Oral Health Centre" is my work. It has not been submitted before for any degree or exam at any other tertiary institution. Complete referencing has been used to acknowledge all sources.

Signed  on the 26/01/2023

Dedication

Dedicated to the memory of my loving father, Mr Yusuf Rawat, who worked hard to finance my undergraduate studies and sadly succumbed to cancer in 2014.

Acknowledgments

I would like to begin by thanking the Almighty for helping and guiding me to complete this research report.

A special appreciation to my supervisor, Professor Phumzile Hlongwa, for her vast knowledge, work ethic, continuous support, patience, motivation and guidance throughout this research.

My sincere gratefulness to my amazing husband, Naeem Timol, for his love, support and for so lovingly taking the extra time to entertain our children during my studies.

I would like to thank my children, Yusuf and Yaseera, for their patience and understanding throughout the time of this research.

I would also like to thank my dear mother, Roekshana Rawat, who supported and motivated me to complete this research and was readily available to look after my children so that I could finish my research.

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

Abstract

Objectives: To assess the prevalence of malocclusion and orthodontic treatment needs of patients treated by undergraduate students at Wits Oral Health Centre.

Materials and Methods: 124 pre-treatment orthodontic study models were reviewed. The Angle's classification was used to classify malocclusion and the Dental Aesthetic Index (DAI) scores categorised the severity of malocclusion and orthodontic treatment needs. The prevalence of malocclusion was determined by the percentage of patients in the sample who were categorised by DAI as definitive, severe and handicapping malocclusion. Stata version 16 was used to analyse the data and statistical tests were conducted at 5% significance level.

Results: The prevalence of malocclusion was estimated to be 92.74%. The mean DAI score was 39.54, ranging from 23 to 94. Handicapping malocclusion requiring mandatory treatment presented in 60.48% of the sample. Severe and definite malocclusion presented in 19.35% and 12.9% of the sample respectively, indicating a need for treatment. Minor malocclusion requiring minimal or no orthodontic treatment was in 7.26%. Angle's classification showed that most of the study sample (n=101; 81.45%) had a Class I malocclusion, followed by Class III (n=12; 9.68%) and Class II (n=11; 8.87%). There were no statistically significant differences between the DAI scores and the Angle's classification of malocclusion, p=0.9.

Conclusion: Angle's classification and the DAI scores showed that all patients in the study sample presented with malocclusion. However, 92.74% of the sample was deemed requiring orthodontic treatment by the DAI.

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Abbreviations/Acronyms

AC	Aesthetic Component
AOB	Anterior Open Bite
AR	Ameera Rawat
DAI	Dental Aesthetic Index
DHC	Dental Health Component
ICON	Index of Complexity, Outcome and Need
IOTC	Index of Orthodontic Treatment Complexity
IOTN	Index of Orthodontic Treatment Need
mm	millimeters
N	frequency
PAR	Peer Assessment Index
PH	Phumzile Hlongwa
PI	Principle Investigator
SD	Standard Deviation
UG	Undergraduate
WOHC	Wits Oral Health Centre

Chapter 1: Introduction and Literature Review

1.1 Malocclusion

The term malocclusion is used to describe the incorrect placement of the teeth in the dental arches when the jaw closes (1). Malocclusion is also described as a deviation from the normal occlusion known as a Class I molar relationship with incorrect alignment of teeth (2). Zou and co-workers reported that malocclusion is a global dental concern and has a different impact on the individuals that are affected (3). Malocclusion has been ranked third among oral pathologies (4, 5). Malocclusions can present as abnormalities of the dentition individually or collectively, abnormalities of the position of arches and/or abnormalities of the skeletal relationship of the maxilla and mandible (6, 7)

The most common type of malocclusion falls within the category of Class 1 malocclusion (8-10). There are three classes of malocclusion that has been described by utilizing the position of the mesio-buccal cusp of the permanent maxillary first molar occluding with the mandibular first permanent molar (11). Numerous authors classified the aetiology of malocclusion differently (6, 12-15). Salzmann based his classification on prenatal (genetics; congenital) and postnatal factors (developmental, functional, and environmental) (13). Graber's classification included general (extrinsic) factors and local (intrinsic) factors (14). Moyer's classification categorised the aetiology of malocclusion as: hereditary factors, developmental cause of unknown origin, trauma related factors, physical agents, habit related factors, and diseases (15). Proffit's classification included specific causes, environmental causes, and genetic causes of malocclusion (6, 12).

1.2 The Aetiology of Malocclusion

The cause of malocclusion is multifactorial; and there is usually no single causative factor of malocclusion (6, 7, 12). A multitude of genetic and environmental influences contribute to malocclusion and is strongly associated with the prevalence of malocclusion (16, 17). Genetic and environmental factors should be sought after and perfectly balanced for a normal occlusion to develop (17). Myosin 1H gene, a collagenous protein, contributes to the development of the craniofacial complex and is strongly associated with Class I and II and more predominantly with Class III malocclusions (18, 19). Early loss of teeth can result in many dental issues including malocclusion (3, 20). A 2008 study on 7-11-year-olds, found a decline in the prevalence of malocclusion when early tooth loss was excluded, and the prevalence of Class I and Class III

malocclusion reduced by 11.4% and 4.5% respectively (21). A 2016 study assessed the association between malocclusion traits, oral habits and mouth breathing in children. The authors reported a positive association between overjet, open bite and posterior crossbite, and mouth breathing (22). A 2019 cross-sectional study on 8-9-year-old Thai children with mixed dentition, found that early loss and carious teeth were the main problems that resulted in malocclusions (7). Different oral maxillo-facial tissues can be affected by the causative factors of malocclusion, which includes effects on the soft tissue (gingival disease, periodontal disease or trauma); bone (skeletal bone protrusion or retrusion, alveolar bone loss at some areas around malposition /misaligned teeth) and/or the neuromuscular tissue (headaches, sleep disorders or temporomandibular joint dysfunction) (7, 23, 24).

1.3 Prevalence of Malocclusion

The prevalence of malocclusion varies from one country to another, between different gender and race, and with age. The different age range, ethnicity, number of subjects and the differences in populations that are studied have an impact on the prevalence rate of malocclusions in different studies (25).

A systematic review conducted on studies up to 2016 from a few databases reported that Class I malocclusions had the highest prevalence globally 74.7% (31 – 97%) and it was found to be higher in Africans (26). Class II malocclusions had a global prevalence of 19.56% with a wider range of distribution between countries and, presented with the highest prevalence in Caucasians and lowest prevalence in Africans (26). Class III malocclusions had the lowest prevalence globally, 5.93% (1-20%) (26). A systematic review and meta-analysis study in 2020 used 77 studies from across the world, and reported a worldwide prevalence of 56% with a higher prevalence rate in Africa (81%) followed by Europe (72%) (27).

The prevalence of malocclusion in high-income-countries ranged from 60.5% to 93% (28-31). The Index of Orthodontic Treatment Need (IOTN) was utilized on the data from a Nutrition Examination Survey (NHANES III) in 1998, in which it was reported that the prevalence of malocclusion in the United States of America was 65% (28). A 2001 study done on 507 Latin Americans found a malocclusion prevalence of 93% (29). In Columbia, a study of 17 -year -old children attending a paediatric clinic found a prevalence of malocclusion to be 88.1% (30). A 2005

study done in New Zealand on 12- to 13-year-olds, using the Dental Aesthetic Index, found that 60.5% of the sample presented with a malocclusion (31).

The prevalence of malocclusion in low- to- middle- income countries ranged from 47.92% to 89.9% (32-36). The Malaysian children aged 13- 17 years were classified using Angle's classification, and found to have a prevalence of malocclusion of 93% (32). The prevalence of malocclusion amongst the Iranian children aged between 3 and 18 years, was reported to be 85.31% (33). A 2018 Brazilian cross-sectional study, conducted on 10- 15-year-old students that attended schools in the year 2012, found that 57.3% of the sample presented with a malocclusion (34). A systematic review and meta-analysis on studies previously conducted on Chinese school children, found a prevalence of malocclusion of 47.92% (35). In India, 13–15-year-olds children showed a prevalence of malocclusion of 89.9% using Angle's classification (36).

The prevalence of malocclusion in Africa has been studied by several authors, which ranged from 32% to 93% (4, 10, 37-42). A 2013 study at King Faisal Hospital in Rwanda reported that the prevalence of malocclusion was 89%. (4). In 2018 Goyal and co-workers found a prevalence of 93% in a sample of 12- 40-year-old patients attending the same hospital in Rwanda (37). In Nigeria the prevalence of malocclusion was found to be 88.2% on 13 to 20 years old, using Angle's classification and Index of Complexity and Orthodontic Treatment Need (ICON) (10). The prevalence of malocclusion of school children in Egypt found to be 73.8% using Angle's classification (38).

The prevalence of malocclusion in South Africa ranged from 32% to 52.3% (39-42). A 2004 study that defined the oral health status of people and the probable tendencies in oral diseases in South Africa (found that the prevalence of malocclusion of 32% (39). The DAI was used to measure the prevalence of malocclusion of 12-year-old school children in seven provinces in South Africa, the prevalence of malocclusion was reported to be 52.3% (40). A study on malocclusion of 12year-old children in Limpopo, utilising the DAI, found the prevalence of malocclusion of 47% (41). In Cape Town the IOTN was used to assess malocclusion in school children and the prevalence of malocclusion was found to be 46.6 % (42). The South African studies (39-42) showed that more than a third of the of their study samples presented with a malocclusion that required orthodontic care.

1.4 Preventative and Interceptive Orthodontic Treatment

Preventive orthodontic treatment aims to promote normal development of occlusion and assists with the prevention of a malocclusion (43). The main objective for prevention of malocclusion is the appropriate recognition, control and management of environmental factors to adjust the cranio-facial structures (44). It has been reported that preventative orthodontic treatment conducted while the dentition is still developing, during the period when a child possesses active growth, can aid in decreasing the progression rate of some malocclusions (3, 7).

Interceptive orthodontic treatments aid in re-establishing a normal occlusion when a malocclusion has just started developing (43). The objective of interceptive orthodontic treatment is to minimise malocclusion progression from transitional dentition into the permanent dentition (45, 46). Preventative and interceptive treatment modalities may be simpler and cheaper when compared to fixed orthodontic treatment and are can be offered by most general dentists (46).

Dental features that can pre-set the need for interceptive orthodontic treatment were studied on 532 children, and 63% of children that required orthodontic treatment were reported (45). These features included: - crossbite; deep bite; open bite; overjet (>5mm); crowding; spacing of teeth; midline diastema; premature loss of deciduous teeth and missing teeth (45). The need for interceptive orthodontic treatment was studied among 7 – 10-year-old children that attended a few dental health clinics in Western Cape, South Africa (47). It was reported that 79% of the children needed interceptive orthodontic treatment at these clinics (47). Studies have recommended preventative and interceptive orthodontic treatment at an early age to possibly aid in reducing the prevalence of malocclusion worldwide (7, 43, 48).

1.5 Treatment of Malocclusion

The benefits of orthodontic treatment for malocclusion are manifold which may include restoring function, aesthetics and the psychological wellbeing to affected individuals. A systematic approach should be used when considering treatment of individuals with malocclusion (49). Patients with facial syndromes and developmental problems should be treated holistically and referred to a specialist because they might need a multidisciplinary approach. The profile of the patient’s face needs to be investigated thoroughly so that more severe problem might require treatment beyond general dentists’ skills. The assessment of dental and occlusal problems which include missing

teeth, crowding, incisor irregularity, spacing, crossbite, overjet and open bite should also be evaluated for severity and considered for specialised orthodontic treatment (49).

1.5.1 Early treatment

Oral health practitioners need to decide if orthodontic treatment should commence during the primary or early mixed dentition or wait until all or most of the permanent teeth are present (late-mixed dentition). The decision is usually based on individual cases. A study reviewed the literature from 1991 to 1999 and the authors found that postponing orthodontic treatment may be beneficial (50).

1.5.2 Functional Appliances

Functional appliances guide the forces that are generated from growth, muscle function and tooth eruption to correct a malocclusion (51). Functional appliances are indicated to treat Class II and Class III skeletal malocclusions by enhancing the growth of the maxilla and the mandible respectively (51, 52).

1.5.3 Removable appliances

Removable appliances are constructed for individual dental arches, and they can be removed from the mouth by the patient. They are used to tilt individual teeth within the dental arch and for arch expansion by moving groups of teeth They can also be used as an adjunct to fixed appliance treatment and for retention of post-orthodontic treatment. (51, 52).

1.5.4 Fixed Appliances

Fixed appliances are attached to teeth and can be used for three-dimensional bodily tooth movement in one or both dental arches (51, 52). They are indicated for use by specialist orthodontists. Severe malocclusions may require adjunctive orthognathic surgery (52).

1.6 Orthodontic Treatment Indices

Orthodontic treatment needs indices are used to study the importance of treatment and will assist with selecting which patients should be treated in cost-strained situation (53). The indices are utilized to strategize for the provision of orthodontic treatment mostly in public sector institutions (54). They are also vital in studies on the prevalence of malocclusion and malocclusion severity (54). The advantages of an orthodontic treatment need index include: the need for any form of

orthodontic care is recognised and prioritised, patients presenting with severe malocclusions and an absolute need for orthodontic treatment are recognised to get urgent treatment, and patients are protected against overtreatment (42, 55).

Orthodontic treatment needs indices have developed over time and they should be reliable, reproducible, and valid (53). Shaw and co-workers (56) have separated occlusal indices into 5 categories, namely: 1. diagnostic (Angle's classification (11)), 2. epidemiological (Summers Occlusal Index (54)), 3. orthodontic treatment need indices (DAI (57), Index of Orthodontic Treatment Need (IOTN) (58)), 4. orthodontic treatment outcome (Index of Complexity, Outcome and Need (ICON) (59)) and 5. Index of Orthodontic Treatment Complexity (IOTC) (60).

1.6.1 Angle's Classification

Angle was the first to classify malocclusion in 1899 (11). He built his classification on the relations of the maxillary and mandibular first permanent molar teeth (11). A normal occlusion was described in relation to the mesio-buccal cusp of the first maxillary permanent molar occluding with the mesio-buccal groove of the first mandibular permanent molar (11). Furthermore, the upper central incisors; lateral incisors and canines should overlap one third of the opposing crown length of mandibular teeth (11). Contrary, a malocclusion can be defined as the irregularity which results in a deformity or impedes function (1); therefore, a Class I malocclusion was then described as a Class I molar occlusion with crowded or rotated premolar or /and anterior teeth (11). A Class II malocclusion is described when the mesio-buccal cusp of the first permanent molar in the maxilla occludes after the mesio-buccal groove of the first permanent molar in the mandible. Two divisions of Class II malocclusion have been described: - Class II division 1 has an enlarged overjet that is greater than 4 mm, Class II division 2 shows upper central incisor that are retroclined, with a deep overbite (11). Class III malocclusions occurs when the mandibular jaw is positioned anterior to the maxillary jaw and is associated with mandibular prognathism or a hypoplastic maxilla or both (11). It is described when the mesio-buccal cusp of the first permanent molar in the maxilla occludes before the mesio-buccal groove of the first permanent molar in the mandible (11).

Angle's Class I and Class III malocclusion have been modified by Dewey (61) based on the malposition of anterior teeth in these malocclusions. 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 (61). Dewey further divided Angle's Class III malocclusion 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 (61).

1.6.2 Summers Occlusal Index

Summers developed an Occlusal Index (OI) due to the disagreement between examiners regarding the study of occlusion for epidemiological purposes (54). The OI is composed of diverse scoring systems and methods for the different phases of the dental development (54). Nine characteristics are scored: dental age, overjet, overbite, posterior crossbite, molar relationship, tooth displacement, midline rotations, posterior open bite, and missing permanent teeth (54).

1.6.3 Index of Orthodontic Treatment Need

The index of orthodontic treatment needs (IOTN) was formulated by Brook and Shaw in 1989 (58). The IOTN has a dental health component and an aesthetic component (58), with each component graded and recorded separately.

- The dental health component (DHC) has five grades of the need of treatment, which are Grade 1-5. Grade 1- no treatment, Grade 2- little treatment need, Grade 3-moderate need for treatment, Grade 4- great need for treatment and Grade 5 - very great need for treatment (58). Based on the cut-off points established for each occlusal trait, there is a calculable risk to the dentition.
- The aesthetic component (AC) assesses and records the aesthetic impairment presented by malocclusion (58). It uses a series of ten photographs which shows different levels of attractiveness and unattractiveness (58). Photographs 1 to 4 category have an orthodontic treatment need that is none or minimal, photographs 5 to 7 category have an orthodontic treatment need that is moderate and photographs 8 to 10 category have an orthodontic treatment need that is definitive (**Figure 1**) (58).

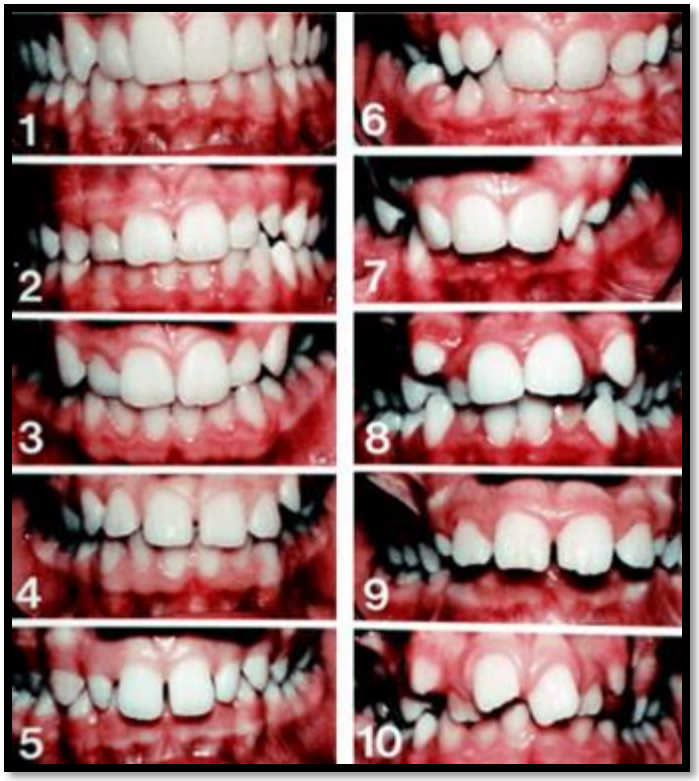

Figure 1: The AC of the IOTN (58)

The IOTN has been modified into two categories: An orthodontic treatment need is categorised by Grade 8 to 10 (definite need for orthodontic treatment) or no orthodontic need treatment is categorised by Grade 1 to 7 (no definite need for orthodontic treatment) (62).

1.6.4 Index of Complexity, Outcome and Need

The index of complexity, outcome and need (ICON) was developed by Daniels and Richmond due to limitations of the IOTN (59). The following features are evaluated in a malocclusion: - AC component of the IOTN, presence of crossbite, anterior vertical relationship, upper arch crowding/spacing and buccal segment anterior-posterior relationship (59). These five features are then multiplied by the weightings and a final score is obtained to determine the need of orthodontic treatment (59). An ICON score of 42 or less indicates no need of treatment, whilst a score of more than 42 indicates a need for orthodontic treatment (59). The complexity of a malocclusion is interpreted based on a scale of five grades using the ICON scores from pre-treatment models (59). A pre-treatment score of less than 29 is considered as an easy complexity grade; 29-50 is considered as a mild complexity grade, 51-63 is considered as a moderate complexity grade, 64-

77 is considered as a difficult complexity grade and >77 is considered as a very difficult complexity grade (59). An ICON score less than 31 when measured on post-treatment models indicates that the treatment outcome is "acceptable" while a score greater than 31 indicates an unacceptable treatment outcome (59). The advantage of evaluating complexity assist in identifying the correct setting where a patient can receive orthodontic care, advises the patient on the possibility of treatment success and identifies the difficulty on how long will it take to treat a specific malocclusion (53).

1.6.5 Index of Orthodontic Treatment Complexity

The index of orthodontic treatment complexity (IOTC) was derived to grade orthodontic complexity by Liewellyn and co-workers in 2007 (60). The IOTC grades the complexity of a case. The IOTC assesses pre-treatment study models, and orthodontic complexity score is assessed using a scale of six grades (1- easy, 2-4 moderate, 5-extremely complex and 6-impossible needing orthognathic surgery before orthodontic treatment can commence (60). Three occlusal factors are selected in order of importance from a list of 11 occlusal traits that are in no specific order (60). Occlusal factors are then multiplied by its corresponding weighting and scores are then added up to get a final complexity score (60).

1.6.6 The Dental Aesthetic Index

The DAI was developed in the United States by Cons and Jenny in 1986 (57). It is an epidemiological measuring tool used worldwide to determine the severity of malocclusion and the need for orthodontic treatment in a population (46). The World Health Organisation has recognized the DAI and recommended it to be used as an epidemiological index (63)(67). The DAI can also be used to prioritise orthodontic treatment in government institutions (9). The DAI is specifically designed for use in the permanent dentition however it has been used in mixed dentition with a slight variation, omitting missing teeth due to unerupted teeth commonly seen in the mixed dentition (40, 64-67). A 1993 study reported that the use of the DAI in a mixed dentition sample performed well when compared to its use in the permanent dentition (68).

The DAI focuses on the 'aesthetic and psychosocial' properties of malocclusion (8, 9). The aesthetic and clinical aspects are linked mathematically to yield a score that joins the physical and aesthetic components of the occlusion (57). Each component is scored, and the total score indicates severity and need for treatment (57). Ten occlusal traits are assessed and the total DAI scores,

depending on the severity, are divided in to four categories :-A score lower than or equal to 25 indicates no or minor malocclusion requiring no or minimal treatment, a score of 26 to 30 indicates a definitive malocclusion with elective need for treatment, a score of 31 to 35 indicates a severe malocclusion requiring definitive need for treatment and a score greater than 36 indicates a handicapping malocclusion with an obligatory need for treatment (57). Limitations of the DAI have been reported (9, 69), however it has been reported that it can be used without amendments (9).

1.7 The Needs and Demands for Orthodontic Treatment

The needs for orthodontic treatment are commonly used to narrate the amount of treatment that an individual requires based on the clinician's assessment, while demands denotes the treatment that patients appeal for themselves (70). The orthodontic treatment demand is also described as the yearning of an individual to receive orthodontic care for oneself or their dependents (42, 71). The demands for orthodontic treatment have increased as the personal health, expectations, finances and education of the population improves (42). The needs and demands for orthodontic treatment vary in different populations (42, 71), due to the "availability of treatment; acceptability of treatment; and accessibility of treatment" (70). "Availability of treatment": relates to the frequency of dentists that are available at a precise site, in the private and public sector (70). "Acceptability of treatment": describes how an individual accepts different types of treatment, which is affected by personal finance, education and cultural background (70). "Accessibility of treatment": describes how easily is the treatment accessible for an individual who needs orthodontic care (70).

1.9 Statement of Purpose

The orthodontic clinic at Wits Oral Health Centre (WOHC) is part of the teaching/academic hospital and is a referral centre for Gauteng Primary Health Clinics and the surrounding provinces of North West, Mpumalanga, Limpopo and Free State. This study will be unique since there is no report on the prevalence of malocclusion at Wits Oral Health Centre, even though a few studies were conducted previously in South Africa (39-42). Studies on the prevalence of malocclusion are crucial, not only for the actual treatment thereof but also for planning oral health services related to management of malocclusion especially in the limited and resource depleted tertiary institutions offering orthodontic treatment in the public sector.

1.10 Aim of the study

The aim of this study was to assess the prevalence of malocclusion and orthodontic treatment needs of patients treated at Wits Oral Health Centre (WOHC) by the undergraduate (UG) dental students.

1.11 The Objectives of the Study

1. To determine the type of malocclusions using the Angle's classification among patients treated by UG students at WOHC.
2. To describe the demographic profile of patients with malocclusion treated by UG students at WOHC.
3. To evaluate the severity of malocclusion and orthodontic treatment needs of these patients using the DAI scores.
4. To determine if there is any correlation between the Angle's classification of malocclusion and DAI scores.

Chapter 2: Materials and Methods

2.1 Study Design

This was a retrospective, cross-sectional study, over a period of five years from 1 January 2015 to 31 December 2019. Pre-treatment records of patients treated by the undergraduate dental students at Wits Oral Health Centre (WOHC), Department of Orthodontic undergraduate clinic was reviewed.

2.2 Sample Size

The size of the sample was calculated at a 95% confidence interval to be 239 using Epi- info (72), based on a previous prevalence of malocclusion of 47.7% from the study conducted in 2005 (40). A further 20% was added to this sample for missing data, therefore the sample size was calculated to be 287.

2.3 Sampling Technique

A randomised sampling method was used with a random start. The numbers 2-3 were put in a hat, the number 3 was picked, then every third record was chosen until the sample size was reached.

2.4 Inclusion Criteria

- Pre-treatment study models with wax bite registration were used in the study.
- Study models that were highly accurate and properly trimmed according to accepted norms and standards (73).

2.5 Exclusion Criteria

- Records of patients with severe abnormalities of the craniofacial structure, such as clefts of the lip and palate.
- Study models with absence of a wax bite, making the occlusal relationships of the models uncertain.
- Models with broken teeth.

2.6 Examiner Calibration

Preliminary calibration exercises for the Principal Investigator (AR) were undertaken to familiarize the examiner with the DAI administrative forms and the instructions as set out in the guideline of measurement tool. Ten pre-treatment study models of orthodontic patients from the archived records of the Department of Orthodontics, WOHC, were selected for calibrating the

examiner on the use of the DAI. These records were excluded from the study sample. The PI was calibrated by the supervisor (PH) who has been calibrated in the use of the DAI, until level of agreement was reached. The Kappa inter-rater agreement was 0.91.

2.7 Data Collection

Patients records in the study sample were allocated unique number which were recorded on the data collection sheet (Appendix 1) for anonymity and confidentiality. Demographic information (age, gender and race) from the patient's clinical records were reviewed and recorded.

Angle's classification (11), including Dewey's modification (61) (**Table 1**) was utilised to assess the type of malocclusion from pe-treatment study models in the permanent dentition. The study models in the mixed dentition stage were assessed using Angle's classification only.

Table 1: Angle's Classification with Dewey's Modification

Angle's Classification	Dewey's Modification
Class I - mesio-buccal cusp of the first permanent molar in the maxilla occludes with the mesio-buccal groove of the first permanent molar in the mandible.	Class 1, Type 1 -Crowding of the maxillary anterior teeth; Class 1, Type 2 - proclined maxillary incisors; Class 1, Type 3 - the presence of an anterior crossbite; Class 1, Type 4 - the presence of a posterior crossbite; Class 1, Type 5 - mesioversion of molars.
Class II - A Class II malocclusion is described when the mesio-buccal cusp of the first permanent maxillary molar occludes after the mesio-buccal groove of the first mandibular permanent molar. Two divisions have been described: Class II division 1 has an enlarged overjet > 4 mm, Class II division 2 shows a retroclined central upper incisor with an enlarged overbite	
Class III - described when the mesio-buccal cusp of the first maxillary permanent molar occludes before the mesio-buccal groove of the first mandibular permanent molar.	Class III, Type 1 - teeth that are well aligned and dental arches, with anterior biting of teeth at the edge of a relationship; Class III, Type 2 - crowding of the mandibular incisors with normal overjet but molars in Class III Class III, Type 3 - crowding of the maxillary incisors; with the maxilla that is underdeveloped and anterior crossbite being present

Source (11, 61)

Each pair of study models was measured twice on a flat surface using an orthodontic calliper as shown (**Figure 2**). Each occlusal trait was measured in millimeters. The two measured scores were added and the average was recorded on the Dental Aesthetic Index form (Appendix 1). The average measurement was then multiplied by the weight of each trait and the constant was added to obtain the total DAI score.

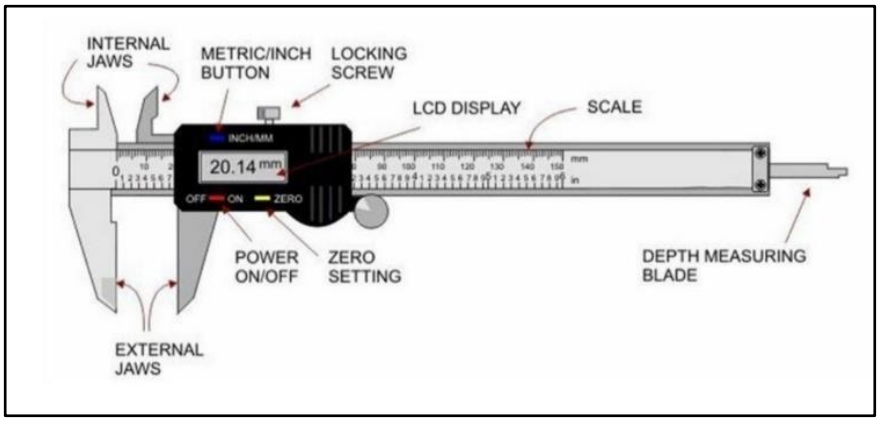

Figure 2: A Digital Electronic Calliper

The digital calliper consists of the following parts:

- Internal Jaws is used to measure internal dimensions like length between upper and lower incisors in an anterior open bite.
- Meter or inch button is used to choose the unit of measurement.
- Locking Screw is used to set the calliper at a desired measurement.
- Liquid Crystal Display screen displays the measurements in imperial or metric scale.
- Scale has a sliding platform carrying a Vernier scale and it holds the depth measuring blade that can be used for analogue measurements.
- Depth measuring Blade is used to measure depth like in overjet measurements.
- On and off power switch.
- External Jaws is used to measure the external dimensions like the mesio-distal width of teeth.

The DAI (57) was utilized to determine the severity of malocclusion and the orthodontic treatment needs in the permanent dentition study models. The study models in the mixed dentition stage were assessed using the modified DAI which omits the missing teeth component of the DAI (64, 65), and the severity of malocclusion and treatment need were then determined.

The DAI identified ten occlusal traits and mathematically derived a single score using regression equation as follows: DAI score (Appendix 1) = "**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)" (57). **Table 2** shows the DAI score categories used to determine the severity of malocclusion and orthodontic treatment needs.

Table 2: DAI Score Categorization of Malocclusion and Treatment Need

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

Data collected was transferred to a MS Excel spread sheet, saved in a password protected computer to which only the PI and supervisor could access. Data from the MS Excel spread sheet was exported to Stata statistical software package (version 16), which was used for data analysis. Categorical data (gender, race, age, type of dentition, DAI scores and Angle's classification with Dewey's modification for Class I and III are presented as frequency and percentages. The prevalence of malocclusion was determined by calculating the percentage of the total number of

the sample who were categorised as having a definitive, severe and handicapping malocclusion according to the DAI scores.

2.8 Error of Measurement

Repeat measurements of 10% of the study models were re-examined by the PI (AR), two weeks after the initial measurements, to test for the intra-examiner reliability using interclass correlation. The supervisors (PH) also measured these records to assess the inter-examiner reliability. Kappa score (**Table 3**) for intra-examiner reliability was 0.9 and 0.7 for inter-examiner reliability which showed an overall good and acceptable agreement.

Table 3: Reliability of Measurements

	Intra-Examiner Reliability	**Inter-Examiner Reliability**
Agreement	92.31%	84.62 %
Expected agreement	46.75%	47.34 %
Kappa	0.8556	0.7079
P-value	<0.001	<0.001
Reliability	0.9167	0.7709

2.9 Ethical Considerations

Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg to conduct this research project under reference number M210413 (Appendix 2). Permission was received from Hospital Research and Risk Committee (Appendix 3) and the Head of the Orthodontic Department (Appendix 4) at WOHC to access patient records. Inform consent was not sought since the study was a record review. Furthermore, the PI is registered with the Health Professions Council of South Africa and understands the importance of confidentiality. The patient's records were completed anonymously and coded to protect the patient's identity. The details that could be used to identify individuals were not recorded in the record review form to ensure anonymity and confidentiality.

Chapter 3: Results

3.1 The Study Sample

We reviewed 287 pre-treatment orthodontic study models of patients treated by undergraduate students at WOHC, 163 were excluded from the study because of incomplete data, and the final sample was 124 records.

Most of the sample were males (n=68; 54.84%) compared to females (n= 56; 45.16%). The Africans showed predominance for race (n=91; 73.39). The majority of the sample presented with mixed dentition n=110 (88.71%) and permanent dentition was found in n=14 (11.29%) (**Table 4**). The prevalence of malocclusion was 92.74%.

Table 4: Demographic Characteristics of the Sample

Socio-demographic Characteristics	Frequency (n=124)	Percentage (%)
Gender		
Male	68	54.84
Female	56	45.16
Race		
African	91	73.39
Coloured	10	8.06
White	7	5.65
Indian	5	4.03
Other	11	8.87
Type of dentition		
Mixed	110	88.71
Permanent	14	11.29

3.2 Sample Age and DAI Score

The mean age of the sample was 9.72 (SD ± 1.52) years, with the age ranging from 6 to 13 years. The overall mean DAI score of our sample was 39.54 (SD ±10.88) ranging from 23 to 94 (**Table 5**). The Shapiro Wilk test showed that there was no statistically significant difference for age and DAI (p=0.23).

Table 5: Mean Age and DAI Score of the Sample

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Age	124	9.72	1.52	6	13
Total DAI Score	124	39.54	10.88	23	94

3.3 Angle's Classification of Malocclusion

The Angle's classification of malocclusion is shown in **Table 6**. Most of the study sample (n=101; 81.45%) had a Class I malocclusion.

Table 6: Angles Classification of Malocclusion

Angle's Classification	Frequency (n)	Percentage (%)
Class I malocclusion	101	81.45
Class II malocclusion	11	8.87
Class III malocclusion	12	9.68
Total	124	100

3.4 Distribution of Malocclusion according to Angle's Classification by Gender

Females had a higher predominance of Class I (n=57; 45.97%) and Class III (n= 8; 6.45%) malocclusion when compared to males. However, males showed predominance of Class II malocclusions compared to females as presented in **Figure 3**. There were no significant differences in the malocclusion classes and gender (Pr = 0.125; $p \geq 0.05$).

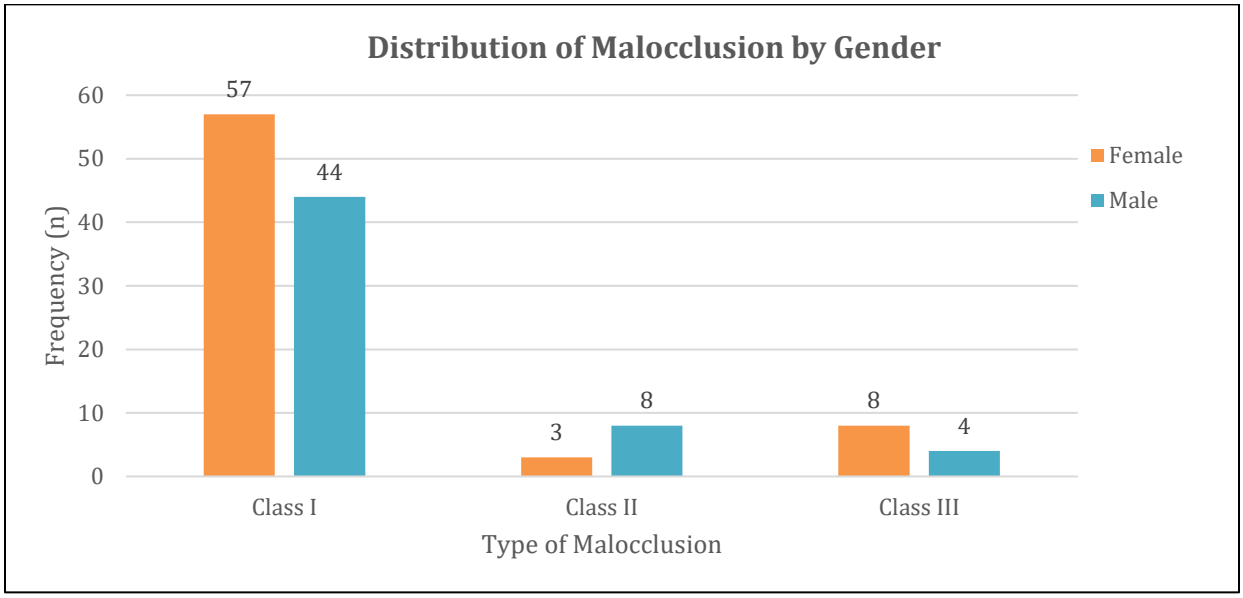

Figure 3: Distribution of Malocclusion based on Gender

3.5 Distribution of Malocclusion by Race

The distribution of malocclusion according to race is shown in **Table 7**. Africans showed predominancy of Class I, II and III malocclusions compared to Coloureds, Whites, Indians and Others. The "Other" category represented those records without the race recorded. The result showed no statistically significant differences between the proportion of classes of malocclusion amongst race (Pr = 0.264; $p \geq 0.05$).

Table 7: Angle's Classification of the Malocclusion by Race

Variables	Categories	Class I n (%)	Class II n (%)	Class III n (%)	P-value
Race	African	76 (61.29)	7 (5.65)	8 (6.45)	0.264
	Coloured	6 (4.84)	2 (1.61)	0	
	White	5 (5.0)	0	1 (0.81)	
	Indian	6 (4.84)	0	0	
	Other	8 (6.45)	2 (1.61)	3 (2.42)	
Total	124 (100%)	101(81.45)	11 (8.87)	12 (9.68)	

3.6 Distribution of the Sample according to the DAI Score

The result presented in **Figure 4** show that most of the study sample (n=75; 60.48%) had handicapping malocclusion and required mandatory orthodontic treatment. Severe malocclusion was found in 19.35% (n=24) who required orthodontic treatments and definitive malocclusion was found in n= 16 (12.9%) requiring elective treatment. Those with minor malocclusion (n=9; 7.26%) required slight or no orthodontic treatment.

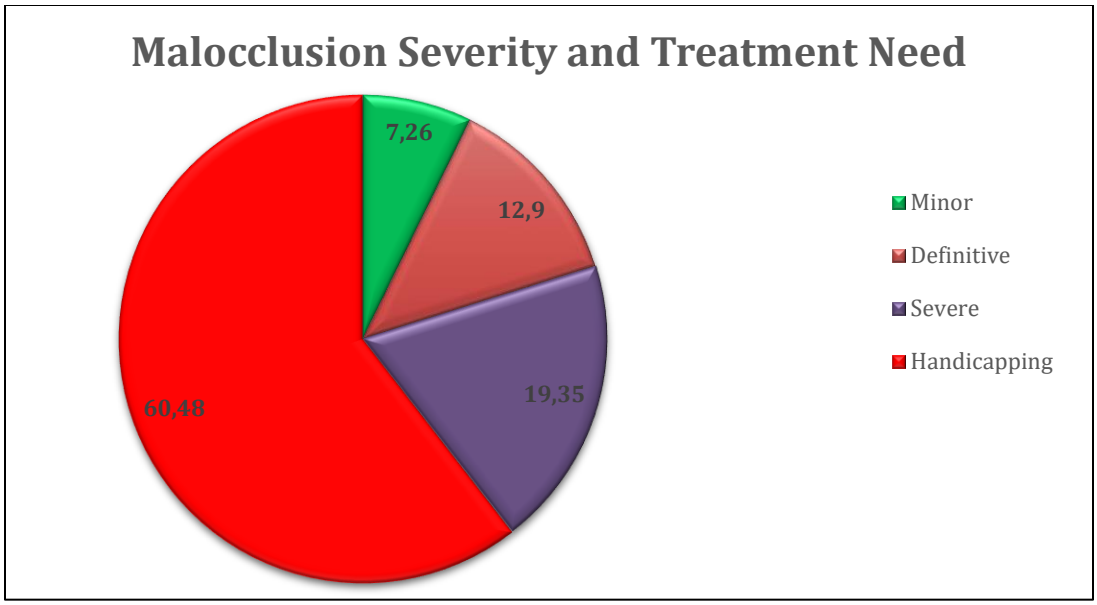

Figure 4: Malocclusion Severity and Treatment Need

3.7 DAI Treatment Need according to Gender

The result presented in **Table 8** shows that there was a higher number of females (n=65; 52.41%) that had malocclusion and required treatment compared to males (n=50; 40.32%). There were more males (n=6; 66.67%) than females (n=3; 33.33%) that needed no or minimal orthodontic treatment. The results showed no statistically significant difference between the gender in terms of treatment needs (Pr = 0.247; $p \geq 0.05$; Pearson chi-square= 4.1416).

Table 8: DAI Treatment Need according to Gender

Gender	No treatment (n, %)	Elective treatment (n, %)	Need treatment (n, %)	Mandatory treatment (n, %)
Female	3(33.33)	11(68.75)	16(64.0)	38(51.35)
Male	6(66.67)	5(31.25)	9(36.0)	36(48.65)
Total	9(100)	16(100)	25 (100)	74(100)

3.8 Distribution of 10 Occlusal Traits according to DAI Components

Malocclusion traits according to the DAI is illustrated in **Table 9** for permanent dentition (n=14) and mixed dentition (n=110). Missing teeth was not included in the assessment of the mixed dentition stage, using the DAI (68, 73). It was assumed that all unerupted permanent teeth were present (73). Anterior mandibular irregularities were the most found DAI malocclusion trait in both the mixed dentition and permanent dentition. The least common DAI malocclusion trait was missing teeth. Anterior mandibular irregularity was the most common occlusal trait (n=121; 97.58%), followed by anterior maxillary irregularity (n=120; 96.77%) and the least commonly found was missing teeth (n=7; 5.65%).

Table 9: Malocclusion Traits according to DAI Components

DAI Component	Mixed dentition n=110 (n/%)	Permanent Dentition n=14 (n/%)	Total Sample n=124 (n/%)
Missing Teeth	0	7 (50)	7 (5.65)
Crowding	87 (79.89)	12 (85.71)	99 (79.84)
Spacing	96 (87.27)	10 (71.43)	106 (85.48)
Midline Diastema	27 (24.5%)	2 (14.3%)	29 (23.39 %)
Anterior maxillary irregularity	106 (96.36)	14 (100)	120 (96.77)
Anterior mandibular irregularity	107 (97.27)	14 (100)	121 (97.58)
Anterior maxillary overjet	91 (82.73)	14(100)	105 (84.68)
Anterior mandibular overjet	29 (26.36)	2 (14.29)	31 (25.0)
Vertical anterior open bite	49 (44.55)	3 (21.43)	52 (41.94)
Molar relationship	81 (73.64)	13 (92.86)	94 (75.81)

3.9 Association between DAI Score and Angle's Classification

Table 10 shows the results for the association between DAI score and Angle's classification. There were no statistically significant differences between the DAI score and the three classification groups, (Pr=0.8958, $p \geq 0.05$).

Table 10: Association of DAI Score and Angles Classification

Angle's Classification	Mean DAI Score	SD for DAI Score	P-value
Class I	39.74	11.03	0.8958
Class II	38.27	9.22	
Class III	38.92	11.74	

Chapter 4: Discussion

Our study assessed the prevalence of malocclusion from 124 pre-treatment study models of patients treated by undergraduate students at a dental school and found a prevalence of 92.74 %. The results are expected because the study was conducted at WOHC Orthodontic Department which is a centre for undergraduate and postgraduate training in orthodontics. Patients requiring orthodontic treatment are referred by general dental practitioners and government dental clinics for tertiary care at WOHC. The percentage of patients (7.26 %), not deemed to have definitive, severe and handicapping malocclusion by the DAI, did present with minor malocclusion that required minimal orthodontic treatment.

The prevalence rate of malocclusion for our study findings was comparable to prevalence rate reported in other studies (4, 9, 26, 37). The high prevalence rate of malocclusion found in our study was similar to the findings of other studies reported in the literature (4, 37). Goyal and co-workers used the DAI to assess malocclusion at a hospital in Rwanda and found a prevalence of malocclusion range of 89% and 93% (4, 37). The prevalence rate of malocclusion of 81% has been reported in Africa (26). Contrary to our study findings, the prevalence of malocclusion in South Africa ranged between 32% to 52.3% in previous studies (39-42).

Angle's Classification of Malocclusion

Class I malocclusion is a global problem, which has been highlighted by Alhammadi and co-workers in a systematic review study to have a prevalence of 74.7% (31 – 97%), world-wide (26). The authors used a mixed sample from different settings (school, health centres and communities). The findings of our study showed that Angle Class 1 malocclusion (81.45%) was the most predominant type of malocclusion while Class II malocclusions (8.87%) was the least common. These findings are similar with the results of other studies done in South Africa (40, 74) , USA (28), Nigeria (10), Rwanda (37) and Mauritius (75).

Aiken and co-workers conducted a study in Nigeria in 2014 (10). They reported that most children (80.3%) presented with Angle Class I malocclusion (10). A 1981 study conducted in Soweto by Hirschowitz and co-workers reported Class I malocclusions to be the most prevalent type of malocclusion in 79.5 % of their sample (74). Class III malocclusion were found in 9% of their

sample while a slightly higher prevalence of Class II malocclusion (12.4%) was reported (74), compared to our study.

In 1998, the Nutrition Examination Survey (NHANES III) reported that African Americans displayed the most severe type of malocclusion, with Class I malocclusion being the most prevalent and Class II malocclusion being the least prevalent (28). A slightly lower prevalence of Class I malocclusion (66.3%) was described in a 2012 study at a College of Dentistry in Mauritius (75). The authors described that Class I malocclusion was more commonly found and higher than Class II and III malocclusions (75), which is similar to our findings.

A 1993 study done in South African school children using the DAI, found that Class II malocclusion (n=62.86%) were more predominant, however, a third of the sample presented with a Class I malocclusion (68). Similarly, a Turkish study found that Class II (44.7%) malocclusions were more common (76). Class II malocclusion showed predominance in these studies compared to our study findings which could be due to racial and age differences.

Distribution of Malocclusion by Gender

The results of our study showed that females had a higher predominance of Class I and Class III malocclusion when compared to males. However, males had a higher number of Class II malocclusions than females. Females tend to have a greater concern for their aesthetic; hence, they seek orthodontic care more often than males thus presenting with a higher predominance of malocclusion (77). Furthermore, the developmental stages of females differ when compared to males (78) and this difference could possibly also contribute to the variation in the female maturity and orthodontics treatment demands. The results of our study had similar findings with the previous studies conducted in South Africa (79), Libya (80), Nigeria (10) and Mauritius (75) regarding gender differences.

Jacobson conducted a study in 1967 and evaluated 460 crania and mandibles of black South Africans (79). The findings of his study showed that 97.4% of females presented with Class I malocclusion compared to the males (96.4%) (79). These findings were similar to our study showing that females had a greater predominance of Class I malocclusion compared to males.

Similarly, studies conducted in Nigerian (10), Mauritius (75) and Libyan (80) also reported more females presenting with Class I malocclusion compared to males.

Distribution of Malocclusion by Race

Malocclusion varies according to race and ethnicity (77). Africans showed predominancy of Class I, II and III malocclusions in our study compared to Coloureds, Whites, Indians and other races. Our results were similar to previous studies (26, 40). Alhammadi and co-workers carried out a systematic review and found that Class I malocclusions was most common globally with a higher predominance in Africans (26). In 2005, van Wyk and co-workers reported that black South Africans predominantly presented with a Class I malocclusion compared to Whites, Coloured and Indian/Asians (40).

Our results on the distribution of malocclusion according to race are contrary to a study in Mauritius (75) and Kuwait (81) which found that malocclusions presented more commonly in Asians than in Africans. The results of these studies could possibly differ to our study due to the lower racial distribution of Africans in Mauritius and Kuwait.

Distribution of the Sample according to DAI Score

Majority of our study sample (60.48 %) presented with a handicapping malocclusion and required orthodontic treatment that was mandatory. Changes in the frequency of malocclusion occurs in different stages of development of the dentition (30). The DAI correctly predicts the proportion of subjects requiring treatment but can overestimate treatment need in mixed dentition (64, 68, 82). Our study sample had 88.71 % with mixed dentition which could explain the handicapping malocclusions presentation in most of the sample. A study analysed the malocclusion of 10-year-olds and re-examined the same patients at 13-years old (82). They found that fewer children had a malocclusion at age 13-years (82). Nonetheless the results of our study coincide with studies previously conducted in South Africa (9), Brazil (83) and Rwanda (4).

In 2010, Maumela and Hlongwa evaluated the use of the DAI to prioritize the need for orthodontic care at the University of Limpopo in South Africa. They found that 80% needed orthodontic treatment (9), which was similar to our study. Cardoso and co-workers used the DAI on randomly selected orthodontic study models from a University in Brazil. They found that 89% of the sample required treatment (83), which was also similar to our study findings. Similarly, Goyal and co-workers in Rwanda also reported that 89% of the sample required orthodontic treatment (4).

Slightly lower frequencies were reported in a Saudi Arabian study (84) with 63% of the sample presented with a malocclusion requiring orthodontic treatment, a South African study (40) with 47.7% and a Brazilian study (77) at 58.7% compared to our study findings.

DAI Treatment Need according to Gender

Our study findings showed that the majority of females had a malocclusion and required treatment when compared to males. More females had a definitive, severe and handicapping malocclusion compared to their male counterparts. Males presented with no or minimal malocclusion which needed no or minimal orthodontic treatment. The gender distribution should be interpretated with care as the developmental stages could contribute to the different distribution of the DAI that is found between males and females (40, 78). Similarly, a 2013 Rwandan study (4) showed that 55% of females had handicapping malocclusion requiring mandatory treatment compared to fewer males (48%). A previous study in South Africa (40) reported 50% of females having minimal or no malocclusion compared to males (44.79%), which was contrary to our findings.

Distribution of the Occlusal Traits according to the DAI

Visible Missing Teeth

The number of missing permanent incisors, canines and premolars in both dental arches were determined. The 'missing teeth' component for permanent canines and premolars was excluded for mixed dentition as they might have not erupted when their primary predecessors have not exfoliated. Seven of the permanent dentition study models, presented with missing teeth. This presented 5.65% of the study sample. Similarly, to our study, the findings of Drummond and co-workers reported that 8.57% of their study sample had one or more missing teeth (40). Slightly higher rates of missing teeth have been reported in Rwanda at 14% (4) and Kwa-Zulu Natal at 55.3% (78) compared to our study. The cause of the missing teeth was not investigated in our study, however, congenitally absent teeth or extraction of teeth in order to relieve dental problems has been reported (40, 85).

Incisal Segment Crowding

Crowding in the incisor region is explained as inadequate space that is present between the left and right canine teeth resulting in insufficient space for all four anterior teeth to be positioned normally in the dental arch (86). Crowding can cause teeth to be displaced or rotated out of position

in the dental arch (86). Crowding in mixed dentition affects 50 % of children and usually worsens as children transition from mixed to permanent dentition (87). Minimal increase of arch dimension in the anterior segment during development is often adequate to overcome only minimal arch crowding, therefore crowding tends to continue into the permanent dentition stage especially if initially severe (40). The causes of crowding were not explored in our study, the probable causes could be early extraction of primary molars, dental caries, dentoalveolar discrepancies or jaw discrepancies (48).

Our study findings showed that crowding (n= 99; 79.84%) was the common occlusal trait. Similar results to our findings regarding crowding were reported by Goyal and co-authors in Rwanda, with 81% of their study sample having crowding (4). Similarly, Uzuner et al., in Turkey reported 88.2% of crowding from their study sample (88).

Contrary to our study findings, lower frequencies of crowding have been reported in India (48) at 26.7 % and South Africa (78) at 38.2%. These differences could be due to variabilities in sample size, racial differences, ethnicity and geographic location of the studies.

Incisal Segment Spacing

Incisal segment spacing is explained as an occurrence of a space that is in excess, between the left and right canine teeth, which surpasses 1-2 mm that is usually sufficient space for four incisors to be aligned normally in the dental arch (86). Examination for spacing was done on both upper and lower incisal segments, and our findings showed that 85.48% of the sample had incisal segment spacing in both upper and lower dental arch. Incisal spacing was the third most common malocclusion trait measured. Contrary to other studies who reported lower frequencies of spacing in South Africa (40), Rwanda (4) and India (48). The causes of spacing was not investigated, however, it can be due the incidence of parafunctional habits, dentoalveolar discrepancies or jaw discrepancies (48). The higher frequency showed in our study compared to other studies could be attributed to the higher number of mixed dentition sample where spacing is commonly found with deciduous teeth.

Midline Diastema

A midline diastema is described as a gap of more than 2mm between the two permanent maxillary incisors (86). Midline diastemas is commonly seen in mixed dentition and usually resolves as

patient transitions to permanent dentition unless the maxillary labial frenum prevents closure (40, 48). The causes of midline diastema were not investigated in our study, however detrimental habits (tongue thrusting and mouth breathing), central incisor dilaceration, labial frenum abnormality, microdontia and dento-alveolar discrepancies could contribute to the formation of midline diastemas (48).

Our study sample showed 23.38% with midline diastema, which was more commonly found in the mixed dentition. A South African study reported a higher frequency (36.3%) of midline diastema but mixed dentition was excluded in their sample (78). Similarly, to our study, 27% of the sample from a Rwandan study had a midline diastema (4). In 2005, Drummond and co-workers reported midline diastema in mixed dentition of 18.77% compared to permanent dentition at 15.98% (40). However, the overall frequency of midline diastema in mixed and permanent dentition (16.67%) was lower than our study findings (40). Other studies have also reported lower frequencies, 18.9% of Turkish children had midline diastema (88), 18.3% of 12- to 15-year-old Indians had midline diastema (48) and 8.72% of 12-year-old Brazilian children had midline diastema (89).

Anterior Maxillary Irregularity

Maxillary irregularity in the anterior segment is measured when teeth are either displaced from or rotated out of their normal alignment, the upper incisors are used to recognize the greatest irregularity (86). The causes of this irregularity were not investigated in our study; however, genetic and environmental factors could be contributory factors (48).

Anterior maxillary irregularity (97.58%) was the second most common DAI malocclusion trait in our study sample. Similar findings of high frequencies of 79% in Rwandan (4) and 89.9% in Turkey (88) are comparable to our study. However, lower frequencies of anterior maxillary irregularity have been reported by other studies at 59.5% (39), 59.52% (40) and 68.1 % (78).

Anterior Mandibular Irregularity

Mandibular anterior irregularity is when teeth are either displaced from or rotated out of their normal alignment, the lower incisors are used to recognize the greatest irregularity (86). The causes of this irregularity were not investigated however genetic and environmental factors could be contributory factors (48).

Anterior Mandibular irregularity (96.77%) was the most common DAI malocclusion trait in our study sample. Similar findings of high frequency of 70.7 % in South Africa (78) is comparable to our study. However, lower frequencies of anterior mandibular irregularity have been reported by other studies at 53.06% in South Africa (40) and 62% in Rwanda (4).

Anterior Maxillary Overjet

Anterior maxillary overjet is described as the measurement of the horizontal distance between the most prominent labio-incisal edge of upper incisors and the corresponding opposing lower incisor's anterior surface (86). Maxillary overjet tends to improve with age (40).

Maxillary overjet was present in 84.68% of our sample. Similarly, a high frequency of maxillary overjet was found in other studies at 88.91% in South Africa (40), 75% in Rwanda (4) and 80.8% in Indonesia (90) which are comparable with our study. A lower frequency was found in another South African study at 68.1% (78).

Anterior Mandibular Overjet

Anterior mandibular overjet ensues when the anterior teeth in the mandible protrude labially beyond the opposing upper anterior teeth, which is also known as reversed or negative overjet (86). This malocclusion trait is commonly associated with Angles Class III malocclusions or anterior crossbite (40). The causes of this malocclusion trait were not investigated however genetic predisposition, discrepancies in the dento-alveolar width and growth variations can contribute to its occurrence (48).

Anterior mandibular overjet presented in 25% of our study sample. Similarly, a frequency of 28.2% in Turkey (88) was comparable to our study. However, lower frequencies of mandibular overjet at 10.43% (40) and 15% (4) has been reported. These studies had larger sample sizes compared to our study.

Anterior Open Bite

Anterior open bite (AOB) is the vertical measurement of the space between the upper and the lower incisors when they are not overlapping in normal overjet and overbite (86). The causes of this malocclusion trait were not investigated however dento-alveolar discrepancies, para-functional habits like thumb sucking and growth variations can contribute to its occurrence (48).

AOB presented in 41.94% of our study sample, which is considerably higher when compared to other studies at 7.7%, 14% and 21.48% (4, 40, 78). The difference in the AOB findings between other studies and our study could possibly be attributed to the population group and the type of sample which was studied in our study. AOB is commonly found among young children with mixed dentition (91), which could possibly explain the higher frequency of AOB in our study which composed of predominantly mixed dentition.

Antero-Posterior Molar Relationship

The antero-posterior molar relationship is explained as the relationship that occurs when the mesiobuccal cusp of the first maxillary permanent molar occludes with the buccal groove of the first mandibular permanent molar (11). The dental arches are examined bilaterally while the teeth are in occlusion, however the side with the most abnormal relationship is utilized (86).

An abnormal antero-posterior molar relationship was found in 75.81% of our study sample. Similarly, high frequencies of an abnormal antero-posterior molar relationship have been reported at 76.9% in Indonesia (90) and 71.11% in South Africa (78). Contrary to our findings, a lower frequency was found at 44.52% in South Africa (40). The different findings could be due the different sample size used in our study.

Association of DAI Score and Angles Classification

The correlation between the DAI score and Angle's classification was studied. There was no significant difference between the mean DAI score and the three classification groups of Angle's classification (p-value>0.8958). The complementary use of both the indices seems possible which is supported by studies conducted in Brazil (89) and Turkey (88).

Limitations of the study

- Our study evaluated pre-treatment study models only, the radiographs of the patients were not evaluated. This limitation resulted in not knowing whether the missing teeth were congenitally absent, impacted or extracted.
- Patients who were referred to the undergraduate orthodontic clinic for orthodontic treatment were only included in this study.

- We had estimated that 287 pre- treatment study models for the sample size, however we encountered limitations:
    - Most of the pre-treatment study models and bite registrations were missing for the period 2015 to 2019.
    - Most study models were not labelled and were not in model boxes or were in the incorrect box with other models.
    - Some of the study models were not correctly trimmed or not trimmed at all according to the accepted norms and standards (73).
    - Some of the patient's records were missing or not captured.

The findings of our study cannot be generalized but need to be interpreted with caution. Even with the above limitations, our study was able to report the data for measuring trends and patterns.

Chapter 5: Conclusions and Recommendations

Conclusions

- All patients in the study sample presented with malocclusion according to Angle's classification.
- The DAI deemed 92.74% of the sample required orthodontic treatment.
- No significant differences were found between Angle's classification of malocclusion and the DAI scores.
- A high frequency of anterior mandibular irregularity, anterior maxillary irregularity, spacing and anterior maxillary overjet was detected from the 10 occlusal traits of the DAI.
- The WOHC undergraduate dental students are providing orthodontic treatment to patients in the mixed dentition stage, this is the correct age group for preventative and interceptive orthodontic treatment.

Recommendations

- The DAI should be used in the mixed dentition stage to assess malocclusion together with radiographs so that missing permanent teeth can be evaluated.
- Preventative and interceptive orthodontic treatment has been shown to be beneficial in reducing and preventing the severity of malocclusion. Therefore, part of programs offering for orthodontic care in public health clinics should include these treatments.
- The DAI can be used to prioritize patients and can assist with budgeting and resource allocation for orthodontic care in public dental health clinics in South Africa.
- Epidemiological surveys need to be conducted on a larger population in the permanent and mixed dentition stages in South Africa, to assess the prevalence of malocclusion because few studies have been done with convenient samples and most of them are outdated.
- Further studies need to be conducted to evaluate the outcome of interceptive and preventive orthodontic treatment on our study sample cohort.
- Future studies need to be conducted and evaluate where are the patients with malocclusion coming from, who is referring them for treatment and correlate that to the prevalence of malocclusions.

- Gauteng Department of Health must consider creating specialist orthodontist post in district clinics to assist with the treatment of malocclusion that requires fixed orthodontic treatment.

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Appendix 1: Data Collection Form

The Prevalence of Malocclusion and Orthodontic Treatment Needs of Patients Treated by Students at Wits Oral Health Centre

Patient Unique Number: …….

Part A- Demographic data from patient record files:

Gender: …… Age: ……...

Race: …….

Type of dentition (pre-treatment stage): ……

Part B- Pre-treatment models:

Angle Classification: ……

Dewey's modification for Class I / Class III: …….

Dental Aesthetic Index:

	DAI Components	Measured Weights	Rounded Weights	Total
1	Number of visible teeth that are missing (incisors, canines and premolar teeth in the maxilla and mandible)		6	
2	Crowding in incisal segments- 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 millimeters		3	
5	Largest anterior irregularity in maxilla in millimeters		1	
6	Largest anterior irregularity in mandible in millimeters		1	
7	Anterior maxillary overjet in millimeters		2	

8	Anterior mandibular overjet in millimeters		4	
9	Vertical anterior open bite in millimeters		4	
10	Anterior posterior molar relationship largest deviation from normal either left or right- 0=normal, 1= half cusp either mesial or distal, 2= 1 full cusp or more either mesial or distal		3	
11	Constant		13	
	Total DAI score			

Appendix 2: Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr A Rawat

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M210413

NAME: (Principal Investigator)	Dr A Rawat
DEPARTMENT:	School of Oral Health Sciences Department of Orthodontics Dental School University
PROJECT TITLE:	*The prevalence of malocclusion and orthodontic treatment needs of patients treated by students at Wits Oral Health Centre*
DATE CONSIDERED:	2021/04/30
DECISION:	Approved unconditionally
CONDITIONS:	Professor Nemutandani removed as co-investigator on 2022/09/13
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor P Hlongwa
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/06/24

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

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 submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **April** and therefore reports and re-certification will be due in the month of **April** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Rawat — Signature of Principal Investigator

13/09/22 — Date

Appendix 3: Permission from the Hospital Research and Risk Committee

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 3890 Email: Julitha.Molepo@wits.ac.za

29 July 2021

Dr A. Rawat
Orthodontics Department
Faculty of Health Sciences
University of the Witwatersrand
Johannesburg

RE: PERMISSION TO CONDUCT RESEARCH

REFERENCE: HRRC/July/08/2021

It is my pleasure to grant final approval to conduct your research at Wits Oral Health Centre titled "The prevalence of malocclusion and orthodontic treatment needs of patients treated by students at Wits Oral Health Centre".

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,

Dr J. Molepo

HRRC Chairperson

Date: 03/08/2021

Appendix 4: Permission from Head of Department of Orthodontics

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

School of Oral Health Sciences
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8th floor, Area 385, Johannesburg General Hospital, Park Town
Private Bag 3, Wits, 2050

Department of Orthodontics

Date: 2021/03/01

The Chairperson

Research Committee

The Faculty of Health Sciences

The University of the Witwatersrand, Johannesburg.

Dear Sir/Madam

RE: Permission to do research in the Department of Orthodontics

Student: Dr Ameera Rawat Student no: 359523

Title: **The Prevalence of Malocclusion Among Patients Treated by Students at Wits Oral Health Centre**

This letter serves to confirm that I am granting permission for Dr Ameera Rawat to conduct research in the Department of Orthodontics towards a Master of Science in Dentistry (MSc Dent). Degree code (MCA07), Programme code (MFAORTD60).

Yours Sincerely

Dr Mosidi Makofane, Head of Clinical Department (Orthodontics)

Signature: Date: 2021/03/01

Appendix 5: Turn- it in Report

359523:Research_Report_Final_Turn_It_In.docx

ORIGINALITY REPORT

16%	13%	11%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	hdl.handle.net Internet Source	1%
2	Submitted to King's College Student Paper	1%
3	Submitted to University of Bolton Student Paper	1%
4	repository.up.ac.za Internet Source	<1%
5	www.intechopen.com Internet Source	<1%
6	sada.co.za Internet Source	<1%
7	Submitted to Sankalchand Patel University Student Paper	<1%
8	drmuna.com Internet Source	<1%
9	G.D. Singh. "Morphologic determinants in the etiology of class III malocclusions: A review", Clinical Anatomy, 1999	<1%