THE EFFECT OF THE GONIAL ANGLE, RAMUS LENGTH, AGE AND GENDER ON THE TEMPOROMANDIBULAR OPENING INDEX

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of

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THE EFFECT OF THE GONIAL ANGLE, RAMUS LENGTH, AGE AND GENDER ON THE TEMPOROMANDIBULAR OPENING INDEX

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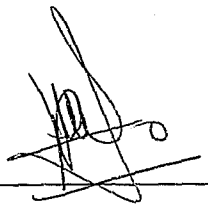
Declaration

I, Pusetso Moipolai, declare that this research report is my own work. It is being submitted for the degree of Master of Dentistry in the branch of Prosthodontics in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.



23 day of AUGUST, 2000.

This report is dedicated to my mother, for realising the potential in me and encouraging me every step of the way.

Abstract

Disorders of the temporomandibular joint (TMD) are the most common chronic pain conditions in the dental population. The cardinal signs and symptoms of these disorders are pain in orofacial muscles and / or joints; joint sounds; and limitation of mandibular movement.

Limitation of mandibular movement is usually assessed by measuring linear mouth opening. However, this has a number of limitations. It is dependent on variables such as age, gender and ramus length. A new measure of movement was therefore developed, the temporomandibular opening index, which was found, in a limited study to be independent of age and gender.

In this study, several variables - age, gender, gonial angle and ramus length - were studied to determine their effect on the temporomandibular opening index. This temporomandibular opening index was determined as a ratio between active (voluntary) and passive mouth opening (Miller et al., 1999).

Forty-two subjects who did not exhibit signs and symptoms of TMD were recruited to the study.

Ramus length, gonial angle, gender, and age were tested for association with the temporomandibular opening index. Linear regression analysis showed that there was no evidence of a relationship between the TOI and any of the variables tested. The analysis showed that the temporomandibular opening index was not dependent on gender ($p>0.644$); gonial angle ($p>0.327$); ramus length ($p>0.248$) and age ($p>0.690$).

This suggests that, as the temporomandibular opening index is also independent of both age and gender, it is a better indicator of limitation of oral opening than linear mouth opening measurements. In addition, it can also be used to categorise TMD patients. It is a cost effective, simple aid in the diagnosis of these disorders.

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Abbreviations

EMG	Electromyography
MRC	Medical Research Council
TMD	Temporomandibular Disorders
TM	Temporomandibular
TMJ	Temporomandibular Joint
TOI	Temporomandibular Opening index
AROM	Active Range of Motion
PROM	Passive Range of Motion
cGRP	Calcitonin Gene Related Peptide
TENS	Transcutaneous Electrical Nerve Stimulation

PREFACE

The broad long-term goal of this project is to develop and use an opening index to aid in the clinical diagnosis and categorisation of patients with temporomandibular disorders (TMD). If it can be shown that the TOI is independent of gonial angle, ramus length, age, and gender, it would be a better indicator of limitation of oral opening than linear mouth opening measurements. As it can also be used to categorise TMD patients, it is a cost effective, simple aid in the diagnosis of these disorders (Miller et al., 1999).

AIMS

The specific aims of the project are:

1. To study the relationship of the gonial angle, and the TOI in a group of patients with no TMD.
2. To examine the relationship of the TOI and gender in this group.
3. To examine the relationship of the TOI and age in this group.
4. To study the relationship of the ramus length and the TOI in this group.
5. To study the potential of TOI as a diagnostic tool.

All patients were examined for TMD using the procedure described by Bezuur et al. (1988) and Hansson (1988), and those presenting with signs and symptoms of TMD were excluded from the study.

1.0 INTRODUCTION

Temporomandibular disorders are a group of disorders of the orofacial musculature, as well as the temporomandibular (TM) joint (McNeill, 1983; Mohl & Dixon, 1994). TMD is recognised as the most common chronic orofacial pain condition confronting dentists and other health care providers (Dworkin et al., 1990). Numerous epidemiological studies have examined the prevalence of TMD in given populations (Okeson, 1993; McNeill, 1997). A conservative estimate of the number of people in the general population with some form of TMD is between 40 to 60% (Dworkin et al., 1990; Lipton et al., 1993; Okeson, 1993.). Females are more likely to seek treatment than males [4:1] (Franks, 1964; Dworkin et al., 1990; Salonen et al., 1990). Female susceptibility to TMD is not explained simply by sex-linked behaviour, such as treatment-seeking behaviour, coping style, and illness behaviour, as is frequently suggested but not scientifically supported (Pullinger et al., 1988). Some studies suggest that the joint laxity (Hesse et al., 1990; Buckingham et al., 1991; Westling & Helkimo, 1992) and hormonal status influence the development of TMD (Saville, 1968; Sonkin & Cohen, 1968; Abubaker et al., 1993; Campbell et al., 1993). Studies suggest that about 33% of the

population present with at least two or more signs and symptoms of TMD, even though only 5% seek professional assistance (De Kanter, 1980). The percentage seeking treatment is reported to be relatively constant no matter in which country the study was done (Agerberg & Carlsson, 1972; Jagger & Wood, 1992; Kitai et al., 1997; Luz et al., 1997). This means that in a country such as the USA, 10 million people will seek treatment. In South Africa it would suggest that ? million patients would require help.

Functional disorders of the masticatory system are probably the most common TMD complaints of patients seeking dental treatment (Kuttila et al., 1997). TMD most often manifests with a muscular functional abnormality (Cooper, 1996, 1997). They are usually characterised by limitation or deviations in mandibular range of motion, pain in the peri-auricular area, the temporomandibular joint (TMJ), or the muscles of mastication and joint sounds during mandibular function.

Structural changes of the TMJ are also reported to be common (Hansson et al., 1983). The structural changes would elicit similar symptomology as functional changes. Also, structural changes might prevent a wide range of vertical jaw motion.

The aetiology of TMD is accepted as being multifactorial (Ash, 1986; Fricton et al., 1988; De Boever & Steenks, 1991). To simplify how TMD symptoms arise the following formula has been suggested:

Normal Function + An Event > Physiologic Tolerance → TMD Symptoms.

(Okeson, 1993)

Muscle hyperactivity seems to play a significant role in the aetiology of TMD (Haber et al., 1983). This may be the result of parafunction, such as bruxing and clenching, or stress (Lundeen et al., 1987; Schiffman et al., 1992; Vanderas, 1995; Widmalm et al., 1995).

There is a high morbidity associated with this condition (Kuttila et al., 1998). Knowledge of molecular and cellular processes of pathologic states has not matured to a point that clinical diagnostic markers are available or within immediate reach, although a number of studies have investigated mediators of inflammation in joint fluid [cGRP, neuropeptide Y, substance P and others.] (Appelgren et al., 1993).

Cross sectional data suggest a decline in prevalence with age, and in contrast to chest and back pain, facial pain is less prevalent among older persons than among younger persons (Von Korff et al., 1988; Pereira et al., 1994). It is also possible that in the older age groups, other problems override the facial pain, hence it is perceived as being less.

It also needs to be emphasised that poorly collected or biased clinical data are as misleading as is the reliance on device-derived numbers that supposedly should eliminate human uncertainty. Some of the diagnostic aids that have recently been questioned include the utilisation of patient questionnaires (Smith et al., 1992). It is suggested that, although valuable, questionnaires should be interpreted with caution (Gerstner et al., 1994) as they often do not correlate with clinical findings (Clark et al., 1993; Lobbezoo-Scholte et al., 1995).

It has been claimed that far too many instruments and devices gather data that are not of value in making clinical decisions (American Academy of Orofacial Pain, 1996). This has led to guidelines being laid down by the American Dental Association for the acceptance of instruments as aids in the diagnosis of TMD (American Dental Association, 1991). Although many of these devices may have the potential to be clinically useful, their reliability, validity, safety, and efficacy have yet to be established (Lund et al., 1995; Clarke et al., 1997). Presently, reliability, validity, safety, and efficacy have been established for only a few diagnostic tests used for the diagnosis of orofacial pain (Mohl et al., 1990 parts I, II and III).

One of the cardinal signs of TMD is limitation of jaw movement. This parameter may be assessed by several methods e.g., through linear measurement, lateral and protrusive excursive measurement. Assessment of mouth opening relies on recording 3 vertical opening measurements:

1. Maximum comfortable opening. This is attained by asking the patient to open the mouth until pain is felt, at which point, the patient is asked to stop.

2. Full unassisted opening (otherwise known as active range of motion [AROM]. This is attained by asking the patient to open the mouth as widely as possible.

3. Assisted opening - known as passive range of motion [PROM]. This is attained by asking the patient to open as widely as possible and then the operator applies a gentle, steady force to determine if the mouth can be opened any wider.

The linear measurement range is of the order 36mm to 44 mm (Stegenga et al., 1993). It is reported to decrease with increasing age (Szentpétery, 1993).

Some of the methods and instrumentation used to measure mandibular movement include:

1. Electronic mandibular (jaw) tracking (Feine et al., 1988; Theusner et al., 1993; Tsolka et al., 1993; Cooper, 1997). The use of jaw-tracking devices for the diagnosis of TMD or other orofacial pains is not recommended at this point in time, because of the limitations of the instrumentation employed and the ambivalence of the data obtained.
2. Electromyography (Lund and Widmer, 1989; Rugh and Davis, 1990; Schroeder et al., 1991). Increased EMG activity can be influenced by the level of jaw opening (Lindauer et al., 1993). A comprehensive review of the scientific literature concluded that there is not yet sufficient evidence to support the use of EMG for the evaluation or differential diagnosis of orofacial pain (Lund and Widmer, 1989; Mohl et al., 1990; Lund et al., 1995).

3. Muscle stimulator systems e.g., Transcutaneous Electrical Nerve Stimulation (TENS).

4. Linear measurements (Dworkin et al., 1990; Westling & Helkimo, 1992) -- using millimeter rulers (McCarroll et al., 1987) and vernier calipers (Mezitis et al., 1989).

5. Imaging e.g., plain radiography (transcranial, transpharyngeal [Meng et al., 1987]); panoramic radiography; cephalometric radiographs (Habets et al., 1987; Weijs et al., 1989; Matillaa et al., 1995; Muto & Kanazawa, 1997); tomography (Knoernschild et al., 1991); computed tomography (Paz et al., 1988); arthrography (Watt-Smith et al., 1993); magnetic resonance imaging (Donlon et al., 1987; Sanchez-Woodworth et al., 1988); radionuclide imaging (Kartzberg et al., 1984; Kircos et al., 1988) e.t.c.

6. Sonography - the clinical significance and reproducibility of TM joint sounds is still not clear (Heffez and Blaustein, 1986; Widmer, 1989; Hardison and Okeson, 1990).

7. Mandibular goniometer (Dijkstra et al., 1995).

8. Mandibular excursiometer (Danis & Mielenz., 1997).

9. Thermography - the use of thermography for the diagnosis of orofacial pain has yielded conflicting results (Pogrel et al., 1989; Mohl et al., 1990).

10. Vibration analysis - data showing that vibration analysis is useful in the selection of appropriate patient therapy are lacking, even though some studies do report encouraging results (Christensen, 1992; Wabeke et al., 1992; Ishigaki et al., 1994)

As knowledge of TMD has increased, so has the sophistication of diagnostic procedures. Often these diagnostic tools are expensive to undertake, require technical know-how, and are time consuming (Mohl et al., 1990, 1994). Although possibly useful in research, most of these methods are not suitable for routine clinical use (Dworkin and LeResche, 1992; Garofalo et al., 1996; Clark et al., 1997), and their impact on clinical diagnosis is at this time rather limited.

Linear jaw opening measurements have been used as a diagnostic tool in the assessment of TMD (Dijkstra et al., 1995). It is usually determined by measuring the maximum opening that the patient can voluntarily achieve, from the incisal edge of the maxillary anterior teeth to the incisal edge of the mandibular anterior teeth (Westling & Helkimo, 1992) including the vertical overbite (McCarroll et al., 1987). However, this measurement has limitations. For example, it is significantly dependent on gender, where males show greater vertical jaw opening of 3mm – 5 mm (Pullinger et al., 1988; Dworkin et al., 1990), and is influenced by mandibular (ramus) length (Dikjstra et al., 1995). Dworkin et al. (1990) attribute the consistent gender difference in the amount of vertical jaw opening to biologically based differences in the physical stature of males and females. However, this is not validated scientifically. In addition, measurement of linear mouth opening does not allow division of TMD patients into diagnostic groups.

As linear jaw measurement has some limitations and proposed alternatives are costly and complex, a new simple index of mouth opening was developed, called the Temporomandibular Opening Index (TOI). The TOI is based on both active and passive opening. It is given by the formula:

$$TOI = \frac{\text{Passive opening}_{(mm)} - \text{maximum voluntary opening}_{(mm)}}{\text{Passive opening}_{(mm)} + \text{maximum voluntary opening}_{(mm)}} \times 100$$

The objective of this study was to examine the effect of age, gender, ramus length and gonial angle on the TOI in patients without signs and symptoms of TMD. As the development of this index is still at an initial stage, one of the aims of the study was to try and establish what parameters, if any; have an influence on this index.

In a pilot study, this index was found useful as an examination tool and also as a parameter in categorising different diagnostic groups. Identification of different subgroups within TMD patient groups has been documented (Miller et al., in press; Visser et al., 1995). The pilot study found that the TOI of a myogenous group of TMD patients differed significantly from that of a group with anterior disc displacement with reduction and a group of patients with closed lock (Miller et al., in press).

2.0 Materials and Method

Forty-two patients presenting to the University of the Witwatersrand School of Oral Health Sciences, Department of Orthodontics were examined. All the patients included in the study were assessed for TMD using the procedure of Bezuur et al. (1988) and Hansson (1988), and any patient who presented with signs and symptoms of TMD was excluded from the study.

Other exclusion criteria were:

1. Subjects had to be dentate
2. They had to have all their teeth present excepting the third molars or first premolars
3. There had to be an absence of periodontal disease and rampant caries
4. Subjects were not to be medically compromised or
5. Have certain systemic conditions, such as fibromyalgia.

For all the cases, the gonial angle and ramus length were calculated from lateral cephalometric radiographs (Fig. 1a & b). The vertical ramus length was calculated with the aid of a digitiser (Kontron Videoplan Digitiser - Fig. 2). The gonial angle was measured on the lateral cephalometric radiograph using a mathematical protractor. Fig. 1c shows the datum lines used to define the gonial angle (Fish, 1979). These measurements were taken from lateral cephalometric radiographs.

The vertical ramus length was measured on the lateral cephalometric radiographs using points which corresponded to the uppermost midmost point on the head of the condyle (articulare) and gonion. The linear distance between these two points was measured with the digitiser. Five consecutive measurements were done on each radiograph and the mean value utilised. (Fig. 3a & b).

The stomatognathic examination for TMD was based on that described by Bezuur et al. (1988) and includes anamnesis, active and passive mouth opening, lateral and protrusive mandibular movement, joint sounds, endfeel [a measure of tissue elasticity reflected by the nature of the resistance felt by the examiner just prior to the border for a passive joint movement] (Fig. 4a), joint play [measure of TM joint surface roughness] (Fig. 4b), dynamic and static pain tests, palpation of the muscles and joints and cervical spine movements (Clarke et al., 1997; Okeson, 1995).

Dynamic pain test requires slight manual resistance executed by the examiner (Fig. 5a). Static pain test will present as any pain that is reported during provoked active mandibular movements against heavy resistance from the hands of the examiner (Fig. 5b). During this test, the mandible is not supposed to move.

One examiner undertook measurement of the maximum voluntary oral opening (active) (Fig. 6a) and passive oral opening (Fig. 6b). These measurements were utilised in the determination of the TOI. The active and passive mouth opening for each study subject was measured as follows, using a Boley gauge (Fig. 7). Opening distances were measured from the mesial incisal edge of the maxillary central incisors to the mesial incisal edge of the mandibular central incisors. Precision of measurement was to the nearest 0.1mm. For active opening, patients were instructed to open their mouths as wide as they possibly could without any assistance (Fig. 6a). Passive opening was then measured as described by Hansson et al., 1980 (Fig. 6b).

The TOI was then calculated from the formula:

$$TOI = \frac{\text{Passive opening}_{(mm)} - \text{maximum voluntary opening}_{(mm)}}{\text{Passive opening}_{(mm)} + \text{maximum voluntary opening}_{(mm)}} \times 100$$

The examination for TMD diagnosis was performed independently by another examiner. Neither was aware of the other's determination.

Informed consent was obtained both verbally and in writing from each study subject or the parent or guardian, prior to the measurements being taken (Appendix 1).

Fig. 1(a) Gonial angle measurement

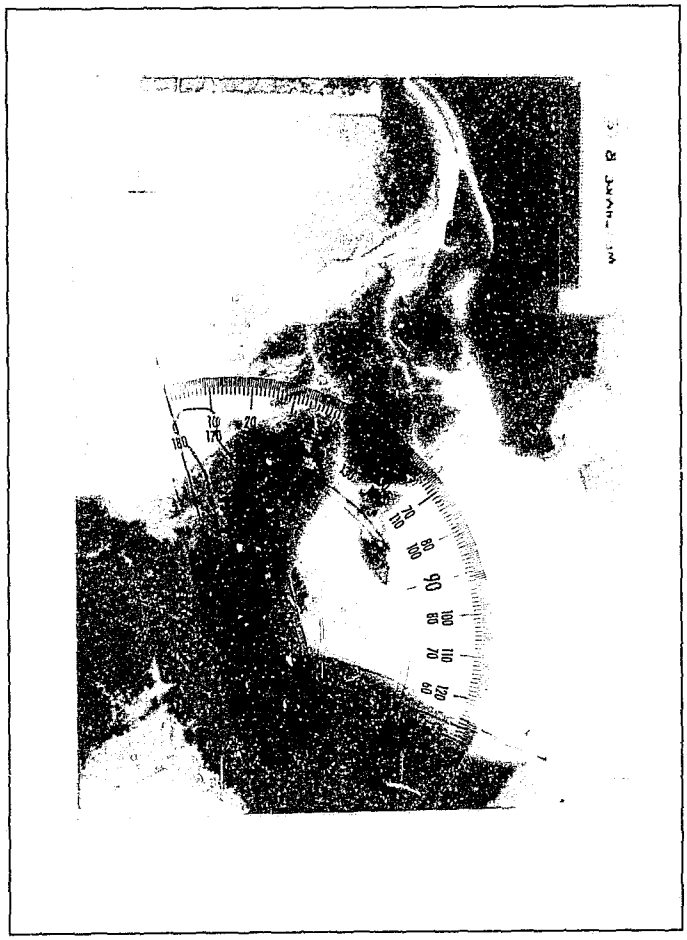


Fig. 1(b) Ramus length calculation – illustrating the two points used to measure the vertical ramus length

Fig. 1(c) Datum lines used to define the gonial angle

Fig. 2 Kontron Digitiser

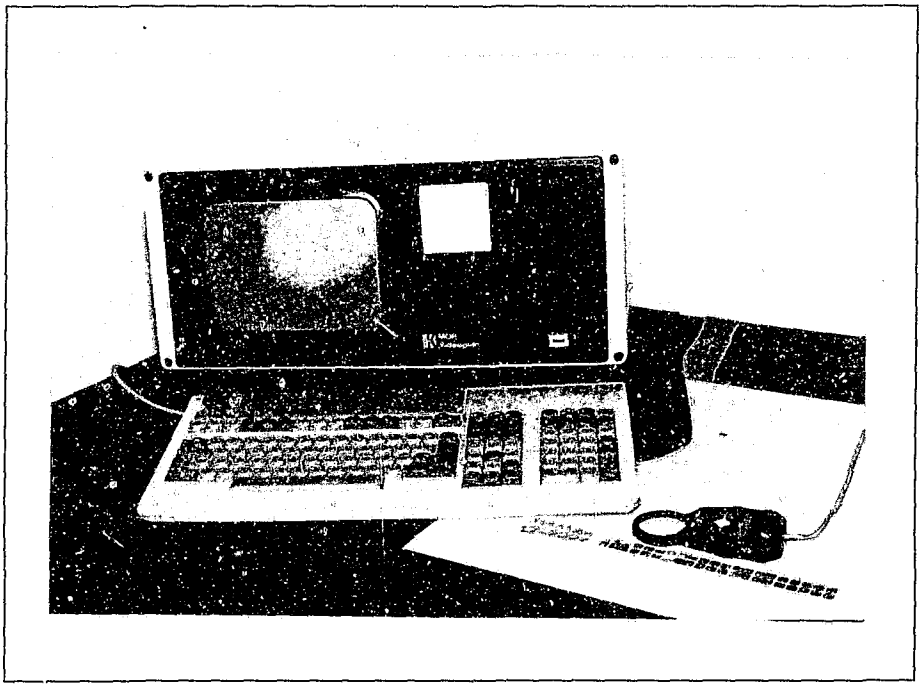


Fig. 3(a) Measuring the vertical ramus length with the Digitiser. The Digitiser is on the uppermost midmost point on the head of the condyle

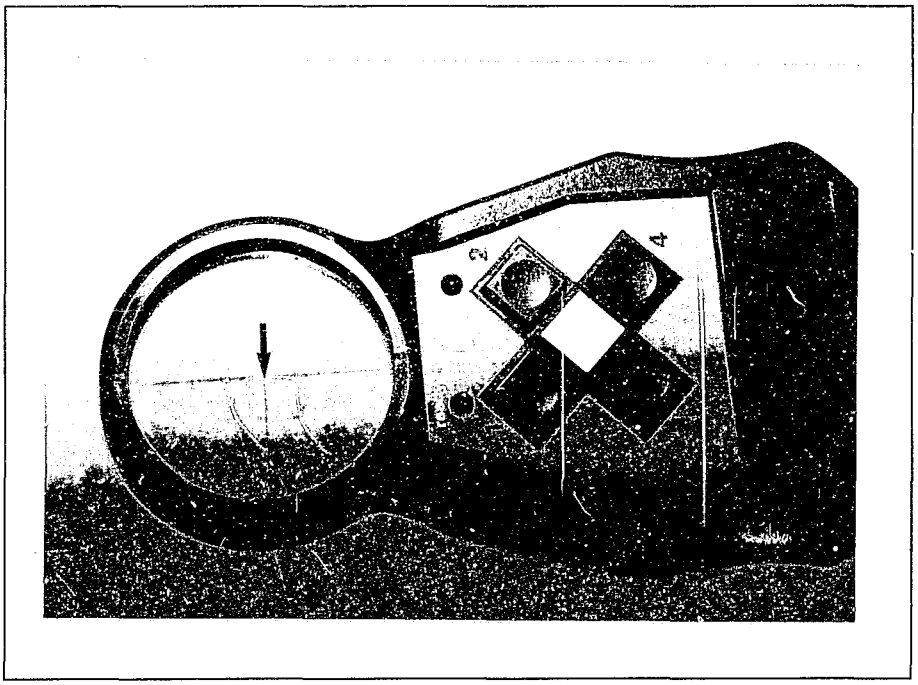


Fig. 3(b) Measurement of the vertical ramus length on the Digitiser. The mean of the five consecutive measurements was used

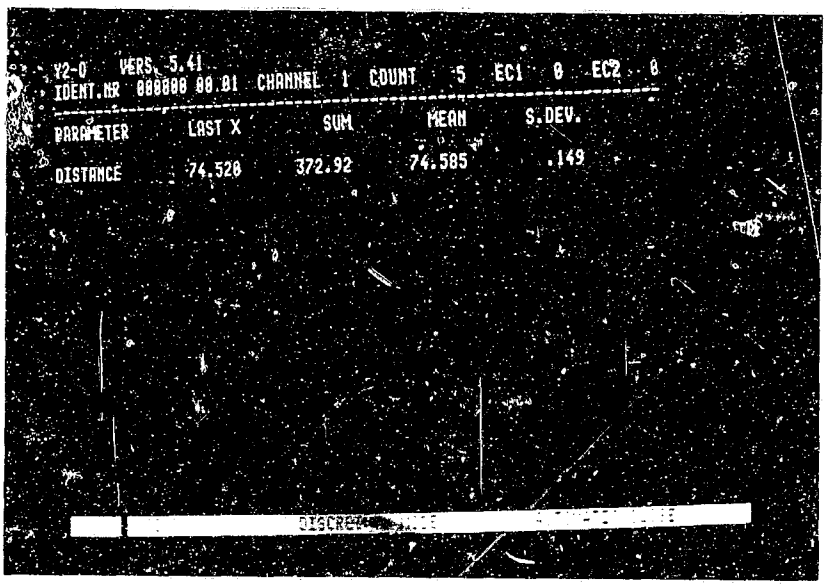


Fig. 4(a) Endfeel determination

Fig. 4(b) Jointplay determination

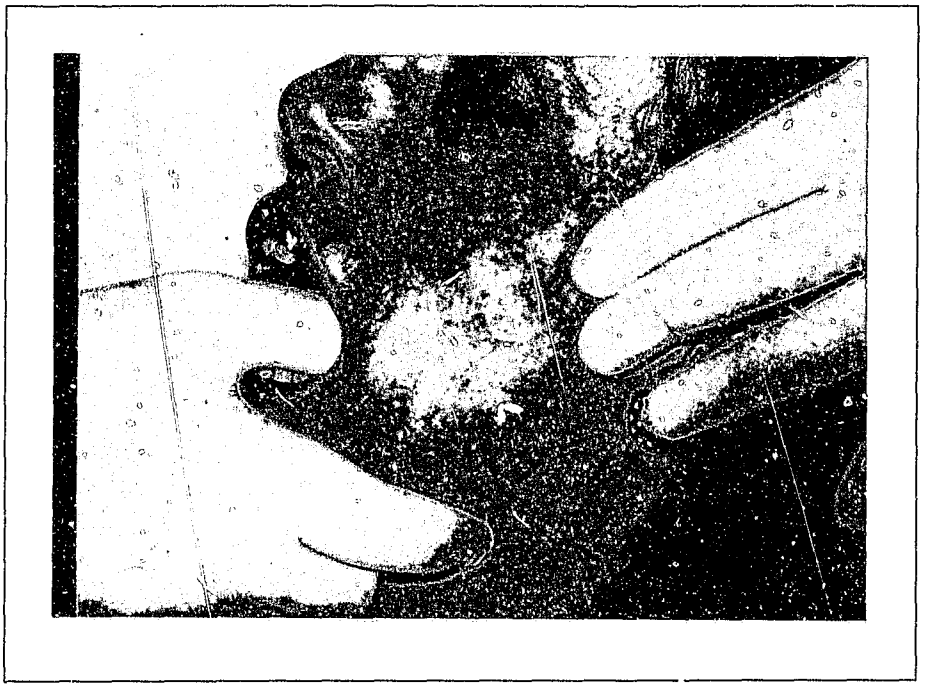


Fig. 5(a) Dynamic pain determination

Fig. 5(b) Static pain determination

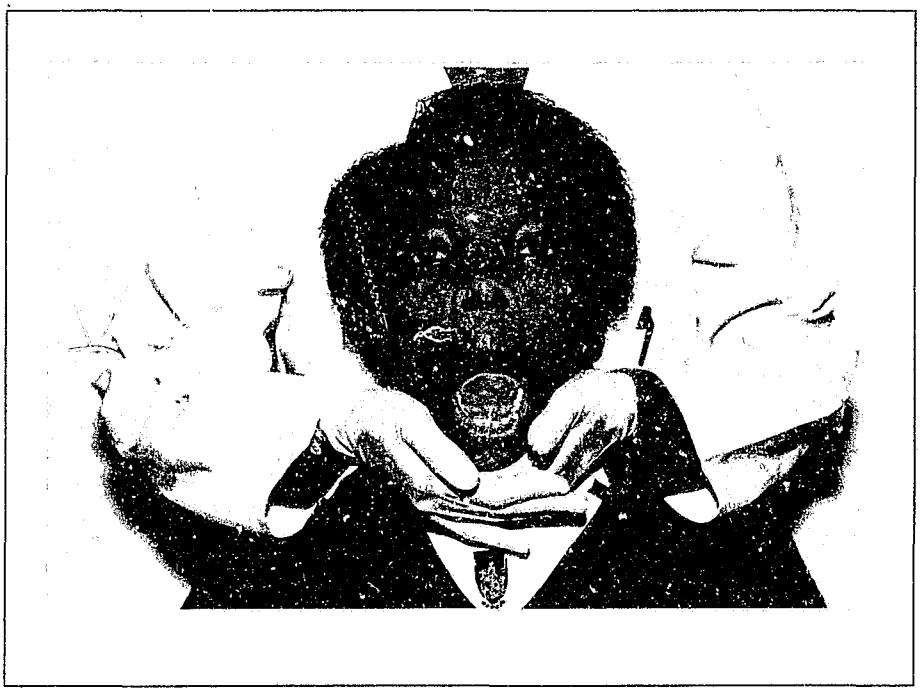


Fig. 6 (a) Maximum voluntary (active) oral opening

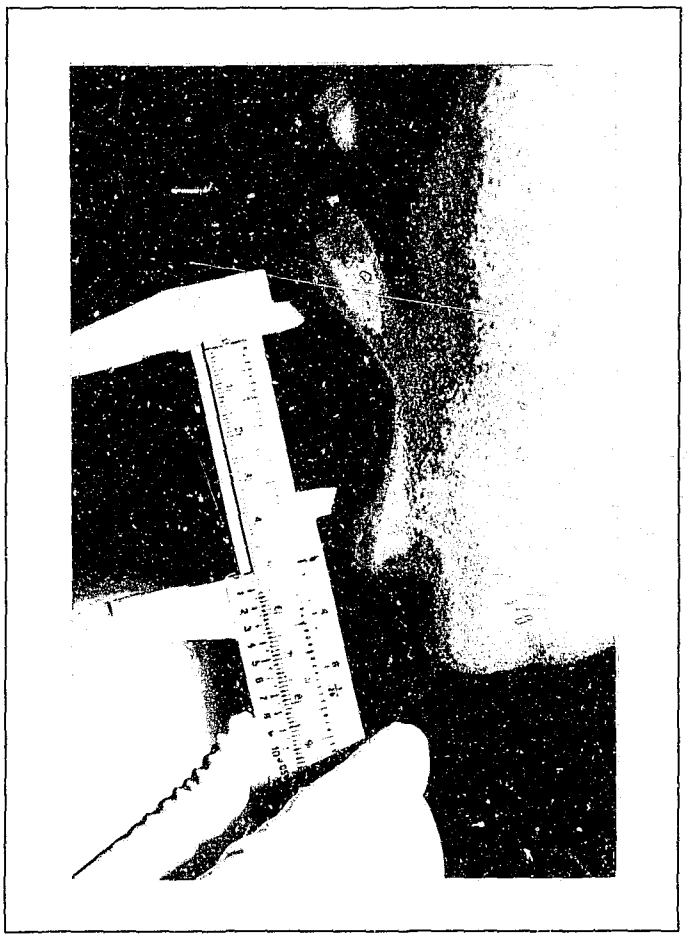
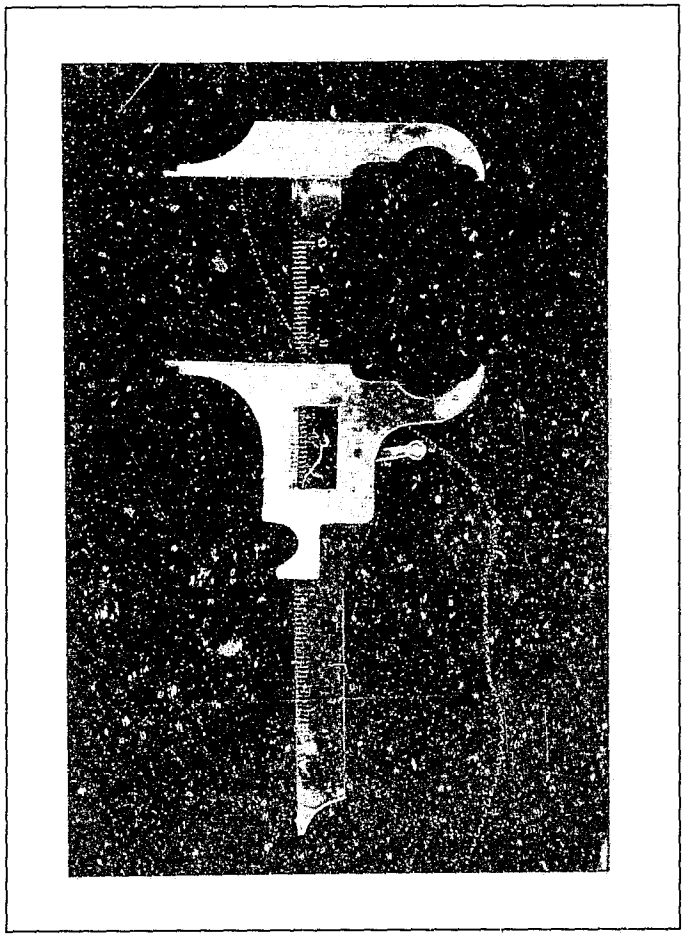


Fig. 6 (b) Passive oral opening

Fig. 7 Boley gauge



2.1 Statistical Analysis

The data analysis was performed by the South African Medical Research Council (MRC). The data was analysed using statistical software including SAS, Strata and Genstat. The primary outcome is the TOI as defined above. This was analysed using linear regression analysis. The assumptions of normality and homogeneity of variance were checked, and conclusions taken. Additionally, socio-demographic data was collected on all study subjects. Linear regression analysis was used to explore the effect of these variables on the effect they may have on the TOI.

3.0 Results

Table 1 records patient age, gender and TOI and Table 2 also includes the ramus length and gonial angle measurements for all the patients. Table 3 records the data for the study group. The raw research data is recorded in Appendix 3.

Analysis of covariance showed no significant difference between all the variables examined. Jointly they explained 6.6% of variation. Regression analysis showed that there was no association between the TOI and age ($p>0.690$); gender ($p>0.644$); gonial angle ($p>0.327$) and ramus length ($p>0.248$).

Note that the above analyses show that there is no evidence of a relationship between the TOI and any of ramus length, gonial angle, age and gender.

Inter and intra observer agreement was calculated according to the method of Bland and Altman (1986). The mean was not significantly different from zero. In clinical studies differences greater than 1.28 would be significant (Appendix 5).

Complete statistical analysis is given in Appendix 2.

Table 1. The TOI with Age and Gender

Number	Age (Years)	Gender	Passive Opening (mm)	Active Opening (mm)	TOI (%)
1	25	Female	46.1	44.9	1.32
2	15	Female	55.2	42.2	13.35
3	13	Male	53.9	47.3	6.52
4	16	Male	54.3	50.5	3.63
5	16	Male	57.0	52.9	3.73
6	24	Female	63.7	56.9	5.64
7	26	Male	61.5	59.3	1.82
8	17	Female	46.4	43.2	3.57
9	19	Female	62.3	54.0	7.14
10		Male	50.5	44.0	6.88
11	15	Female	44.7	40.5	4.93
12	12	Female	52.8	47.8	4.97
13	13	Male	49.5	44.8	4.98
14	15	Female	49.6	45.9	3.87
15	23	Female	41.7	38.5	3.99
16	15	Female	36.4	35.1	1.82
17	15	Male	50.7	48.2	2.53
18	27	Female	54.5	49.9	4.41
19	68	Male	41.1	36.1	6.48

20	21	Female	39.3	34.5	6.50
21	21	Female	54.8	52.1	2.53
22	25	Female	43.1	35.1	10.23
23	32	Male	55.8	51.4	4.10
24	12	Female	49.1	40.9	9.11
25	18	Male	46.7	36.3	12.53
26	23	Male	64.6	58.3	5.14
27	32	Female	49.2	44.5	5.02
28	47	Male	62.2	58.8	2.81
29	15	Male	45.4	41.8	4.13
30	21	Female	58.3	53.3	4.48
31	21	Male	65.0	57.7	5.95
32	17	Male	48.7	43.7	5.41
33	15	Female	57.8	51.8	5.47
34	36	Female	59.5	54.6	4.28
35	47	Male	54.7	50.6	3.89
36	44	Female	48.9	42.8	6.65
37	22	Female	48.3	43.7	5.00
38	41	Female	53.3	47.8	5.44
39	55	Female	46.2	43.5	3.01
40	29	Female	46.9	35.2	14.25
41	29	Male	69.7	65.6	3.03
42	22	Male	51.3	49.2	2.09

Table 2. The TOI with Age, Gender, Ramus length & Gonial Angle Measurements

Number	Age (Years)	Gender	TOI (%)	Mean ramus length (mm)	Gonial angle (°)
1	25	Female	1.32	55.330	126.5
2	15	Female	13.35	50.645	123.5
3	13	Male	6.52	56.574	129.0
4	16	Male	3.63	68.688	122.5
5	16	Male	3.73	54.529	134.0
6	24	Female	5.64	58.614	111.0
7	26	Male	1.82	64.957	122.0
8	17	Female	3.57	53.156	135.0
9	19	Female	7.14	52.181	130.5
10	17	Male	6.88	55.524	127.5
11	15	Female	4.93	54.490	125.5
12	12	Female	4.97	46.027	128.0
13	13	Male	4.98	57.624	128.5
14	15	Female	3.87	53.492	134.5
15	23	Female	3.99	58.618	141.0
16	15	Female	1.82	49.922	135.5
17	15	Male	2.53	51.034	132.0
18	27	Female	4.41	62.305	133.0
19	68	Male	6.48	59.239	136.0

20	21	Female	6.50	60.202	117.5
21	21	Female	2.53	59.286	125.0
22	25	Female	10.23	61.641	121.0
23	32	Male	4.10	66.102	124.0
24	12	Female	9.11	57.631	130.0
25	18	Male	12.53	55.250	131.5
26	23	Male	5.14	64.923	135.5
27	32	Female	5.02	51.137	125.5
28	47	Male	2.81	66.539	118.0
29	15	Male	4.13	54.184	123.5
30	21	Female	4.48	61.192	131.5
31	21	Male	5.95	61.412	131.5
32	17	Male	5.41	58.039	137.5
33	15	Female	5.47	54.981	132.0
34	36	Female	4.28	57.805	119.5
35	47	Male	3.89	59.616	119.0
36	44	Female	6.65	61.584	130.5
37	22	Female	5.00	63.430	117.0
38	41	Female	5.44	59.919	121.0
39	55	Female	3.01	53.376	125.5
40	29	Female	14.25	56.918	117.0
41	29	Male	3.03	65.165	110.5
42	22	Male	2.09	68.627	129.0

Table 3. Data for the Study.

	n=42
Female	24
Male	18
Mean age (years)	24.7
Age range (years)	12-68
Mean TOI (%)	5.30
standard deviation (TOI)	2.93

4.0 Discussion

This study found that the TOI in a group of individuals who exhibited no signs or symptoms of TMD, was independent of gender, age, ramus length and gonial angle.

Ramus length, gonial angle, gender and age were tested as possible explanatory variables for the TOI. The mean TOI was calculated as 5.30%. Analysis of covariance showed that there was no association between the TOI and age ($p>0.690$); gender ($p>0.644$); gonial angle ($p>0.327$); and ramus length ($p>0.248$). Linear regression analysis showed that there was no evidence of a relationship between the TOI and any of ramus length ($R^2=0.0332$), gonial angle ($R^2=0.0571$), age ($R^2=0.0665$), and gender ($R^2=0.0624$).

Earlier studies by Pullinger et al. (1987) and Dijkstra et al. (1995) found that linear mouth opening, which is a common and usual way of assessing for limitation of mandibular movement was dependent on ramus length, age, and gender.

Linear regression analysis showed that the TOI was independent of age (R^2=0.0665; p>0.690). This is a significant advantage over linear mouth opening, which has been shown to be dependent on age (Pullinger et al., 1987)

It can therefore be concluded that, from this study, the TOI is a better clinical tool than linear mouth opening for the examination of TMD patients, as unlike other measures of mandibular movement, it is less dependent on age, gender, ramus length, and gonial angle.

In addition, the TOI is able to differentiate various categories of TMD patients more effectively than the other established means of mouth opening (Miller et al., 1999).

The TOI seems to differentiate two subgroups of myogenous TMD patients, one with a TOI clustered about the upper quartile, and one with a TOI clustered about the lower quartile. It is possible that the group clustered around the upper quartile corresponds to the weak muscle group suggested by Visser et al. (1995) in their EMG studies of myogenous TMD patients.

Visser et al. (1995) found that they could identify two myogenous TMD groups using EMG. One of the parameters differentiating these groups was also found to be endfeel distance. Based on endfeel distance it has been suggested that the upper quartile TOI group corresponds to Visser's weak muscle group and the lower TOI group corresponds to the strong muscle group. The differences between the TOI in these groups suggest that this may be a useful aid in differentiating between closed lock and myogenous groups of patients (Miller et al., In press).

Four orthopaedic tests (Bezuur et al., 1988) have been found useful, particularly in clinical practice, to differentiate TMD patients into two broad categories; those with an arthrogenous and those with a myogenous TMD (Naeije & Hansson, 1986). It has been found recently, that by including the TOI in the short screening exam, it is possible to refine this gross diagnosis into patients with a closed lock, anterior disk displacement with reduction (ADD) and a weak and strong muscle group.

These studies have shown that the TOI is a simple, quick and cost effective way of assessing limitation in mandibular movement in TMD patients. It has the advantage of being independent of some of the variables that plague linear mouth opening measurements and also can help differentiate these patients into diagnostic categories that are helpful clinically.

This simple clinical procedure has also been used to follow treatment progress in certain TMD patient groups (Miller et al., In press). By considering its relationship to condylar asymmetry in TMD patients useful insights can be gained into the mechanisms of development of these disorders (Miller, personal communication).

Together with the screening examination discussed previously it would be of great value in a country with limited resources and access to expensive equipment and expertise.

5.0 Conclusion

The temporomandibular opening index was found to be independent of age ($p>0.690$); gender ($p>0.644$); gonial angle ($p>0.327$); and ramus length ($p>0.248$). It is also useful in categorising TMD patients into diagnostic groups.

5.1 Clinical Significance

This study aims to show that the TOI is independent of gonial angle and ramus length. This would indicate that, as it is also independent of both age and gender, it is a better indicator of limitation of oral opening than linear mouth opening measurements. As it can also be used to categorise TMD patients, it is a cost effective, simple tool in the diagnosis of these disorders, particularly in countries with limited resources, both fiscal and in terms of manpower.

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Appendix 1.

Informed Consent Form & Information Letter

Consent Form
Department of Restorative Dentistry
University of the Witwatersrand
Project on the Temporomandibular Opening Index

Dear (Mr, Mrs, Ms, Dr)_____

Hello. I am Dr Moipolai and I work and study in the Department of Restorative Dentistry as a Trainee Prosthodontist Specialist.

As part of the programme, I have to undertake a research project. My project entails setting up standards to enable us to diagnose and categorise different groups of disorders of the jaw joints and related muscles. This is part of a large research project currently being done in the department. I shall be grateful if you would participate in my study.

If you agree, a standard examination of the muscles of mastication and the jaw joint will be performed. In addition, I shall measure how much you can open your mouth, with a special type of ruler.

This will be done in two ways. Firstly how much you yourself can open your mouth. Secondly, how much you can open with a gentle pressure on the jaw from the dentist.

This is generally painless. Slight discomfort may be present if you already have pain in the facial muscles.

The other part of the study will utilise your orthodontic radiographic records to get the measurements that we need as part of the study. These are: the ramus length and the gonial angle. These measurements will be obtained from your orthodontic radiographic records, and therefore you will not be required to undergo further radiographic exposure for this study.

I will require to see you once only to take these measurements.

Participation in the study is completely voluntary. If you do not want us to use the measurements from the examination or you wish to withdraw at any time this will not affect your Orthodontic treatment in any way.

I agree to the use of measurements from my orthodontic treatment and also agree to be examined for inclusion in this study, on a voluntary basis.

Name of patient / Guardian / Relative _____

Research Number _____

Date _____

Patient Examination For TMD (Bezuur et al, 1988)

Patients to be included in the study should have
1. no rampant caries
2. no major periodontal disease
3. age between 13 - 65 years of age
all teeth present excepting third molars or not more than one other tooth

Employ the Four Orthopaedic Tests

1 **End-feel** - (please tick which) Stiff Elastic

2. **Joint play** - (please tick which) Rough Smooth

3. **Static pain** – (indicate as +,++, or +++)

4. **Dynamic pain** – (indicate as +, ++, or +++)

Also check for:
1. **Trauma**

2. **Facial pain** including headache if present more than 2x weekly

3. **TMJ clicking** when present at time of examination

4. **TMJ crepitations** when present at time of examination

5. **Limitation of oral opening** - when maximum oral opening does not permit accommodation of more than 2 digits between the incisal edges

6. **Deviation of the mandible during opening** - any deviation visible in the frontal plane during opening

Exclude any patient exhibiting any of these signs or symptoms

TOI (measured with a Boley gauge) - measured from the mesial incisal edge of the maxillary central incisors to the mesial incisal edge of the mandibular central incisors

Active maximal opening = mm

Passive maximal opening = mm

Appendix 2.

Complete Statistical Analysis.

Table 1.1

Linear regression analysis of relationship of ramus length, gonial angle, gender and age with TOI.

Igende_1 being Female subjects

Igende_2 being Male subjects

i. gender Igende_1-2 (naturally coded; Igende_1 omitted)

Analysis of variance

Source	SS	df	MS
Model	23.3249609	4	5.83124023
Residual	327.443764	37	8.84983146
TOTAL	350.768725	41	8.55533476

Number of subjects	= 42
F(4, 37)	= 0.66
Prob > F	= 0.6244
R-squared	= 0.0665
Adj R-squared	= -0.0344
Root MSE	= 2.9749

Therefore, jointly they explain 6.6% of variation.

TOI	Coef.	Std. Err	t	P>[t]	95% Conf. Interval	
ramus	-.0975649	.1038911	-0.939	0.354	-.3080682	.1129385
gonial angle	-.0640115	.0701939	-0.912	0.368	-.2062378	.0782148
Igende_2	-.4908597	1.022893	-0.480	0.634	-2.563437	1.581718
age	-.0157263	.0391141	-0.402	0.690	-.094979	.0635264
cons	19.69257	12.0497	1.634	0.111	-4.722442	44.10757

Age is therefore not significant.

Table 1.2

Linear regression analysis of relationship of ramus length, gonial angle, and gender with TOI.

Having eliminated age as a significant factor in determining the TOI, linear regression analysis showed that gender was also not important in the determination of the index.

Source	SS	df	MS
Model	21.8943545	3	7.29811817
Residual	328.87437	38	8. 6545887
TOTAL	350.768725	41	8.55533476

Number of subjects	= 42
F(3, 38)	= 0.84
Prob > F	= 0.4788
R-squared	= 0.0624
Adj R-squared	= -0.0116
Root MSE	= 2.9419

TOI	Coef.	Std. Err	t	P>|t|	95% Conf. Interval	
ramus	-.1075956	.0997324	-1.079	0.287	-.3094933	.0943022
gonial angle	-.0604853	.0688713	-0.878	0.385	-.199908	.0789373
Igende.2	-.4699065	1.010233	-0.465	0.644	-2.515016	1.575203
cons	19.4315	11.89872	1.633	0.111	-4.656211	43.51921

Therefore, gender is not important

Table 1.3

Linear regression analysis of relationship of ramus length and gonial angle with TOI.

Having eliminated age and gender as significant factors in determining the TOI, gonial angle was shown to have no influence on the TOI.

Source	SS	df	MS
Model	20.021834	2	10.010917
Residual	330.746891	39	8.48068951
TOTAL	350.768725	41	8.55533476

Number of subjects	= 42
F(2, 39)	= 1.18
Prob > F	= 0.3179
R-squared	= 0.0571
Adj R-squared	= -0.0087
Root MSE	= 2.9122

TOI	Coef.	Std. Err	t	P>[t]	95% Conf. Interval	
ramus	-.126899	.0897724	-1.414	0.165	-.3084808	.0546828
gonial angle	-.0665268	.0669525	-0.994	0.327	-.2019511	.0688974
cons	21.1189	11.21781	1.883	0.067	-1.571251	43.80906

Therefore, gonial angle is not significant

Table 1.4

Linear regression analysis of relationship of ramus length with TOI.

Source	SS	df	MS
Model	11.6486 ,35	1	11.6486435
Residual	339.120081	40	8.47800204
TOTAL	350.768725	41	8.55533476

Number of subjects	= 42
F(2, 39)	= 1.37
Prob > F	= 0.2481
R-squared	= 0.0332
Adj R-squared	= -0.0090
Root MSE	= 2.9117

TOI	Coef.	Std. Err	t	P>[t]	95% Conf. Interval	
ramus	-.1004982	.0857368	-1.172	0.248	-.2737788	.0727824
cons	11.14375	5.005004	2.227	0.032	1.02826	21.25924

Therefore, ramus length is not significantly associated with TOI.

Note that the above analyses show that there is no evidence of a relationship between the TOI and any of ramus length, gonial angle, age and gender.

Appendix 3.

Research Data.

Measurement of Ramus Length Gonial Angle, Age and TOI

Name	Ramus Length (mm)	1st	2nd	3rd	4th	5th	Gonial Angle (°)	Gender	Age	Passive Opening (mm)	Max. Vol. Opening (mm)	TOI (%)
1		55.237	55.211	55.175	55.329	55.699	126.5	F	25	46.1	44.9	1.32
		55.237	55.224	55.208	55.238	55.330						
			.019	.032	.066	.214						
2		50.523	50.606	50.719	50.673	50.703	123.5	F	15	55.2	42.2	13.35
		50.523	50.564	50.616	50.630	50.645						
			.058	.098	.085	.081						
3		56.608	56.548	56.422	56.706	56.585	129.0	M	13	53.9	47.3	6.52
		56.608	56.578	56.526	56.571	56.574						
			.043	.095	.119	.103						
4		68.193	69.493	68.407	68.100	69.309	122.5	M	16	54.3	50.5	3.63
		68.193	68.812	68.677	68.533	68.688						
			.876	.662	.613	.634						

5		54.327	54.729	54.384	54.489	54.717	134.0	M	16	57.0	52.9	3.73
		54.327	54.528	54.480	54.482	54.529						
			.284	.217	.177	.186						
6		58.295	58.790	58.691	58.592	58.704	111.0	F	24	63.7	56.9	5.64
		58.295	58.542	58.592	58.592	58.614						
			.351	.262	.214	.192						
7		64.955	64.847	65.057	65.216	64.709	122.0	M	26	61.5	59.3	1.82
		64.955	64.901	64.953	65.019	64.957						
			.076	.105	.157	.194						
8		53.613	52.911	53.643	52.369	53.246	135.0	F	17	46.4	43.2	3.57
		53.613	53.262	53.389	53.133	53.156						
			.496	.414	.613	.533						
9		52.494	52.036	52.276	52.036	52.062	130.5	F	19	62.3	54.0	7.14
		52.494	52.265	52.269	52.211	52.181						
			.324	.229	.220	.202						

10		55.930	55.441	55.536	55.118	55.593	127.5	M	17	50.5	44.0	6.88
		55.930	55.686	55.636	55.507	55.524						
			.346	.259	.334	.292						
11		54.133	54.914	54.310	54.535	54.559	125.5	F	15	44.7	40.5	4.93
		54.133	54.523	54.452	54.473	54.490						
			.552	.409	.337	.294						
12		45.787	46.382	45.957	45.783	46.228	128.0	F	12	52.8	47.8	4.97
		45.787	46.084	46.042	45.977	46.027						
			.421	.306	.282	.268						
13		57.605	57.520	57.745	57.547	57.703	128.5	M	13	49.5	44.8	4.98
		57.605	57.563	57.623	57.604	57.624						
			.061	.114	.100	.098						
14.		53.553	53.553	52.915	53.633	53.809	134.5	F	15	49.6	45.9	3.87
		53.553	53.553	53.340	53.413	53.492						
			0.00	.368	.334	.339						
15		58.830	57.884	59.536	58.327	58.512	141.0	F	23	41.7	38.5	3.99
		58.830	58.357	58.750	58.644	58.618						
			.669	.829	.709	.617						
16		49.861	49.394	49.949	50.458	49.949	135.5	F	15	36.4	35.1	1.85
		49.861	49.627	49.735	49.916	49.922						
			.330	.298	.436	.378						

17		51.721	51.532	50.493	50.603	50.820	132.0	M	15	50.7	48.2	2.53
		51.721	51.627	51.249	51.087	51.034						
			.134	.662	.629	.558						
18		62.208	62.577	62.356	62.206	62.178	133.0	F	27	54.5	49.9	4.41
		62.208	62.393	62.380	62.337	62.305						
			.261	.186	.175	.167						
19		58.979	60.428	59.224	59.112	58.451	136.0	M	68	41.1	36.1	6.48
		58.979	59.703	59.543	59.436	59.239						
			1.024	.775	.669	.727						
20		60.952	58.610	60.339	60.747	60.364	117.5	F	21	39.3	34.5	6.50
		60.952	59.781		60.162	60.202						
			1.656		.1066	.927						
21		59.540	59.154	58.386	59.200	60.148	125.0	F	21	54.8	52.1	2.53
		59.540	59.347	59.027	58.070	59.286						
			.272	.588	.488	.641						
22		61.128	62.113	61.125	61.674	62.165	121.0	F	25	43.1	35.1	10.23
		61.128	61.620	61.455	61.510	61.641						
			.697	.569	.478	.507						
23		66.153	65.380	66.166	66.615	66.197	124.0	M	32	55.8	51.4	4.10
		66.153	65.767	65.900	66.079	66.102						
			.547	.450	.513	.447						

24		57.460	59.033	57.085	57.016	57.561	130.0	F	12	49.1	40.9	9.11
		57.460	58.247	57.859	57.649	57.631						
			1.112	1.034	.944	.818						
25		54.734	55.125	55.323	56.016	55.051	131.5	M	18	46.7	36.3	12.53
		54.734	54.929	55.061	55.299	55.250						
			.276	.300	.537	.478						
26		64.317	64.999	65.178	65.027	65.097	135.5	M	23	64.6	58.3	5.14
		64.317	64.658	64.831	64.880	64.923						
			.482	.454	.384	.346						
27		51.348	50.584	51.086	51.189	51.476	125.5	F	32	49.2	44.5	5.02
		51.348	50.966	51.006	51.052	51.137						
			.541	.388	.330	.343						
28		67.050	66.855	66.240	66.476	66.075	118.0	M	47	62.2	58.8	2.81
		67.050	66.952	66.715	66.655	66.539						
			.138	.423	.365	.409						
29		54.588	54.373	53.176	54.247	54.535	123.5	M	15	45.4	41.8	4.13
		54.588	54.480	54.046	54.096	54.184						
			.152	.760	.629	.579						
30		61.140	61.088	61.534	61.041	61.158	131.5	F	21	58.3	53.3	4.48
		61.140	61.114	61.254	61.201	61.192						
			.037	.244	.226	.197						

31		61.357	61.282	61.481	61.420	61.519	131.5	M	21	65.0	57.7	5.95
		61.357	61.320	61.374	61.385	61.412						
			.053	.100	.085	.095						
32		58.176	58.234	57.940	57.801	58.042	137.5	M	17	48.7	43.7	5.41
		58.176	58.205	58.117	58.038	58.039						
			.041	.156	.203	.176						
33		55.364	55.423	54.461	55.011	54.644	132.0	F	15	57.8	51.8	5.47
		55.364	55.393	55.083	55.065	54.981						
			.042	.539	.441	.426						
34		57.479	57.591	58.191	57.920	57.845	119.5	F	36	59.5	54.6	4.28
		57.479	57.535	57.753	57.795	57.805						
			.079	.383	.323	.281						
35		59.701	60.118	59.612	59.403	59.247	119.0	M	47	54.7	50.6	3.89
		59.701	59.910	59.811	59.709	59.616						
			.295	.270	.300	.332						
36		61.633	61.609	62.113	62.191	60.191	130.5	F	44	48.9	42.8	6.65
		61.633	61.621	61.785	61.887	61.584						
			.017	.285	.309	.804						
37		63.359	63.498	63.408	63.507	63.378	117.0	F	22	48.3	43.7	5.00
		63.359	63.429	63.422	63.443	63.430						
			0.098	0.071	0.072	0.069						

38		59.841	60.630	59.721	60.378	59.293	121.0	F	41	53.3	47.8	5.44
		59.841	60.100	59.974	60.075	59.919						
			0.369	0.340	0.343	0.459						
39		52.744	53.280	53.722	53.309	53.826	125.5	F	55	46.2	43.5	3.01
		52.744	53.012	53.249	53.264	53.376						
			0.379	0.490	0.401	0.429						
40		56.867	57.113	56.752	57.030	56.827	117.0	F	29	46.9	35.2	14.25
		56.867	56.990	56.911	56.940	56.918						
			0.174	0.184	0.162	0.149						
41		65.100	65.500	65.008	65.106	65.111	110.5	M	29	69.7	65.6	3.03
		65.100	65.300	65.203	65.178	65.165						
			0.283	0.262	0.219	0.192						
42		68.520	68.111	69.743	68.366	68.394	129.0	M	22	51.3	49.2	2.09
		68.520	68.315	68.791	68.685	68.627						
			0.289	0.849	0.725	0.641						

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

COMMITTEE FOR RESEARCH ON HUMAN SUBJECTS (MEDICAL)
Ref: R14/49 Moipolai

CLEARANCE CERTIFICATE PROTOCOL NUMBER M990111

PROJECT The Effect Of The Gonial Angle And Ramus Length On The Temporomandibular Opening Index

INVESTIGATORS Dr P Moipolai

DEPARTMENT Restorative Dentistry Dept, Wits Oral & Dental Teaching

DATE CONSIDERED 990129

DECISION OF THE COMMITTEE *

Approved unconditionally

DATE 990201 CHAIRMAN.....(Professor P E Cleaton-Jones)

* Guidelines for written "informed consent" attached where applicable.

c c Supervisor: Prof HV Exner
Dept of Restorative Dentistry Dept, Wits Oral & Dental Teaching

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DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10001, 10th Floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

DATE JULY 10, 2000 SIGNATURE .....

PROTOCOL NO.: M 990111

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 5

Inter – and intra-observer Variability

Two Observers / Same Time

			Examiner 1				Examiner 2		
Number	Age	Gender	Active	Passive	TOI		Active	Passive	TOI
1	23	F	46.66	49.43	2.85		46.60	49.39	2.91
2	51	F	36.82	39.50	3.56		38.53	41.32	3.49
3	56	M	36.46	38.36	2.54		33.01	34.32	1.94
4	43	F	47.82	50.90	3.12		47.30	50.83	3.60
5	66	M	34.09	37.97	5.38		39.04	43.15	5.00
6	16	F	49.29	50.14	0.86		49.30	50.09	0.90
7	23	F	52.40	53.75	1.27		51.02	52.19	1.13
8	22	F	58.45	59.36	0.77		56.25	59.16	2.52
9	21	F	46.38	46.83	0.47		45.95	46.30	0.38
10	29	M	51.23	53.45	2.12		51.07	53.60	2.41

Inter – and intra-observer Variability

One Observer / Two Different Times. One Day Apart

			Examiner 1				Examiner 1		
Number	Age	Gender	Active	Passive	TOI		Active	Passive	TOI
1	23	F	46.66	49.43	2.85		47.7	50.50	2.85
2	51	F	38.30	42.50	5.20		36.82	39.50	3.56
3	56	M	36.50	40.00	4.58		36.46	38.36	2.54
4	43	F	49.4	53.3	3.92		47.82	50.90	3.12
5	66	M	34.40	37.90	4.84		34.09	37.97	5.38
6	16	F	49.27	50.16	0.90		49.29	50.14	0.86
7	23	F	52.72	54.89	1.74		52.40	53.75	1.27
8	29	M	51.23	53.45	2.12		50.20	52.00	1.76

Within observer repeats

Bland and Altman's 95% limits of agreement. For one observer on two different occassions (n=8)

0.60125 +/- 2 x 0.865

or (-1.129 ; 2.3310)

Between observer (n=10)

-0.154 +/- 2 x 0.64

or (-1.434 ; 1.126)

Inter observer agreement was calculated according to the method of Bland and Altman (1986).

(i) The mean is not significantly different from zero.

(ii) We can expect the two observers to give estimates of TOI that differ by less than 1.28 in either direction.

Thus in any clinical study we would like to detect differences that are greater than 1.28 (and preferably > 2)

Note

The repeat observations had a wider interval due to one outlier.

Omitting the outlier:

Limits of agreement

0.396 +/- 2 x 0.69

(-0.984 ; 1.776)

Not significantly different to zero and with two observers on the same subject differing by less than 1.38.

That is, there is very little difference between intra and inter observer variability.