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THE DEVELOPMENT OF A SCREENING ASSESSMENT FOR TEMPOROMANDIBULAR DISORDERS

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Dedication

To Memory of my grandfather Yao zuo tang and grandmother Zhang pei ying who can not live to see their only grandson reach this far in his study.

To my beloved father Yao yu ming and my mother Zhao ya ping for their love, support and encouragement throughout my life.

To my sister Yao xiao yan for her accompany and support during challenging time of my study.

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Abstract

Study Aim: The purpose of this study was to develop a brief, valid and reliable screening tool for Temporomandibular Disorders (TMDs) from the comprehensive clinical assessment used for Research Diagnostic Criteria for TMD (RDC/TMD) assessment. Specifically this tool should discriminate TMD patients from dental pain, headache and non-pain patients in general medical and dental practices.

Material and methods: A TMD assessment, consisting of a questionnaire and general clinic examination, of four subject groups (Group1- patients with TMD; Group2-Dental pain; Group3-headache; Group4-no pain) were compared. Principal Component Analysis (PCA) was carried out to reduce dimensionality of variables which generated from the assessment. Stepwise logistic regression was utilised to develop the predictive models for TMD patients with high levels of sensitivity and specificity. Receiver operating characteristics (ROC) curve was used to illustrate the accuracy of predictive models. Classification trees and five-fold cross validation were also used to build and assess the stability of a simple classification model (Model two).

Results: Two predictive models were developed. Model one consisted of one self-report question (i.e. whether orofacial pain was experienced in the last month) and clinical exam variables over three broad groupings (i.e. muscle pain on palpation, pain during jaw movement and joint sounds on palpation). The sensitivities of Model one were equal or more than 90% at different cut-off points. The area under ROC curve of this model was 0.978 (95% CI, 0.957 to 0.999).

Model two followed three steps. Step one consisted two self-report questions (i.e. whether the subject was older than 36 years or experienced orofacial pain in the last month). Step two comprised six questions regarding the pain experience and jaw function. Step three included five clinical exam variables (i.e. joint pain on mouth opening, muscle pain on protrusive jaw movement, joint sound on mouth closing, TMJ pain and masseter pain). The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of model two for this particular sample were 93.8%, 92.6%, 81.1% and 97.8% respectively.

Conclusion: Both of these two predictive models can reliably distinguished TMD subjects from dental pain, headache and non-pain sujects. However, compared to the first model, the second model required less clinic examination suggesting it is more efficient for screening purposes of TMD.

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List of Abbreviations

AAOP	American Academy of Orofacial Pain
BDI	Beck Depression Inventory
CES-D	Center for Epidemiological Studies Depression
CT	Computed Tomography
CVT	Conventional Tomography
EPQ	Eysenck Personality Questionnaire
GCPS	Graded Chronic Pain Scale
ICC	Intra-class Correlation Coefficients
JPF	Jaw Pain and Function
MMPI	Minnesota Multiphasic Personality Inventory
MPI	Multidimensional Pain Inventory
MRI	Magnetic Resonance Image
NPV	Negative Predictive Value
PCA	Principal Component Analysis
PHQ	Patient Health Questionnaires
PPV	Positive Predictive Value
PRS	Panoramic Radiographs
RA	Rheumatoid Arthritis
RDC	Research Diagnostic Criteria
ROC	Receiver Operating Characteristics
SCL-90	Symptom Checklist-90
SEMG	Surface Electromyography
TMD	Temporomandibular Disorder
TMJ	Temporomandibular Joint

Literature Review

Chapter 1: Temporomandibular Disorders (TMDs)

1.1 *Definition of TMDs.*

In 1934, a group of patients who had pre-auricular pain, clicking and popping of the joint, tinnitus and other symptoms were described by James Costen and those symptoms were called "Costen syndrome" (Costen, 1934). Since then, various terminologies had been presented in the literature to describe similar pain and functional disturbances of the masticatory system, such as temporomandibular joint syndrome, temporomandibular joint pain dysfunction syndrome, craniomandibular disorder etc. (Okeson, 1997). The term 'Temporomandibular Disorder' which was suggested by Bell is now used widely (Bell, 1982).

Over the years, researchers and clinicians have attempted to define TMDs in a broadly acceptable way (Okeson, 1997, Suvinen et al., 2005, Laskin, 2007). This is an essential precondition to reach a consensus on diagnostic criteria and management decisions of TMDs. Currently, the following contemporary definitions have been recommended:

"Temporomandibular disorders (TMDs) are defined as a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joint and associated structures, or both."

---------- AAOP TMD Guideline (McNeil, 1993)

"Temporomandibular disorders (TMDs) refer to a cluster of medical and dental conditions affecting the temporomandibular joint and surrounding tissues. The term TMD has been used to characterize a wide range of conditions diversely presented as pain in the face or jaw joint area, headaches, earaches, dizziness, masticatory musculature hypertrophy, limited mouth opening, closed or open lock of the TMJ, abnormal occlusal wear, clicking or popping sounds in the jaw joint, and other complaints. The severity of these presenting conditions may range from noticeable but clinically insignificant signs to seriously debilitating pain or dysfunction."

----------National Institutes of Health Technology Assessment Conference Statement (National Institutes of Health, 1996)

Thus there is broad agreement that TMDs encompass pain and impaired function in and about the temporomandibular joints and jaw muscles. This has led to the focus on the development of diagnostic classification systems with validity and reliability for research and or clinical utility.

1.2 *Diagnostic Classification of TMDs*

Although many classification systems have been developed over the years (Okeson, 1997), none have been universally accepted by researchers and clinicians. As the causes of TMDs are still not clear, most classification schemes for TMDs have been developed on the basis of common signs and symptoms rather than on aetiology (National Institutes of Health, 1996).

Helkimo index is one of the most widely used indices in the diagnosis of TMD (Otuyemi, 2000). It combines anamnestic and clinical dysfunction index. The anamnestic index (AiI) comprises three degrees which are symptomless (Ai0), mild symptoms (AiI), and severe symptoms (AiII) of TMD. The clinical dysfunction index (Di) is based on the evaluation of five clinical signs: impaired range of movement, impaired function of the TMJ, muscle pain, TMJ pain, and pain on movement of the mandible. The Di index comprises four degrees which are signless (Di0), mild dysfunction (DiI), moderate dysfunction (DiII), and severe dysfunction (DiIII) (Helkimo, 1974a).

A number of other systems were developed such as Farrar's system, Block's system, Eversole and Machado's system, Bell's system, Fricton's system, Eversole and Machado's system, International Headache Society (IHS) classification etc. (Dworkin and LeResche, 1992, Okeson, 1997). These systems have contributed greatly to our current knowledge and some of these are still used today. However, they have some drawbacks in common.

First, most of these systems emphasized classification of the patients according to physical finding. The psychosocial variables on overall evaluation of TMD were neglected. Second, since lacking of supporting data, the reliability and validity of these systems are unknown. Finally, some systems used non-descriptive terms without clear statements regarding difference between the new term and existing term (Dworkin and

LeResche, 1992).

The first well defined diagnostic classification was established by the American Academy of Orofacial Pain in 1990 which comprised five TMD categories and two non-TMD categories (McNeil, 1993). This guideline was updated in 1996 and categories such as myogenous and arthrogenous pain were further subdivided (Okeson, 1996). However, this classification scheme is not suitable for research application as it was developed on clinical impressions (Dworkin and LeResche, 1992).

In 1992, the Research Diagnostic Criteria for TMD (RDC/TMD) was established by an international consortium (Dworkin and LeResche, 1992). The most important advantage of this system is that it first introduced a "dual axis" concept for the classification and assessment of TMDs. It recognized not only physical conditions (axis I), but also psychosocial factors (axis II) which contribute to these disorders. The RDC/TMD has been accepted by the international scientific community (Suvinen et al., 2005). However, it hasn't been determined whether these criteria can be used in clinical practice (Okeson, 1997).

1.3 *Aetiology of TMDs*

The aetiology of TMDs is poorly known and has been considered to be one of the most controversial issues in dentistry (Bonjardim et al., 2005).The causes range from trauma to systemic disease to psychosocial factors. Basically, they can be classified into two groups: biomedical factors and psychological factors.

Biomedical factors

▵Trauma

Generally, trauma can be divided into two types of trauma. Either micro trauma (caused by occlusal discrepancies, parafunctions, etc.) or macro trauma (caused by excessive mandibular movement, sudden pressure etc. from for example a blow to the jaw) was considered to be a trigger to initiate pathologic process thus leading to the symptoms of TMDs (Zarb., 1979). It has been shown that TMD patients reported more traumatic events (Bakland et al., 1988), and patients with a history of trauma had a significantly greater frequency of TMD symptoms compared to those with no trauma history (Plesh et al., 1999).

The trauma/TMDs association has been questioned with the results of an epidemiologic study using randomly selected sample in Canada which couldn't find any significant relationship between trauma and symptoms of TMDs (Locker and Slade, 1988).

▵ Occlusion

Historically, occlusion has been considered an important aetiological factor for TMDs. Over seventy years ago, Costen postulated TMD symptoms resulted from mandibular overclosure after the loss of posterior teeth

(Costen, 1934). Some studies have also suggested an Angle Class II malocclusion would be the important risk indicators for the development of TMDs (Magnusson et al., 2005, Kondo, 2007).

However, many reviews and studies have not found a significant relationship between occlusion and symptoms and signs of TMDs (Conti et al., 1996, Goldstein, 1999, Carlsson et al., 2002). Occlusal variables have been suggested to be cofactors that account for only a small proportion of the TMD population and that some of these occlusal variables may indeed be a consequence rather than a cause of TMDs (Pullinger and Seligman, 2000). Some occlusal scenarios such as Angle Class II, anterior open bite, crossbite, deep bite, the absence of canine guidance on lateral excursions and occlusal interferences have been suspected as risk indicators (Magnusson et al., 2005, Selaimen et al., 2007, Schmitter et al., 2007) and need to be further studied.

Currently, there is no adequate scientific evidence to support the concept that occlusal factors play an important and major role in the aetiology of TMDs.

▵ Rheumatologic disease

As a chronic systemic inflammatory disease, rheumatic disease tends to attack joints in the body. It was claimed patients with rheumatoid arthritis (RA) are more likely to have TMD symptoms in many studies (Koh et al., 1999, Helenius et al., 2005). Other types of rheumatic disease such as Juvenile rheumatoid arthritis, ankylosing spondylitis, Reiter's syndrome and mixed connective tissue disease are also found associated with TMD (Tanaka, 1986, Bakke et al., 2001, Helenius et al., 2005).

It is not unreasonable to expect the TMJ to be affected in polyarthropathies, although the pathological process of how rheumatic diseases affect TMJ is still not clear.

Psychological factors

The temporomandibular joint was considered as the predominant site and cause of TMDs until the 1950s. Schwartz was one of first researchers who emphasized the importance of muscles, and in particular suggested muscle tension as a primary factor in initiating pain and dysfunction (Okeson, 1997, Suvinen et al., 2005). More importantly, psychological stress was implicated as a contributing factor in TMDs (Schwartz, 1955). From this Schwartz's psychophysiological concept was developed and formed a new 'psychophysiological theory' of etiology for muscle spasm by Laskin (Laskin, 1969). The role of psychological factors in assessment and management of pain-related TMDs has attracted more and more attention by researchers. Of all, the following factors were of most interest by investigators:

- Emotional stress

The role of emotional stress in TMDs has been examined in number of studies. Most of them have indicated stress was a potential risk factor for TMDs (Casanova-Rosado et al., 2006). Duckro and colleagues indicated high levels of psychosocial stress were associated with all TMD symptoms except for joint noise (Duckro et al., 1990). Furthermore, it seemed pain related TMD patients reported significantly higher levels of overall stress than non-pain TMD patients (Glaros et al., 2005).

Depression, a major mood disorder has been shown in numerous studies to be prevalent in adult TMD patients (Rantala et al., 2003, Ferrando et al., 2004, Kafas and Leeson, 2006). In addition, higher level of depression has been shown to also be a predictor to develop TMD pain in adolescents (LeResche et al., 2007).

Other types of emotional variables such as anxiety, distress and anger have been found to be prevalent among TMD patients (Ferrando et al.,

2004, Casanova-Rosado et al., 2006).

Although, it is still not clear whether emotional variables are the cause or the consequence of pain, more and more studies demonstrate that emotional factors play an important role in symptoms, symptom impact and treatment outcome of patients with TMD (Turner and Dworkin, 2004, Suvinen et al., 2005, Gatchel et al., 2006).

- Personality

The relationship between personality types and TMD is inconclusive. Ferrando and his colleagues made use of personaility profiles (NEO Personality Inventory-Revised) to evaluate TMD patients and found both muscular and articular pain groups correlated to neuroticism, self consciousness and vulnerability (Ferrando et al., 2004). Similar results have been reported in another study by using a different measure (Eysenck personality questionnaire) (Pallegama et al., 2005).

On the contrary, Parker and his colleagues found chronic temporomandibular pain patients presented similar personality characteristics to those of other chronic pain patients by using Minnesota Multiphasic Personality Inventory (Parker et al., 1993). Marbach also indicated there was no adequate evidence to support the contention that TMD are characterized by a specific premorbid personality (Marbach, 1995).

Additionally, it is difficult to select TMD sufferers from healthy individuals based on personality characteristics (Suvinen et al., 2005).

- Illness Behavior

Illness behavior refers to ways in which individuals perceive, evaluate, and respond to their symptoms. It encompasses not only behavior, but also

cognitive and affective aspects (Dworkin, 1991).

One of the most important illness behaviors in assessment and management of TMDs is somatization which is defined as a tendency to experience and communicate somatic distress in response to psychosocial stress and to seek medical help for it (Lipowski, 1988). Somatization is linked to various behaviors such as hypersensitivity to normal physical sensations (Blackwell and De Morgan, 1996) and frequent use of health care services (Suvinen et al., 2005).

It has been found there is an increase in levels of somatization in TMD patients compared to healthy controls (Yap et al., 2003, Celic et al., 2006, Yap et al., 2002). Furthermore, investigators have also suggested patients with myofascial pain have higher levels of somatization than other TMD groups (Yap et al., 2002, Schmitter et al., 2005).

Apparently, the cause of TMDs can not be simply explained by a single factor. To gain a better understanding of aetiologies of TMDs requires a multidimensional approach. At present, the biopsychosocial model which was developed by Dworkin and colleagues has been popularly used in understanding and assessment of TMDs (Suvinen et al., 2005).

1.4 *Prevalence of TMDs.*

The estimates of prevalence of TMDs vary widely. This is largely because there is no consensus on diagnostic criteria for TMDs. Another reason is lack of appropriate study design, especially in the use of non-representative groups from clinic populations (Locker and Slade, 1988).

Epidemiologic studies on the prevalence of TMDs in the general population are limited. Some of these studies are summarized in Table 1.1.

As Table 1.1 shows, the prevalence of people with one or more TMD symptoms ranged from 3.4% to 62.8%. Joint sounds were most frequently reported in these studies. Most of following studies showed muscular pain was under 8% except for the study which was conducted in Turkey (29.3%). The actual prevalence of joint pain was also inconclusive, with rates varying from 2.9% to 33% (Duckro et al., 1990, Goulet et al., 1995, Otuyemi et al., 2000, Pow et al., 2001, Ozan et al., 2007).

A number of studies have shown the symptoms and signs of TMD were more prevalent in female than in males (Otuyemi et al., 2000, Ozan et al., 2007), although others could not find a difference (Duckro et al., 1990, Goulet et al., 1995, Pow et al., 2001).

As to age differences, some symptoms such as joint sounds, nocturnal bruxing and diurnal clenching were more prevalent in younger respondents (Locker and Slade, 1988, Duckro et al., 1990). Interestingly, people who were more than 55 years old have been reported to experience more severe orofacial pain intensity (Pow et al., 2001).

Table 1.1 Prevalence of major symptoms of TMD in several populations

Author	Number of Subjects	Age	Male/Female	Population	One or more symptoms (%)	Muscular pain (%)	Joint pain (%)	Joint sound (%)	Difficultly opening (%)
Locker et al. 1988	677	18-65	300/377	Toronto,Canada	48.8	7.5	5.5 on opening 7.5 on chewing	25.4	7.4
Paul et al. 1990	500	>21	251/249	St. Louis,USA	29.2	5.8		11	
Goulet J-P et al.,1995	897	>18	400/497	Quebec,Canada			30	30	16
Otuyeme et al 2000	308	17-32	207/101	Nigeria	62.8	3.2	2.9	8.1	4.5
Edmond et al. 2001	1529	>18	769/757	HongKong	3.4		33	29.9	8.2
Fatish et al. 2007	792	15-72	431/361	Turkey		29.3	16.2	28.6	15.9

1.5 *Health care utilization and cost of TMDs*

Little has been reported on the use of health care services and consequent cost among people with TMDs (White et al., 2001). It was reported TMD patients had twice the level of health care utilization and medical claim payments as patients without TMD claims (Shimshak et al., 1997). In another study, Shimshak and DeFuria found the difference between TMD patients and non-TMD patients in utilization and costs in some of the major diagnostic categories, such as nervous, respiratory, circulatory, and digestive areas were even larger at 3:1 (Shimshak and DeFuria, 1998). White found a similar result in their study and further claimed most individuals who seek TMD care were female between 20 and 50 years old (White et al., 2001).

Although prevalence of symptoms and signs of TMD has been reported in the range from 6% to 93%, only 3.6% to 7% of the general population have been estimated to be in need of treatment (Suvinen et al., 2005). Thus it seems prudent to follow recommendations to eliminate unnecessary examinations as well as ineffective treatment modalities, and to decrease the cost of health care for TMD patients (Kuttila et al., 1997). A simple screening procedure which selects patients in need of further assessment and management is an essential process for this.

Chapter 2: Screening

2.1 *What is screening?*

Many definitions of medical screening have been presented in literature.

Screening has been defined as any procedure undertaken in order to detect asymptomatic disease in a population (Walton, 1986). It has been also defined as the systematic testing of asymptomatic individuals for preclinical disease (Black and Welch, 1997).

The Second Report of the UK National Screening Committee proposed screening as a public health service in which members of a defined population who do not necessarily perceive they are at risk of, or are already affected by, a disease or its complications are asked a question or offered a test to identify those individuals who are more likely to be helped than harmed by further tests or treatment to reduce the risk of disease or its complications (Wald, 2001).

Although none of these definitions is universally accepted, some elements are in general agreement. Firstly, screening is the process to identify those individuals who are at a sufficiently high risk of a specific disorder. Secondly, It is systematically offered to a population who has not sought medical attention on account of symptoms of the disease for which screening is being conducted. Finally, its purpose is to benefit the individuals being screened (Wald, 2006).

2.2 *Accuracy of screening*

The accuracy of screening is evaluated by a group of measures including sensitivity, specificity, positive predictive value, negative predictive value.

Sensitivity is defined as the proportion of affected individuals with a positive test result. A highly sensitive test means that there are few false negative results, and thus fewer cases of disease are missed. The level of sensitivity depends on the definition of test positivity (Black and Welch, 1997). The more detailed the investigation, the more cases of disease will be found (Wald, 2006).

Specificity is defined as the proportion of unaffected individuals with a negative test result. A highly specific test means that there are few false positive results. As does sensitivity, specificity also depends of case definition.

Sensitivity and specificity can not be easily determined as different interpretation thresholds can be used in screening (Black and Welch, 1997).

Positive predictive value is the probability that a patient with a positive test result actually has the disease. Negative predictive value is the probability that a person with a negative test result is truly free of disease. Predictive value is determined by the sensitivity and specificity of the test and the prevalence of disease in the population being tested. For example, when the prevalence of preclinical disease is low, the positive predictive value will also be low (Black and Welch, 1997).

The measures and their relationships are illustrated in Table 2.2.

Table 2.1 Accuracy of screening

	TRUE		
	Disease	**No Disease**	
Test Positive	a	b	Total positive
Test Negative	c	d	Total Negative
	Total with Disease	Total without Disease	Total

a : True Positive
b : False Positive
c : False Negative
d : True Negative

Sensitivity = True positive rate =a/a+c

Specificity = True negative rate =d/b+d

Positive predictive value (ppv)= a/a+b

Negative predictive value (npv)=d/c+d

1-Sensitivity = False negative rate

1-Specificity = False positive rate

2.3 *Effectiveness of screening*

The purpose of screening is to prevent or delay the development of advanced disease and its adverse effects (Black and Welch, 1997). Therefore, screening tests are useful only if they reduce mortality or morbidity (Fields and Chevlen, 2006).

Disease specific mortality which refers to the proportion of a population who died of a given disease in a specific time frame is usually employed to evaluate the effectiveness of screening. The biggest advantage of this measure is it can avoid both lead-time and length-time biases (see below) (Alibhai, 2006). However, it has one important limitation: it is always difficult to assign cause of death in patients with multiple illnesses (Moy et al., 2001).

Another outcome measurement is disease specific survival which refers to the number of patients with a specific disease who are alive at a given time point divided by the number of patients who are either alive or have died of the disease. Since report on disease specific survival needs a period time, some bias such as lead-time bias may confound its interpretation (Alibhai, 2006).

2.4 *Bias in screening*

There are three key biases which may affect screening. These biases are selection bias, lead-time bias and length-time bias.

▵Selection bias

Selection bias is defined as a distorted estimate of the effect that results from the way in which subjects are ascertained or selected for the study population and includes factors such as differential surveillance, diagnosis, and referral of persons into the study (Hennekens, 1987). Brawley and Kramer pointed out, that more often than not, those who choose to be screened have better underlying health than those who do not get screened (Brawley and Kramer, 2005).

Although selection bias is impossible to be eliminated completely, it can be minimized by good study design such as randomized trials (Alibhai, 2006).

▵ Lead-time bias

Lead-time is defined as the interval between the diagnosis of disease at screening and when it would have been detected due to development of symptoms (Sasco, 1988).

Lead-time bias occurs when survival is directly compared between screening-detected cases and cases diagnosed clinically. It is because this method results in the former appearing to have a longer survival than the latter (Fig. 1). Therefore, the comparison should be adjusted by subtracting the lead time from screening-detected cases (Black and Welch, 1997). However it must be noted that the lead time is difficult to estimate (Alibhai, 2006).

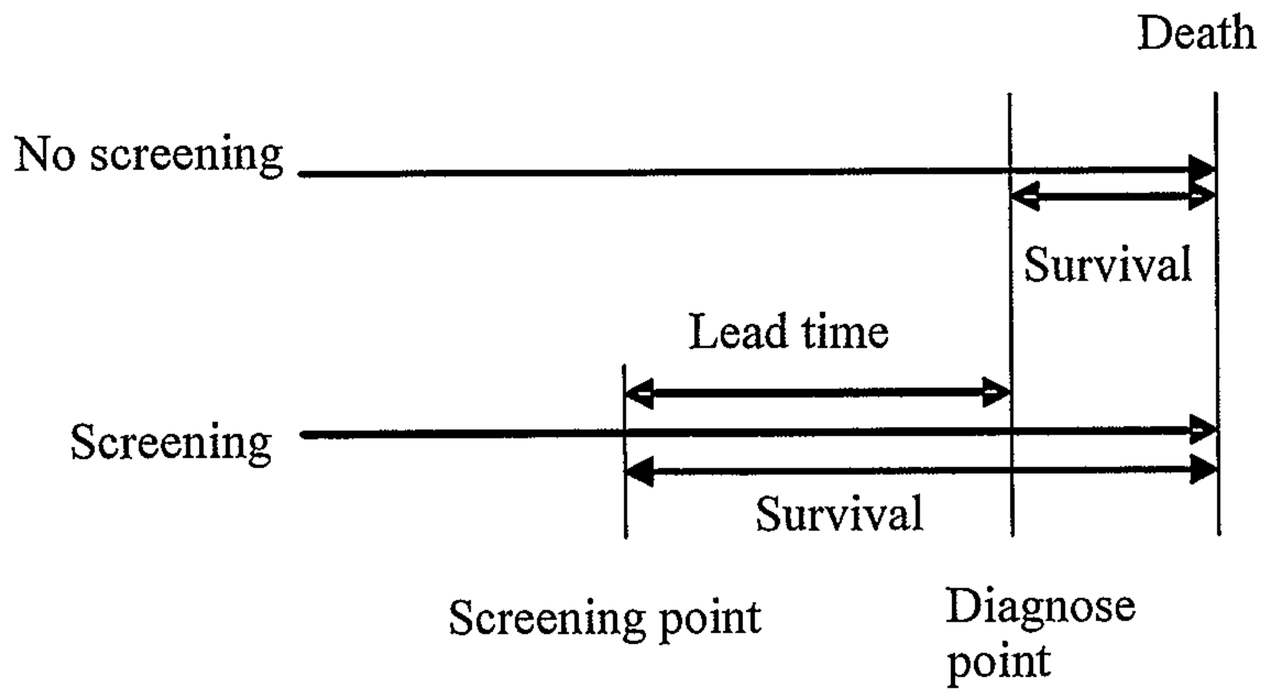


Fig. 1 Lead time bias

△Length-time bias

The length-time bias occurs because comparisons of survival are simply made between screening cases and non-screening cases without considering the rate of disease progression. Figure 2 illustrates the screening programs are more likely to pick up individuals with slowly growing, less aggressive disease. Consequently, those cases picked up during screening will appear to have improved survival, incorrectly ascribed to screening (Black and Welch, 1997, Alibhai, 2006).

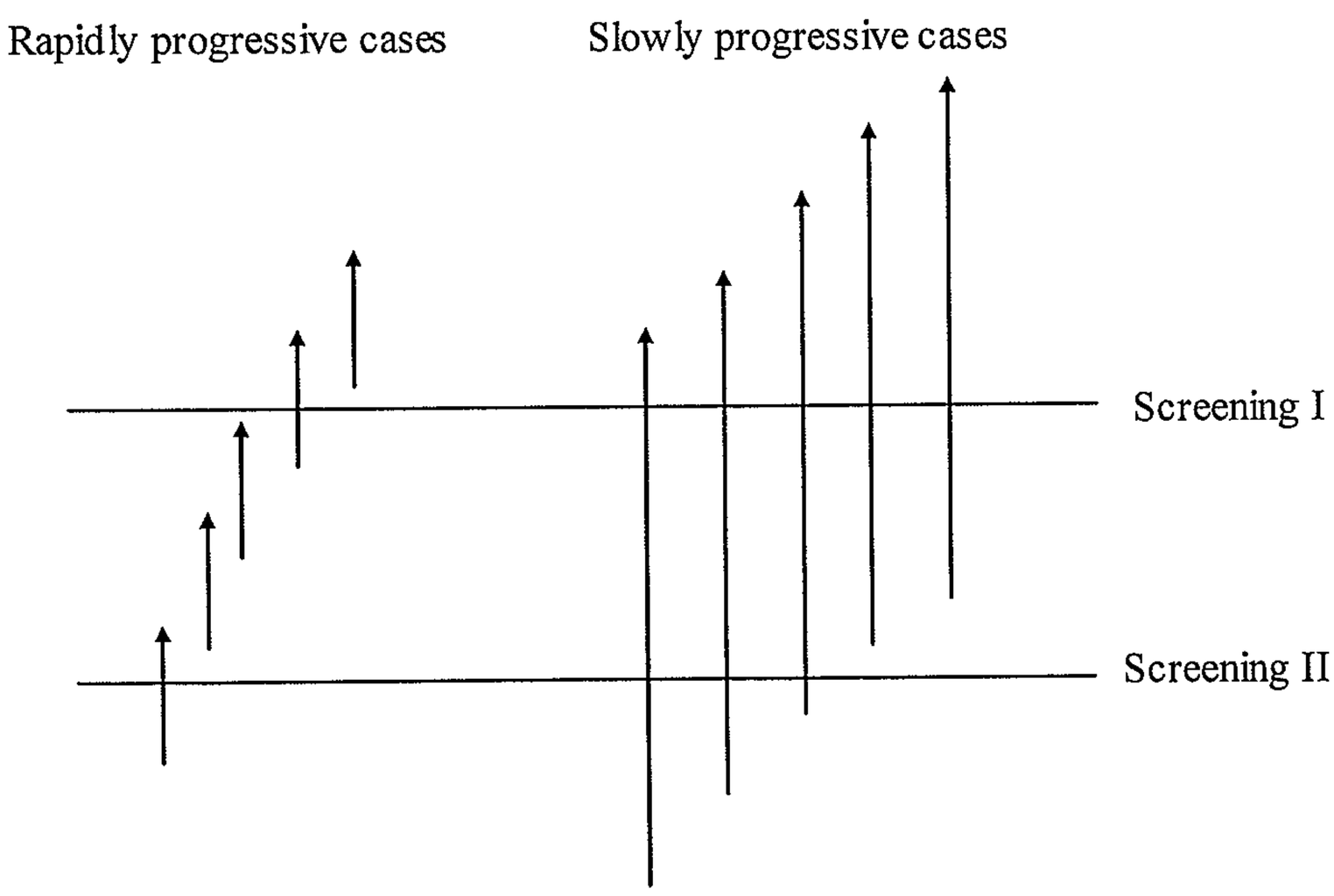


Fig.2 Length time bias

Chapter 3: Screening for TMDs

Over the years, a lot of diagnostic tests have been developed for TMDs. The diagnostic tools include self report questionnaires, clinical examination and imaging tests. However, it is rare to find a test specifically designed for screening purposes. Such screening tests need not only suitable sensitivity and specificity, but should also meet a series of criteria such as being simple, effective and inexpensive before being undertaken (Hickman, 2002).

Frequently, screening tests develop along with innovations in diagnostic technology (Black and Welch, 1997). Consequently, most aspects of the assessment of diagnostic tests can also apply to the assessment of screening tests. Therefore, it is prudent to review the tools which had been used in the diagnostic process of TMDs and evaluate their validity, reliability and cost-effectiveness. In this way, potential screening tests for TMDs can be detected or generated.

3.1 *Self report questionnaires*

Pain is a subjective experience and its assessment is based on an individual's self-report (Merskey and Bogduk, 1994). Since pain is a common complaint of TMD patients, it is essential for clinicians and researchers to identify relevant pain characteristics as well as its impact on the individual, others and society. There are numerous questionnaires that attempt to capture information in a standardized approach (Turk and Melzack, 2001). For TMD, the contemporary questionnaire is a component of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) (Dworkin & Le Resche 1992).

The RDC/TMD was developed for research purposes and comprises of a

number of validated scales (GCPS, SCL-90 Depression scale and SCL-90 Somatization scale-see below). In addition, there were questions designed to evaluate pain intensity, jaw function impairment, as well as demographic information. Acceptable reliability of this questionnaire has been determined in a few studies (see Chapter Four). Apart from the RDC/TMD, comprehensive history questionnaires for TMD which comprise assessment of all aspects of pain are rare. In generalized chronic pain complaints, other comprehensive questionnaires have been developed such as the Multidimensional Pain Inventory (Turner and Dworkin, 2004).

The role of psychological factors in TMDs has been well documented in the literature. Therefore, a lot of instruments have been employed to assess the patients' psychological status (Manfredini et al., 2007). These tools include the Symptom Checklist (SCL-90), Beck Depression Inventory (BDI), Center for Epidemiological studies Depression scale (CES-D) and Patient Health Questionnaires (PHQ) (Turner and Dworkin, 2004).

3.2 *Clinical examination*

There is a lack of consensus on the clinically significant signs and symptoms of TMD (Locker and Slade, 1988). However, three essential symptoms are in general agreement; orofacial pain, joint sounds and limitation in mandibular movement (Glaros et al., 1998).

▵Pain palpation

Palpation has been considered an important method in evaluating the muscle and joint pain (Stockstill et al., 1989, Dimitroulis, 1998). However, there is variability in reports of reliability of palpation (Stockstill et al., 1989, Dworkin et al., 1990, de Wijer et al., 1995, Goulet et al., 1998). Poor reliability has been suggested to be caused by the subjective aspect of the pain response and variability in the examiner's palpation stimulus (Stockstill et al., 1989, Conti et al., 2001). Therefore, it was proposed that improved reliability would be achieved by examiner calibration and using standardized criteria (Stockstill et al., 1989, Dworkin et al., 1990).

Some studies also recommended employing mechanical devices instead of fingertips as the palpation stimulus of muscle tenderness in order to offer a more reliable pressure (Dimitroulis, 1998, Bernhardt et al., 2007). In contrast to these findings, Goulet and coworkers could not find differences between fingertip and instrument palpation in assessment of muscle tenderness (Goulet et al., 1998).

▵ Joint sound assessment

The character and location of joint sounds are usually assessed by palpation or stethoscope auscultation. It has been reported that there is no clear advantage between these two methods of assessment (Dworkin et al., 1990, Wabeke et al., 1994).

The estimated reliability of joint sound assessment ranges from poor to excellent. It has been suggested this was caused by the use of different assessment techniques (Baba et al., 2001). Therefore some electronic instruments such as electrosonography were recommended for recording and analyzing joint sounds (Hashimoto et al., 1989, Prinz, 1998, Deng et al., 2006). However, it has been suggested that the real reason for the variability is the measurement errors originating from variation between observers and from variation in the sound phenomenon (Wabeke et al., 1994).

▵ Mandibular movement measurement

The current standard approach to monitoring mandibular motion restriction is via a millimeter ruler to measure interincisal displacement (Baba et al., 2001). Although the reliability of mandibular movement measurements by using a millimeter ruler demonstrated variability, it was found that reliability of vertical motion measurements was high while those of lateral and protrusive excursive measurements were poor (Dworkin et al., 1990, Wahlund et al., 1998, Goulet et al., 1998).

It also had been reported that the millimeter ruler method was not suitable to assess dynamic movement irregularities such as abnormal but nonrestricted movements (Baba et al., 2001).

3.3 *Imaging tests*

▵ Panoramic radiography

As a diagnostic aid, panoramic radiographs (Prs) are widely used in general dental screening and orthodontic diagnosis and treatment planning. However, there is no consensus on their usefulness in the assessment of TMDs. Goldstein stated Prs were the standard screening radiograph for bony jaw structure in TMD (Goldstein, 1999). It has also been suggested that panoramic variables can help the clinician identify patients with potential internal derangement of the TMJ (Ahn et al., 2006).

On the contrary, Dahstrom and Lindvall assessed validity (the degree to which a test measures what it was designed to measure) and reliability (consistency of a set of measurements or measuring instrument) of Prs for evaluation of bony changes on the condyles in comparison with tomography. They found reliability and specificity were fair, but sensitivity was low (Dahlstrom and Lindvall, 1996). A similar study was conducted by using both MRI and clinical exam as the gold standard and found sensitivity was high, but both specificity and reliability were low. It was concluded Prs were not a reliable method to accurately judge the presence of joint-related TMD (Schmitter et al., 2006).

The biggest disadvantage with this technique is that no information on joint soft tissue status is provided (Dixon, 1995).

However, considering its comparability to other imaging techniques for detecting osseous abnormalities, cost effectiveness, availability, and relatively low radiation dose, the panoramic radiograph is a good choice for a screening view (Dixon, 1995, Magnusson and Karlsson, 2002).

▵ Tomography

The tomographic image is generated by rotating the X-ray beam source and the film cassette in opposite directions around the area of interest (Dixon, 1995). Compared to plane film techniques, the biggest advantage of tomography in assessing TMJ is it can provide a sectional view through the joint (Westesson, 1993).

Computed tomography (CT) is a technologically advanced form of tomography using computerized storage of data from a series of thin X-ray tomographic sections taken from multiple directions (Dixon, 1995). CT imaging provides exquisite detail for bony abnormalities, such as ankylosis, fractures, osseous tumors, and arthrosis. Furthermore, it can provide some information about soft tissues (Westesson, 1993).

However, it has been shown that there was no significant differences between CT and conventional tomography (CVT) in diagnostic accuracy for the detection of bone changes in the condyle (Hintze et al., 2007). In detecting single structural bone changes, CVT was superior to CT (Tanimoto et al., 1990). In addition, CT should not be recommended for the diagnosis of disc position since it is not reliable for visualization of the TMJ disc (Rinchuse and McMinn, 2006).

▵Magnetic resonance image

Magnetic resonance imaging (MRI) had been suggested to be the gold standard for the imaging of TMJ in many studies (Westesson, 1993, Liedberg et al., 1996b, Schmitter et al., 2006). Compared to radiographic tests, MRI has two obvious advantages. Firstly, it can provide more detailed images of both hard and soft tissue of TMJ. Secondly, it is less invasive since it uses relatively harmless superconducting magnets instead of radio waves (Westesson, 1993, Dixon, 1995).

The accuracy of the TMD diagnostic outcomes with MRI has been documented as higher than radiographic tests especially in diagnosing

sideways and rotational disc displacements (Liedberg et al., 1996a, Rinchuse and McMinn, 2006). It has been suggested that MRI is an optimal way to image the hard and soft tissues of the TMJ in patients with signs and symptoms of TMJ disorders (Westesson, 1993). Tomas and colleagues also emphasized the importance for radiologists to detect early MRI signs of dysfunction in order to help avoid the evolution of this condition to irreversible stages (Tomas et al., 2006).

However, it should be noted that there is great variation in interpretation of TMJ images by different radiologists due to their different experience. A diagnosis of a TMD based on MRI made by a single examiner should not be accepted as a "gold standard" of TMD (Widmalm et al., 2006).

Furthermore, a major disadvantage of this technique is cost. Compared to other radiographic tests such as plain radiography and conventional tomography, MRI was found to be more expensive (Limchaichana et al., 2006). Additionally, MRI is contraindicated in patients who have metal particles or implants in their bodies as well as obese or claustrophobic patients (Westesson, 1993, Limchaichana et al., 2006).

▵Arthrography

Arthrography is a technique used to highlight or outline joint structures by using a radiopaque contrast medium to enhance their images on plane or tomographic films (Dixon, 1995). The introduction of arthrography resulted in a significant improvement in understanding TMJ disorders as intraarticular contrast solutions provide information on disc displacement and arthrosis (Westesson, 1993).

Liedberg and coworkers evaluated the diagnostic outcome of arthrography, CT and MRI in the assessment of TMJ disc position by collecting data on sensitivity, specificity, predictive values and likelihood ratios from 400 publications (The likelihood ratio incorporates both the sensitivity and

specificity of the test and provides a direct estimate of how much a test result will change the odds of having a disease.). They found diagnostic outcome for the diagnosis of anterior disc position was higher for arthrography than for CT and MRI (Liedberg et al., 1996a). Similar results were also found in other studies (Westesson, 1993, Rinchuse and McMinn, 2006), however, sensitivity in diagnosing medial and lateral disc displacements with arthrography was low (Westesson, 1993, Dixon, 1995). It was also reported that arthrography with videofluoroscopy was superior to MRI for the diagnosis of early perforations and joint adhesions (Magnusson and Karlsson, 2002).

The disadvantage of this technique is, that as an invasive method, patients may feel some discomfort associated with injecting the contrast medium (Liedberg et al., 1996a, Dixon, 1995). Additionally, the reliability of the result of using this technique is very much dependent upon the skill and knowledge of the radiologist performing the study (Westesson, 1993).

▵ *Ultrasonography*

The principle of ultrasonography is based on the fact that ultrasonic sound waves emitted by a device (transducer), travel through target tissue and partly reflect on transiting the different structures. The reflected ultrasound wave is received by the same device, and then translated to an image (Merritt, 1998).

Compared to other image tests, sonography has advantages such as being noninvasive, inexpensive and fast (Harness et al., 1990, Melis et al., 2007). Sonography has been suggested to be a reliable and valid tool in detecting disc displacement and joint degeneration in some studies (Landes et al., 2000, Hayashi et al., 2001, Melis et al., 2007). However, the reliability and validity of sonography in TMD diagnosis is still questioned since there is a lack of supporting scientific evidence (Mohl, 1993, Lund et al., 1995, Goldstein, 1999).

This technique also has some disadvantages. Firstly, it is very difficult to obtain a satisfactory image of the articular disc and medial part of joint due to the absorption of ultrasonic waves by the lateral portion of the condylar head and zygomatic process of the temporal bone. Therefore, medial disc displacements are not easy to be detected (Landes et al., 2000, Melis et al., 2007). Secondly, it requires well trained and calibrated operators to interpret the images to get a reliable result especially when the images are blurred and not clear (Melis et al., 2007).

3.4 *Surface Electromyography*

Surface EMG (SEMG) is a non-invasive technique to measure muscle activity where surface electrodes are placed on the skin overlying a muscle or group of muscles (Hermens et al., 2000).

Earlier, SEMG had been proposed as a clinically useful method in diagnosing TMD, especially the pain related-TMD (Harness et al., 1990, Cooper et al., 1991). But now, more and more studies have questioned the validity and reliability of this tool in TMD diagnosis (Baba et al., 2001, Klasser and Okeson, 2006, Manfredini et al., 2007). Importantly, studies have suggested a lack of association between TMD patients' symptoms and instrumental signs had been shown (Manfredini et al., 2007). Dworkin and coworkers suggested factors such as different facial pain type, age, gender, thickness of subcutaneous fat would confound the validity of TMD diagnosis with SEMG (Dworkin and LeResche, 1992).

Importantly, the consensus is that SEMG has limited clinical utlility in diagnosing TMD (Mohl, et al.1990, Gonzalez, et al, 2008).

3.5 Findings of screening tests for TMDs

A few studies have specifically investigated developing a screening tool for TMDs. The importance is underscored by the recommendation that a general clinical examination for TMDs be performed on every patient

before any dental treatment which could potentially worsen a pre-existing TMD (Delcanho, 1994).

It has been reported that a simple questionnaire can reliably distinguished between a non-diseased control group and TMD group with 90.3%-97.7% sensitivity and 95.7%-100% specificity (Gerstner et al., 1994). Other studies have also shown very good reliability and validity of a self-reported questionnaire as a screening tool for TMDs or TMD related pain from healthy control group (Unger et al., 1989, Nilsson et al., 2006).

It is important to note that screening tools may be influenced by subject age, as questionnaires for screening purposes used in a healthy population of teenagers was not recommended since their ability to predict clinically assessed signs of dysfunction was inadequate (Nielsen and Terp, 1990).

Among the clinical examination variables, palpation of the TMJ was considered a good method and was reported to be superior to MRI in identifying the joint as the source of pain (Haley et al., 2001, Manfredini et al., 2003).

It was reported that pain on palpation over the TMJ or pain with maximum jaw opening using passive stretch, and pain with lateral movement of the jaw, could distinguish myofascial pain dysfunction patients from headache patients with a sensitivity of 77% and specificity of 85%. In addition, the presence of reciprocal clicking or pain with maximum jaw opening and pain upon palpation of the TMJ can distinguish temporomandibular internal derangement patients from headache patients with a sensitivity of 92% and specificity of 91% (Schiffman et al., 1995).

These studies suggest some valid and reliable variables that can be used when screening for TMDs. Some data demonstrate important variables to differentiate TMDs from non-pain and headache populations. However there is limited information on the screening tool's ability to discriminate TMDs from other cranial and orofacial pain.

Chapter 4: Research Diagnostic Criteria for TMD

Research diagnostic criteria for TMD (RDC/TMD) were developed for research purposes by an international expert group (Dworkin & Le Resche 1992). This diagnostic system offered standardized diagnostic criteria for gathering relevant data and making possible comparison of findings among diverse clinical investigators (Dworkin and LeResche, 1992). As a common diagnostic method, it has been translated into 18 languages and accepted by a 45 member consortium of RDC/TMD-based international researchers who continue to assess its reliability and validity (John et al., 2005).

This TMD diagnostic tool consists of a standardized clinical physical exam and a self-report questionnaire (See appendix D and E). The components of the clinical exam include range of mandibular movements, joint sound palpation, joint (4 sites) and muscle (twenty sites) palpation. The self report questionnaire comprises a series of questions regarding pain intensity, pain-related disability, jaw function impairment, psychological status as well as demographic information.

The particular advantage of this diagnostic system is that it was the first introduction of a dual axis diagnostic system from both a physical and psychological perspective that reflects the complex interaction between these two dimensions of persistent pain. The detailed classification of this diagnosis is outlined as follows:

Axis I Clinical TMD Conditions

IMuscle diagnoses

a Myofascial pain

b Myofascial pain with limited opeing

IIDisc displacement

a Disc displacement with reduction

b Disc displacement without reduction, with limited opening

c Disc displacement without reduction, without limited opening

III Arthralgia, osteoarthritis, osteoarthrosis

Axis II Pain-Related Disability and Psychological Status

Graded chronic pain status

Depression score

Nonspecific physical symptoms score

The reliability of clinical TMD diagnoses by using Axis I of RDC/TMD has been tested in many studies (John et al., 2005, Lobbezoo et al., 2005, Schmitter et al., 2005b, Tomas et al., 2006). Intra-class correlation coefficients (ICC) which were used to evaluate the reliability of each subgroup of RDC/TMD diagnoses in those studies are summarized in Table 4.1. It showed that the RDC/TMD performed acceptable reliability (ICCs were more than 0.4) for most common forms of TMD. Since the prevalence of some types of TMD such as arthritis and arthrosis was low, it was not possible to calculate the ICC. It also showed the importance of recalibration of clinical examiners in improving the reliability of RDC/TMD exam (Tomas et al., 2006).

Few studies have been conducted to test validity and reliability of RDC/TMD self-report questionnaires (Axis II). Dworkin and colleagues compared the data from independent longitudinal and cross-sectional epidemiological studies as well as randomized clinical trials conducted at the University of Washington and the University at Buffalo and found good to excellent reliability, validity, and clinical utility for the Axis II measures of

depression, somatization, and graded chronic pain (Dworkin et al., 2002). Similar results were also found in two other studies by using the Portuguese and German versions of the RDC/TMD Axis II Questionnaire respectively (de Lucena et al., 2006, John et al., 2006).

Although RDC/TMD is widely used as one of most popular diagnostic tools for TMDs, there are still some limitations to this system.

Firstly, this diagnostic system does not cover all the subtypes of TMD due to lack of data on reliability of criteria and assessment methods for rarer disorders (Dworkin and LeResche, 1992).

Secondly, the reliability and validity of some variables, such as clicking during lateral excursion, intraoral muscle palpation, palpation of posterior and submandibular region, in the RDC/TMD have not been demonstrated (Turp and Minagi, 2001, Schmitter et al., 2005b).

Finally, since this diagnostic system was designed for research purposes, its utlility in clinical practice has not been determined (Okeson, 1997).

Table 4.1 Reliability of clinical TMD diagnosis by using Axis I of RDC/TMD

Author	Subjects		ICC							
			Ia	Ib	IIa	IIb	IIc	IIIa	IIIb	IIIc
Schmitter et al., 2005	Patients from Prothodontics Dept. University of Heidelberg Germany		0.68	0.58	0.7	—	0.17	0.49	—	—
John et al., 2005	Data collected from ten international clinic centers		0.51	0.58	0.61	0.31	0.06	0.47	—	—
Thomas et al., 2006	Patients from university clinic of Lude, Sweden	initial	0.83	0.76	0.26	—	—	0.16	—	—
		recalibration	1	1	0.64	—	—	0.73	—	—

ICC Intraclass correlation coefficient: a measure of correlation, consistency or conformity for a data set when it has multiple groups

Ia Myofascial pain
Ib Myofascial pain with limited opeining
IIa Disc displacement with reduction
IIb Disc displacement without reduction, with limited opening
IIc Disc displacement without reduction, without limited opening
IIIa Arthralgia
IIIb Osteoarthritis
IIIc Osteoarthrosis

Chapter 5: Summary and Conclusions

The purposes of this review were to investigate the background of TMDs, understand the basic principles of screening tests as well as evaluate the reliability and validity of current TMD diagnostic tools from which a screening assessment may be potentially developed.

This review revealed a lot of controversial issues concerning aetiology and diagnosis of TMDs.

Since TMDs are usually multifactorial, a biopsychosocial approach should be followed in diagnosing and managing TMDs.

Currently, most of the diagnostic instruments in use have not met the reliable, valid, simple, cost-effective criteria for screening purpose.

RDC/TMD is one of few diagnostic tools which could be potentially transformed to a reliable and valid screening assessment for TMDs. However, further investigations regarding the validity and reliability of each item in this system are required.

Chapter 6: Statement of the Problem

Temporomandibular disorders is a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joints and associated structures (McNeil, 1993).

The aetiology of TMDs is poorly known and has been considered to be one of the most controversial issues in dentistry (Bonjardim et al., 2005). The proposed causes range from trauma to systemic disease to psychosocial factors. Therefore, a multifactorial concept is recommended for understanding the aetiology of TMDs (Suvinen et al., 2005).

Temporomandibular disorders are similar to back pain (a major disabling disorder) in their intensity, persistence and psychological impact (von Korff *et al.* 1988). Furthermore TMD is associated with high health care utilisation (White et al., 2001). Consequently, good patient triage for appropriate management is important in this clinical population.

Signs and symptoms of TMD have been reported variously in the literature. Of those symptoms, three clinical features are in general agreement: orofacial pain, joint sounds and limitation in mandibular movement (Glaros et al., 1998). Nevertheless, it is still a challenge for clinician and dentists to distinguish TMD, especially the painful TMD from some other orofacial pain disorders such as neurological headache and dental pain (pain from pulpal, periodontal and oral mucosal diseases) disorders. It is because they can produce many similar or overlapping symptoms (Wright and Gullickson, 1996 Ciancaglini et al., 2001).

Over the years, a lot of diagnostic tests have been developed for TMDs. The diagnostic tools include self report questionnaires, clinical examination and imaging tests. However, currently, most of the diagnostic instruments in use have not met the reliable, valid, simple, cost-effective criteria for screening purpose.

The Research Diagnostic Criteria for TMD (RDC/TMD), which consist of a clinical physical exam and a self-report questionnaire, were developed by an international expert group in 1992. This system offered standardized diagnostic criteria for gathering relevant data and making possible comparison of findings among diverse clinical investigators (Dworkin and LeResche, 1992). From a screening viewpoint, this diagnostic tool could be potentially transformed to a reliable and valid screening assessment for TMDs.

However, the comprehensive RDC/TMD assessment typically takes 30 minutes which is not suitable for screening patients for TMD in general dental and medical practice settings. Additionally, since this diagnostic system was designed for research purposes, its utlility in clinical practice has not been determined (Okeson, 1997). Further investigations regarding the validity and reliability of each item in this system are required.

The purpose of this study was to develop a brief, valid and reliable screening tool for TMDs from the comprehensive RDC/TMD assessment. This tool should discriminate TMD patients from common head and orofacial pain complaints such as headache, dental pain and non-pain patients in general medical and dental practices.

Chapter 7: Materials and Methods

Subjects

TMD subjects The charts of 124 consecutive patients seeking management at the orofacial pain clinic, Centre for Oral Health, Westmead Hospital during the period December 2006 to December 2007 were reviewed through the database. This sample included a broad spectrum of orofacial pain including TMDs, neuropathic pain, trigeminal neuralgia, and burning mouth syndrome. Those patients who had been diagnosed with a TMD by using RDC /TMD were included in the analysis. The final sample of this group was made up of 96 subjects (27 males, 69 females, mean age 43.1 $\pm$ 16.8 years). The distribution of different diagnostic types in the TMD group is shown in Table 7.1.

Dental pain subjects One hundred and twenty five patients (Table 7.2) seeking emergency dental treatment at the Acute Care Clinic at the Centre for Oral Health were invited to complete the RDC/TMD assessment. Patients without a dental diagnosis or with a concurrent TMD diagnosis, established by the RDC/TMD assessment were excluded from the study Consequently, 8 subjects without dental pain and 15 subjects with a TMD diagnosis were excluded. This group consisted of 102 subjects (47 males, 55 females, mean age 43.2±16.3 years) (Table 7.3).

Headache subjects 72 subjects were recruited from two sources: patients with neurologist-diagnosed headache from the Department of Neurology, Westmead Hospital and staff and students of Westmead Hospital. Recruitment techniques included e-mail and posting of flyers. Four individuals were excluded because they had a concurrent TMD diagnosis based on RDC/TMD assessment. The final sample of this group was reduced to 68 (23 males, 45 females, mean age 45.7±14.7 years).

Nonpain subjects One hundred and twenty three pain-free subjects were selected from staff and students of Westmead Hospital; pain-free patients

who attended the general dental clinic at the Centre for Oral Health. Of the 123 subjects, eight subjects with a concurrent TMD diagnosis established by the RDC/TMD were excluded from analysis. This group comprised 115 subjects (61 males, 54 females, mean age 27.4±6.5 years).

This study was approved by Sydney West Area Health Service, Human Research Ethic Committee and informed consent was obtained from all participants. Subjects completed the History questionnaire of the RDC/TMD prior to examination and in all cases the Englsih version of the RDC/TMD was used even though translations were available in other languages.

Table 7.1 Distribution of different diagnostic types in TMD group

	Frequency	Percent
Group Ia	30	31.30%
Group Ib	41	42.70%
No Group I diagnosis	25	26.00%
Total	96	100.00%
Group IIa (right joint)	18	18.80%
Group IIb (right joint)	3	3.10%
Group IIc (right joint)	3	3.10%
No group II diagnosis (right joint)	72	75.00%
Total	96	100.00%
Group IIa (left joint)	19	19.80%
Group IIb (left joint)	4	4.20%
Group IIc (left joint)	0	0.00%
No group II diagnosis (left joint)	72	75.00%
Missing (left joint)	1	1.00%
Total	96	100.00%
Group IIIa (right joint)	31	32.30%
Group IIIb (right joint)	2	2.10%
Group IIIc (right joint)	1	1.00%
No group III diagnosis (right joint)	62	64.60%
Total	96	100.00%
Group IIIa (left joint)	43	44.80%
Group IIIb (left joint)	4	4.20%
Group IIIc (left joint)	0	0.00%
No group III diagnosis (left joint)	47	49.00%
Missing (left joint)	2	2.10%
Total	96	100.00%

Ia Myofascial pain
Ib Myofascial pain with limited opeining
IIa Disc displacement with reduction
IIb Disc displacement without reduction, with limited opening
IIc Disc displacement without reduction, without limited opening
IIIa Arthralgia
IIIb Osteoarthritis
IIIc Osteoarthrosis

Table 7.2 Distribution of different diagnostic types in dental pain group

Types	Frequency	Percent
Pulpitis	83	66.40%
Periapical infection	6	4.80%
Periodontal and mucosal disease	12	10.40%
Trauma	2	1.60%
Wisdom teeth unerupt	8	6.40%
Dentine hypersensitivity	5	4.00%
Retained root	8	6.40%
Total	125	100.00%

Table 7.3 Assessment result of dental pain group

Result	Number
No pain on examination	8
Concurrently have TMD diagnoses	15
Pain on examination without TMD diagnoses	102*
Total	125

* Final sample size of dental pain group

Methods

All subjects underwent a complete assessment using the RDC/TMD, including a history questionnaire and clinical examination. This was performed by a single calibrated examiner for all subject groups, except the TMD group who were examined by calibrated clinicians in the Orofacial Pain Clinc.

Before the study, training and calibration were performed. The training started with watching RDC/TMD teaching video which was produced by the Department of Oral Medicine of the University of Washington. The following clinical practice training was provided by an experienced examiner. Proper palpation pressure was practiced on a measurement scale initially (2lb force for extraoral muscle and 1lb force for intraoral muscle and joint palpations). The calibration was performed on examination of the same group of five volunteer subects as the experienced examiner.

The examiner wore gloves during the examinations and changed to another pair when changing from the extraoral to intraoral examination. Millimeter rulers were used to measure, between the incisor teeth, range of movement.

History Questionnaire

Subjects were required to complete RDC/TMD history questionnaire which contains 30 questions regarding general health, pain experience, jaw function impairment, pain related disability, emotional distress and demographic information.
Subjects were instructed to select the most appropriate response to each question.

Clinical Exam

The clinical examination assessed:

- Range of mandibular movement on opening, lateral excursions and potrusion;

- Joint sounds (clicks, coarse and fine crepitus) and pain by palpation;

- Muscle pain palpation of 16 extraoral and 4 intraoral sites (right and left anterior, middle, posterior temporalis, superior, middle, inferior masseter, posterior mandibular region, submandibular region, lateral pterygoid region, and tendon of temporalis) were palpated.

The results of the exam were recorded on a clinical examination form. For all subjects with dental pain, headache and TMD, the examination was performed when they were in pain.

Diagnoses

Diagnoses were assigned according to criteria of the RDC/TMD. A computer-generated diagnosis were assigned using e-RDC Verson 1.1(NUS,Singapore). The data from the history questionnaire and clinical examination were entered by hand into a computer. Based on this information, the system automatically generated a summary of findings for each subject who had completed assessment. The summary includes demograghic information, self report characteristics, AXIS I diagnoses and AXIS II profile).

AXIS I TMD diagnostic groups are classifed as follow:

I Muscle diagnoses

a Myofascial pain

b Myofascial pain with limited opeing

II Disc displacement

a Disc displacement with reduction

b Disc displacement without reduction, with limited opening

c Disc displacement without reduction, without limited opening

IIIArthalgia, osteoarthritis, osteoarthrosis

This system assisted the examiner to identify subjects with a concurrent TMD diagnosis in dental pain, headache and pain free groups and excluded them from statistical analysis.

Statistical analysis

The 151 variables (see Table 7.4) were derived from the RDC/TMD history questionnaire and clinical exam form. Fifteen of these variables were continuous and all others were categorical.

For the purposes of analysis, the original variables were grouped as follows:

- general health, oral health and orofacial pain in last month (V1~V3, V74, V75)
- pain related disability (V4~V13)
- jaw function (V14,V16~V25, V27,V29~V41)
- distress (V42~V73)
- socio-demographic (V76~V79, V81,V82, V85, V86)
- jaw movement measurements (V91, V92, V95, V98, V109, V112, V115, V119)
- movement pain (V93, V94, V96, V97, V110, V111,V113, V114, V116, V117)
- joint sounds (V99, V101, V103, V105, V120~V125)
- pain palpation (V126~V151)

The remaining variables (V15, V26, V28, V80, V83, V84, V100, V102, V104, V106, V107, V108 and V118) which were generated from dependent questions were not used in constructing predictive models as they were often missing for many subjects.

The joint sounds and movement pain variables were simplified, prior to analysis by combining as follows:

- joint sound opening= max (V99, V101)
- joint sound closing=max (V103, V105)
- joint sound excursion=max (V120, V121, V123, V124)
- joint sound protrusion=max (122, 125)
- joint pain opening=max (V94, V97)
- muscle pain opening=max (V93, V96)
- joint pain excursion=max (V111, V114)
- muscle pain excursion=max (V110, V113)
- joint pain protrusion=max (V117)
- muscle pain protrusion=max (V116)

Each of these 4 joint sound and 6 movement pain variables were then recoded to dichotomous 0/1 variables – 0 if nothing present, 1 if something present.

Principal Component Analysis (PCA) was carried out to reduce the dimensionality of the classification problem when using that group of variables. Stepwise logistic regression was used to construct predictive models for TMD patients. Receiver operating characteristic (ROC) curves helped us to investigate the accuracy of predictive models as well as the performance of each Principal Component (PC) as a predictor of TMD. Classification trees and five-fold cross validation were also used to build and assess the stability of a simple classification model (Model two). The data were analyzed using the statistical program SPSS version 15.0 for Windows (SPSS Inc. Chicago, United States).

Table 7.4 Original variables and numbers of subjects respond

History questionnaire

	Variable	N
V1	Self perception of general health	381
V2	Self perception of oral health	381
V3	Orofacial pain experience in the past month	381
V4	The first time facial pain happened	191
V5	Frequency of pain	191
V6	Treatment sought	191
V7	Intensity of present pain	191
V8	Intensity of worst pain in the past six months	191
V9	Intensity of usual pain in the past six months	191
V10	Days of activity limitation due to the pain in the past six months	191
V11	Severity of pain interference with daily activity in the past six months	191
V12	Severity of recreational, social and family activity related disability in the past six months	191
V13	Severity of work related disability in the past six months	191
V14	Jaw lock	381
V15	Ability interference to eat because of jaw lock	102
V16	Jaw click	381
V17	Jaw grating or grinding noise	381
V18	Grating or grinding teeth during sleep	381
V19	Grinding teeth or clench jaw during the day	381
V20	Jaw ache or feel stiff when wake up	381
V21	Noise or ring in the ear	381
V22	Bite uncomfortable	381
V23	Systemic arthritic disease	381
V24	Family member who have systemic arthritic disease	381
V25	Swollen and painful joint	381
V26	Persistent pain on joint at least one year	89
V27	Recent injury on face and jaw	381
V28	Jaw pain before injury	24
V29	Headache and migraines	381
V30	Chewing limit because of jaw problem	381
V31	Drinking limit because of jaw problem	381
V32	Exercising limit because of jaw problem	381
V33	Eating hard food limit because of jaw problem	381
V34	Eating soft food limit because of jaw problem	381
V35	Smiling/laughing limit because of jaw problem	381
V36	Sexual activity limit because of jaw problem	381
V37	Cleaning teeth or face limit because of jaw problem	381
V38	Yawning limit because of jaw problem	381
V39	Swallowing limit because of jaw problem	381
V40	Talking limit because of jaw problem	381
V41	Having usual facial appearance	381
V42	In the last month ,distress by headaches	381
V43	In the last month ,distress by losing sexual interest	381

Continued over

Table 7.4 (continued) Original variables and numbers of subjects respond

	Variable	N
V44	In the last month ,distress by faintness or dizziness	381
V45	In the last month ,distress by pains in the heart or chest	381
V46	In the last month ,distress by feeling low in energy or slowed down	381
V47	In the last month ,distress by thoughts of death or dying	381
V48	In the last month ,distress by poor appetite	381
V49	In the last month ,distress by crying easily	381
V50	In the last month ,distress by blaming yourself for things	381
V51	In the last month ,distress by pains in the lower back	381
V52	In the last month ,distress by feeling lonely	381
V53	In the last month ,distress by feeling blue	381
V54	In the last month ,distress by worrying too much about things	381
V55	In the last month ,distress by feeling no interest in things	381
V56	In the last month ,distress by nausea or upset stomach	381
V57	In the last month ,distress by soreness of your muscles	381
V58	In the last month ,distress by trouble falling asleep	381
V59	In the last month ,distress by trouble getting breath	381
V60	In the last month ,distress by hot or cold spells	381
V61	In the last month ,distress by numbness or tingling in parts of body	381
V62	In the last month ,distress by a lump in throat	381
V63	In the last month ,distress by feeling hopeless about the future	381
V64	In the last month ,distress by feeling weak in parts of body	381
V65	In the last month ,distress by heavy feelings in arms or legs	381
V66	In the last month ,distress by thoughts of ending life	381
V67	In the last month ,distress by overeating	381
V68	In the last month ,distress by awakening in the early morning	381
V69	In the last month ,distress by restless or disturbed sleep	381
V70	In the last month ,distress by feeling everything is an effort	381
V71	In the last month ,distress by feelings of worthlessness	381
V72	In the last month ,distress by feeling of being caught or trapped	381
V73	In the last month ,distress by feelings of guilt	381
V74	Self care of general health	381
V75	Self care of oral health	381
V76	Age	381
V77	Gender	381
V78	Country of birth	381
V79	Does this country best represent your race, national origin or ancestry	381
V80	County of national origin or ancestry	57
V81	Education level	381
V82	Work in the past 2 weeks	381
V83	Have a job or business	211
V84	Looking for a job or lay off	184
V85	Marital status	381
V86	Income	381

Continued over

Table 7.4 (continued) Original variables and numbers of subjects respond

Clinic examination

	Variable	N
V87	Painful side of face	381
V88	Painful area on right side	381
V89	Painful area on left side	381
V90	Opening pattern	381
V91	Unassisted opening without pain	381
V92	Maximum unassisted opening	381
V93	Pain on muscle when doing maximum unassisted opening	381
V94	Pain on jaw joint when doing maximum unassisted opening	381
V95	Maximum assisted opening	381
V96	Pain on muscle when doing maximum assisted opening	381
V97	Pain on jaw joint when doing maximum assisted opening	381
V98	Vertical incisal overlap	381
V99	Right joint sound when opening	381
V100	Measurement of right side opening sound	49
V101	Left joint sound when opening	381
V102	Measurement of left side opening sound	47
V103	Right joint sound when closing	381
V104	Measurement of right side closing sound	21
V105	Left joint sound when closing	381
V106	Measurement of left side closing sound	22
V107	Reciprocal click eliminated on protrusive opening(right)	55
V108	Reciprocal click eliminated on protrusive opening(left)	57
V109	Right lateral excursion	381
V110	Pain on muscle when doing right lateral excursion	381
V111	Pain on jaw joint when doing right lateral excursion	381
V112	Left lateral excursion	381
V113	Pain on muscles when doing left lateral excursion	381
V114	Pain on jaw joint when doing left lateral excursion	381
V115	Protrusion	381
V116	Pain on muscles when doing protrusion	381
V117	Pain on jaw joint when doing protrusion	381
V118	Midline deviation (side)	225
V119	Midline deviation (value)	381
V120	Right joint sound on right excursion	381
V121	Right joint sound on left excursion	381
V122	Right joint sound on protrusion	381
V123	Left joint sound on right excursion	381
V124	Left joint sound on left excursion	381
V125	Left joint sound on protrusion	381
V126	Right Temporalis pain (posterior)	381
V127	Left Temporalis pain(posterior)	381
V128	Right Temporalis pain (middle)	381
V129	Left Temporalis pain (middle)	381
V130	Right Temporalis pain (anterior)	381

Continued over

Table 7.4 (continued) Original variables and numbers of subjects respond

	Variable	N
V131	Left Temporalis pain (anterior)	381
V132	Right masseter pain (superior)	381
V133	Left masseter pain (superior)	381
V134	Right masseter pain(middle)	381
V135	Left masseter pain(middle)	381
V136	Right masseter pain(interior)	381
V137	Left masseter pain (interior)	381
V138	Right posterior mandibular region pain	381
V139	Left posterior mandibular region pain	381
V140	Right submandibular region pain	381
V141	Left submandibular region pain	381
V142	Right lateral pole pain	381
V143	Left lateral pole pain	381
V144	Right posterior attachment pain	381
V145	Left posterior attachment pain	381
V146	Right lateral pterygoid area	381
V147	Left lateral pterygoid area	381
V148	Right tendon of temporalis	381
V149	Left tendon of temporalis	381
V150	Right side of tongue	381
V151	Left side of tongue	381

Chapter 8: Results

The total number of subjects across the four groups was 381. The distribution of subject types is shown in Table 8.1. The demographic information including age, gender, country of birth, education, marital status and income of subjects within each group are provided in Table 8.2.

Results of principal component analysis

As mentioned previously, original 151 variables had been classified into nine variable groups. Before constructing predictive models, it was necessary to reduce the dimensionality of these variable sets.

Principal component analysis (PCA) is a technique commonly used to identify linear combinations of variables which capture the main dimensions of a dataset. For each variable group (with the exception of the general and oral health group and the socio-demographic group in which there were fewer variables and these variables had different measurement scales) a separate PCA was performed to reduce the dimensionality and summarized the 'information' available from that group of variables.

In this way, for example, three principal components (PCs) were identified from 10 original pain-related severity variables (Table 8.3). In other words, it reduced the dimensionality of pain from 10 to 3. The PCA results of other variable groups can be seen from Table 8.4 to Table 8.9.

The receiver operating characteristics (ROC) curve illustrated the global performance of each PC as a predictor of TMD. A perfect predictor has an area under curve of 1 since it achieves both 100% sensitivity and 100% specificity. The closer the area is to 0.5, the less utility the predictor has. Therefore, it was clear that none of the PCs of pain-related variable group was a good predictor (Fig. 3). The ROC curves of PCs of other variable

groups are illustrated in Fig.4 to Fig. 9.

Table 8.1 Distribution of subject types

	Frequency	Percent (%)
TMD	96	25.2
Dental pain	102	26.8
Headache	68	17.8
No pain	115	30.2
Total	381	100

Table 8.2 Demographic characteristics of subjects

	TMD	Dental pain	Headache	Nonpain
Mean age±SD	43.1±16.8	43.2±16.3	45.7±14.7	27.4±6.5
	n (%)	n (%)	n (%)	n (%)
Gender				
Male	27 (28.1)	47 (46.1)	23 (33.8)	61 (53.0)
Female	69 (71.9)	55 (53.9)	45 (66.2)	54 (47.0)
Country of birth				
Australian born	51 (53.1)	51 (50.0)	35 (51.5)	50 (43.5)
oversea	45 (46.9)	51 (50.0)	33 (48.5)	65 (56.5)
Education level				
never	1 (1.0)	4 (3.9)	4 (5.9)	0 (0.0)
primary school	4 (4.2)	6 (5.9)	1 (1.5)	3 (2.6)
high school	72 (75.0)	77 (75.5)	32 (47.1)	16 (13.9)
university	19 (19.8)	15 (14.7)	31 (45.6)	96 (83.5)
Marital status				
married, spouse in household	34 (35.4)	43 (42.2)	41 (60.3)	21 (18.3)
married, spouse not in household	6 (6.3)	0 (0.0)	0 (0.0)	3 (2.6)
widowed	8 (8.3)	3 (2.9)	2 (2.9)	2 (1.7)
divorced	7 (7.3)	14 (13.7)	4 (5.9)	1 (0.9)
separated	0 (0.0)	6 (5.9)	3 (4.4)	0 (0.0)
never married	41 (42.7)	36 (35.3)	18 (26.5)	88 (76.5)
Income				
0-14999	44 (45.8)	62 (60.8)	10 (14.7)	55 (47.8)
15000-24999	18 (18.8)	19 (18.6)	10 (14.7)	8 (7.0)
25000-34999	11 (11.5)	12 (11.8)	7 (10.3)	11 (9.6)
35000-49999	6 (6.3)	4 (3.9)	14 (20.6)	5 (4.3)
50000 or more	17 (17.7)	4 (3.9)	24(35.3)	36 (31.3)
Missing	0 (0.0)	1 (1.0)	3 (4.4)	0 (0.0)

Table 8.3 Component matrix (a) of pain-related variable group

	Component		
	1	2	3
Severity of work related disability in the past six months	0.866		
Severity of recreational, social and family activity related disability in the past six months	0.862		
Severity of pain interference with daily activity in the past six months	0.862		
Intensity of usual pain in the past six months	0.748		
Intensity of worst pain in the past six months	0.742		
Intensity of present pain	0.566		
Days of activity limitation due to the pain in the past six months	0.523		
Months since first time facial pain happened		0.676	
Frequency of pain		-0.504	0.664
Treatment sought		0.533	0.63

a 3 components extracted, only values >0.4 in absolute terms shown

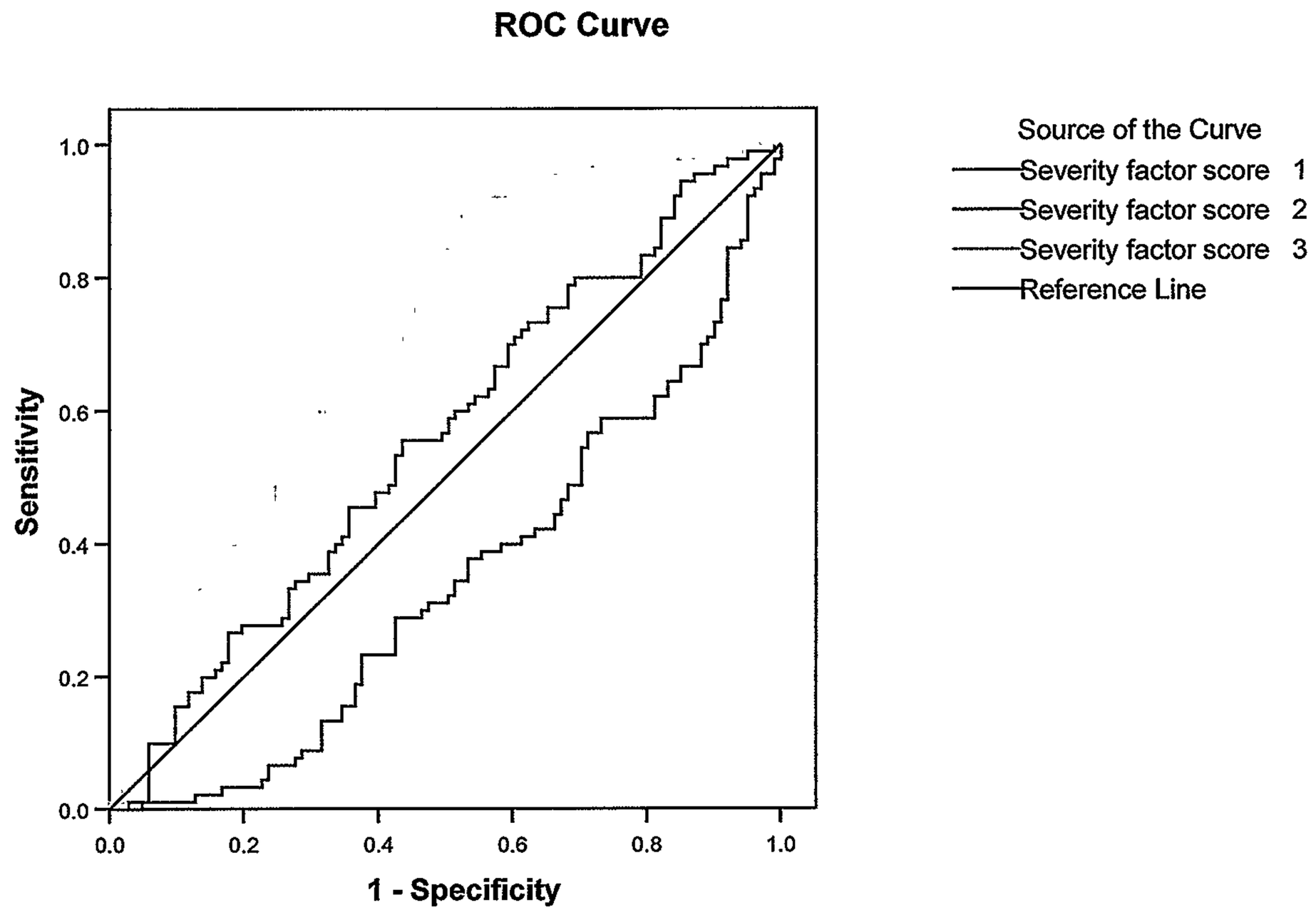
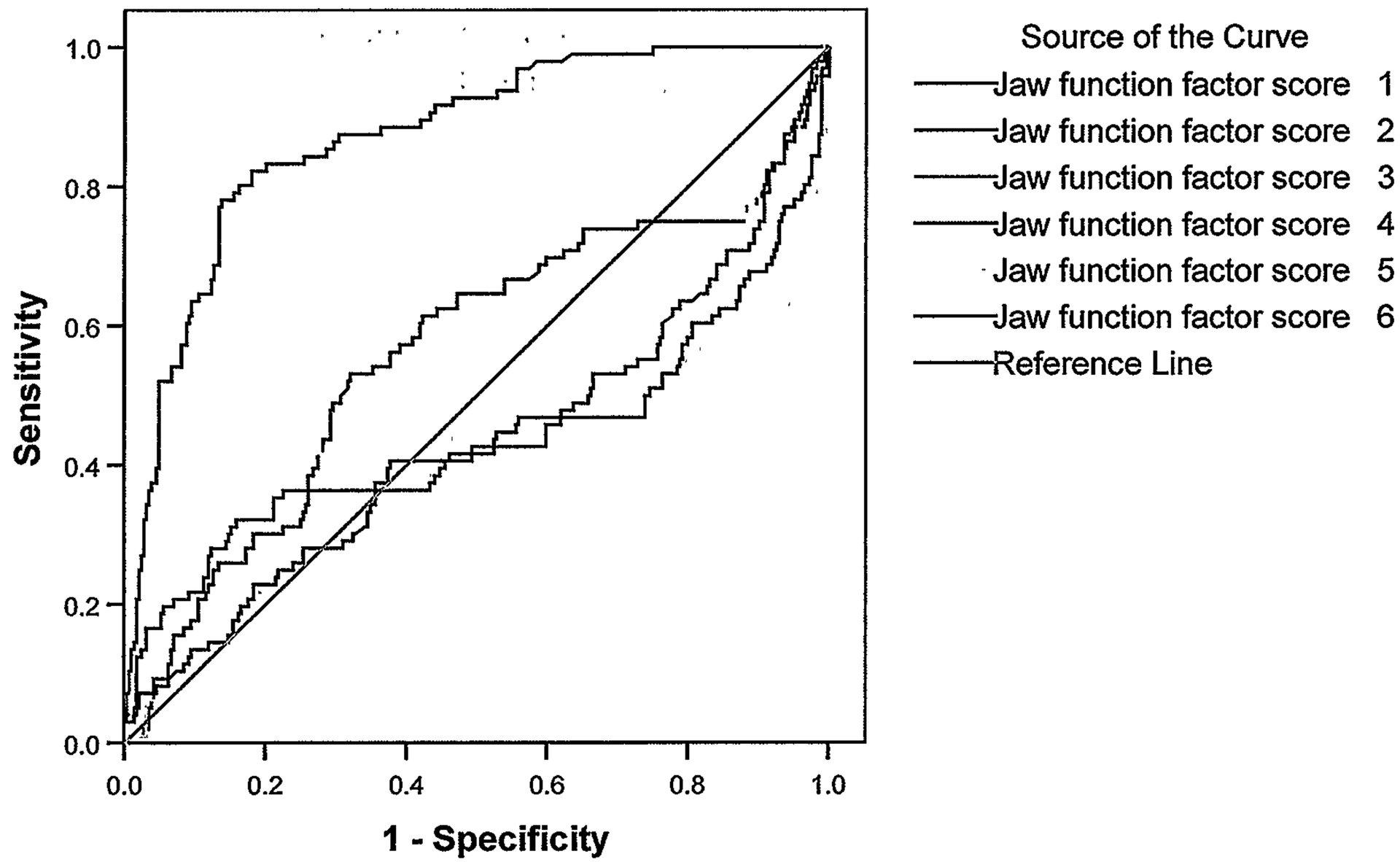


Fig.3 ROC curve of pain related variable group

Table 8.4 Component matrix (a) of jaw function variable group

	Component					
	1	2	3	4	5	6
Chewing limit because of jaw problem	0.791					
Eating hard food limit because of jaw problem	0.764					
Smiling/laughing limit because of jaw problem	0.748					
Yawning limit because of jaw problem	0.709					
Talking limit because of jaw problem	0.679					
Bite uncomfortable	0.662					
Jaw ache or feel stiff when wake up	0.619					
Cleaning teeth or face limit because of jaw problem	0.606					
Having usual facial appearance	0.523					
Jaw click	0.521	0.453				
Exercising limit because of jaw problem	0.518					
Jaw grating or grinding noise	0.482	0.413				
Swallowing limit because of jaw problem	0.461					
Jaw lock	0.45					
Noise or ring in the ear	0.444					
Drinking limit because of jaw problem						
Headache and migraines						
Grating or grinding teeth during sleep	0.409	0.45		0.406		
Grinding teeth or clench jaw during the day		0.444				
Systemic arthritic disease			0.721			
Family member who have systemic arthritic disease			0.609			
Swollen and painful joint			0.541			
Recent injury on face and jaw					0.599	
Eating soft food limit because of jaw problem	0.402				-0.512	
Sexual activity limit because of jaw problem	0.437					0.533

a 6 components extracted, only values >0.4 in absolute terms shown



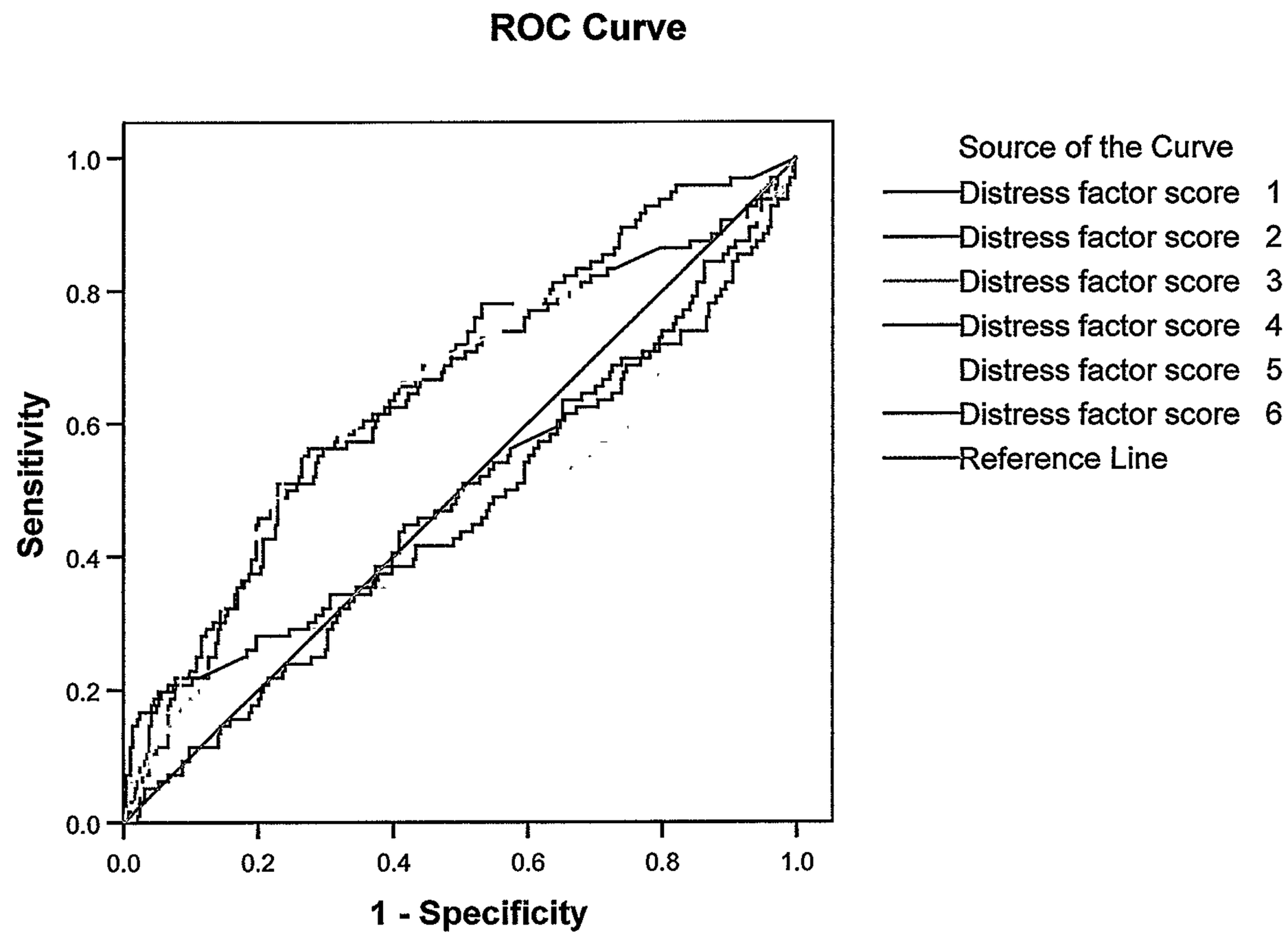
Diagonal segments are produced by ties.

Fig.4 ROC curve of jaw function variable group

Table 8.5 Component matrix (a) of distress variable group

	Component					
	1	2	3	4	5	6
In the last month, distress by feeling blue	0.800					
In the last month, distress by feeling weak in parts of body	0.793					
In the last month, distress by feelings of worthlessness	0.773					
In the last month, distress by feeling everything is an effort	0.765					
In the last month, distress by feeling no interest in things	0.751					
In the last month, distress by blaming yourself for things	0.735					
In the last month, distress by feeling hopeless about the future	0.733					
In the last month, distress by feeling low in energy or slowed down	0.724					
In the last month, distress by feeling lonely	0.722					
In the last month, distress by feeling of being caught or trapped	0.713	-0.458				
In the last month, distress by worrying too much about things	0.691					
In the last month, distress by restless or disturbed sleep	0.684		-0.47			
In the last month, distress by numbness or tingling in parts of body	0.682					
In the last month, distress by soreness of your muscles	0.681					
In the last month, distress by heavy feelings in arms or legs	0.679					
In the last month, distress by feelings of guilt	0.676					
In the last month, distress by hot or cold spells	0.668					
In the last month, distress by thoughts of death or dying	0.667					
In the last month, distress by trouble getting breath	0.653					
In the last month, distress by nausea or upset stomach	0.647					
In the last month, distress by a lump in throat	0.632					
In the last month, distress by pains in the lower back	0.632					
In the last month, distress by trouble falling asleep	0.629		-0.437			
In the last month, distress by crying easily	0.626					
In the last month, distress by poor appetite	0.612					
In the last month, distress by awakening in the early morning	0.571		-0.478			
In the last month, distress by thoughts of ending life	0.541			0.455		
In the last month, distress by losing sexual interest	0.534					
In the last month, distress by pains in the heart or chest	0.513					
In the last month, distress by faintness or dizziness	0.509					
In the last month, distress by headaches	0.421	0.476				
In the last month, distress by overeating	0.417		0.418			0.466

a 6 components extracted, only values >0.4 in absolute terms shown



Diagonal segments are produced by ties.

Fig.5 ROC curve of distress variable group

Table 8.6 Component matrix (a)jaw movement variable group

	Component		
	1	2	3
Maximum unassisted opening	0.927		
Maximum assisted opening	0.905		
unassisted opening without pain	0.849		
Protrusion		0.612	
Vertical incisal overlap		0.594	
Right lateral excursion	0.522	0.523	
Left lateral excursion	0.448	0.522	-0.459
Midline deviation (value)			0.746

a 3 components extracted, only values >0.4 in absolute terms shown

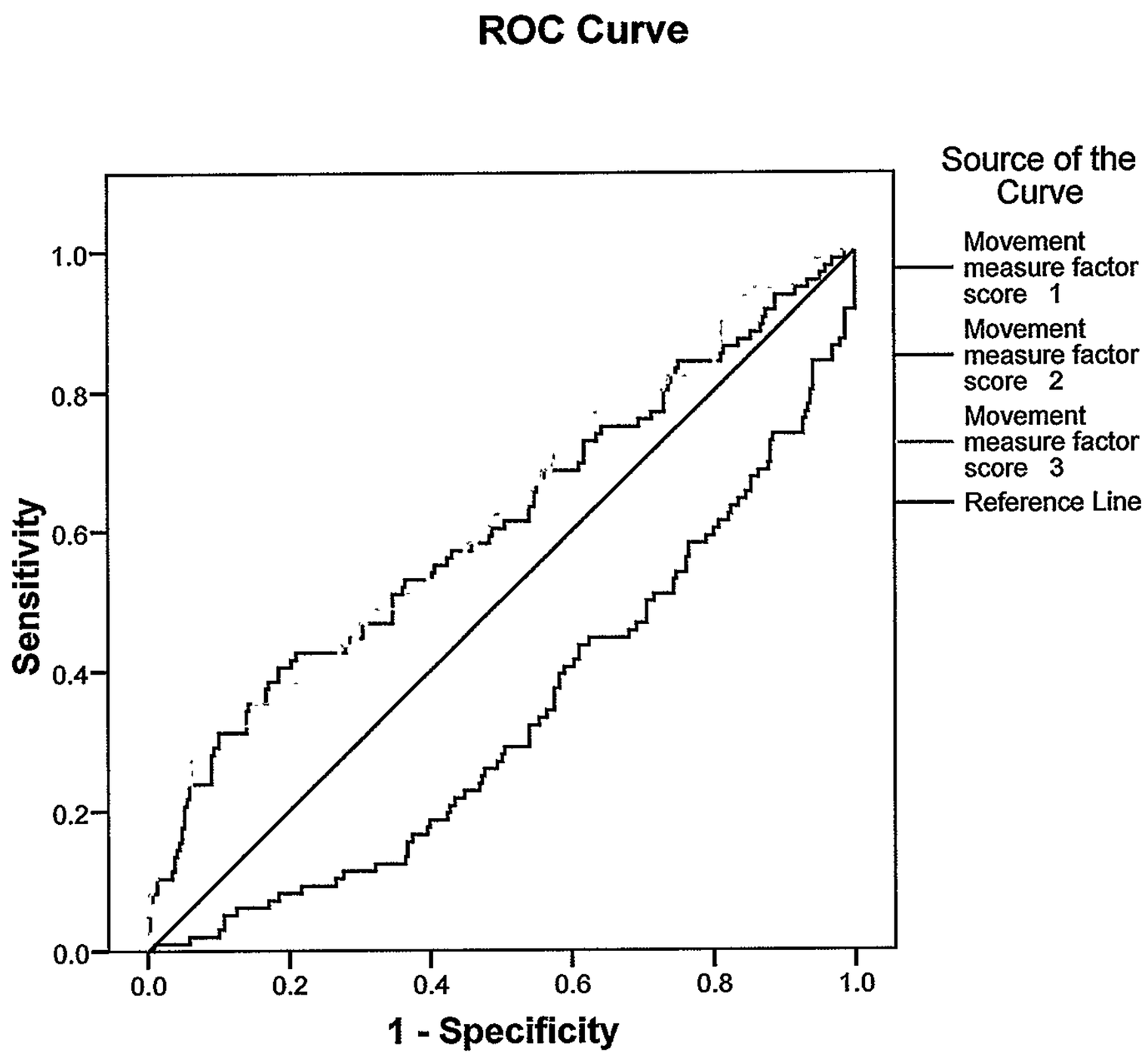


Fig.6 ROC curve of jaw movement variable group

Table 8.7 Component matrix (a) of movement pain variable group

	Component	
	1	2
Joint pain excursion	0.722	-0.407
Muscle pain excursion	0.683	0.408
Joint pain opening	0.669	-0.456
Muscle pain protrusion	0.64	0.412
Joint pain protrusion	0.622	-0.423
Muscle pain opening	0.566	0.565

a 2 components extracted, only values >0.4 in absolute terms shown

Table 8.8 Component matrix (a) of joint sound variable group

	Component
	1
Joints sound closing	0.876
Joint sound opening	0.865
Joint sound protrusion	0.812
Joint sound excursion	0.674

a 1 components extracted.

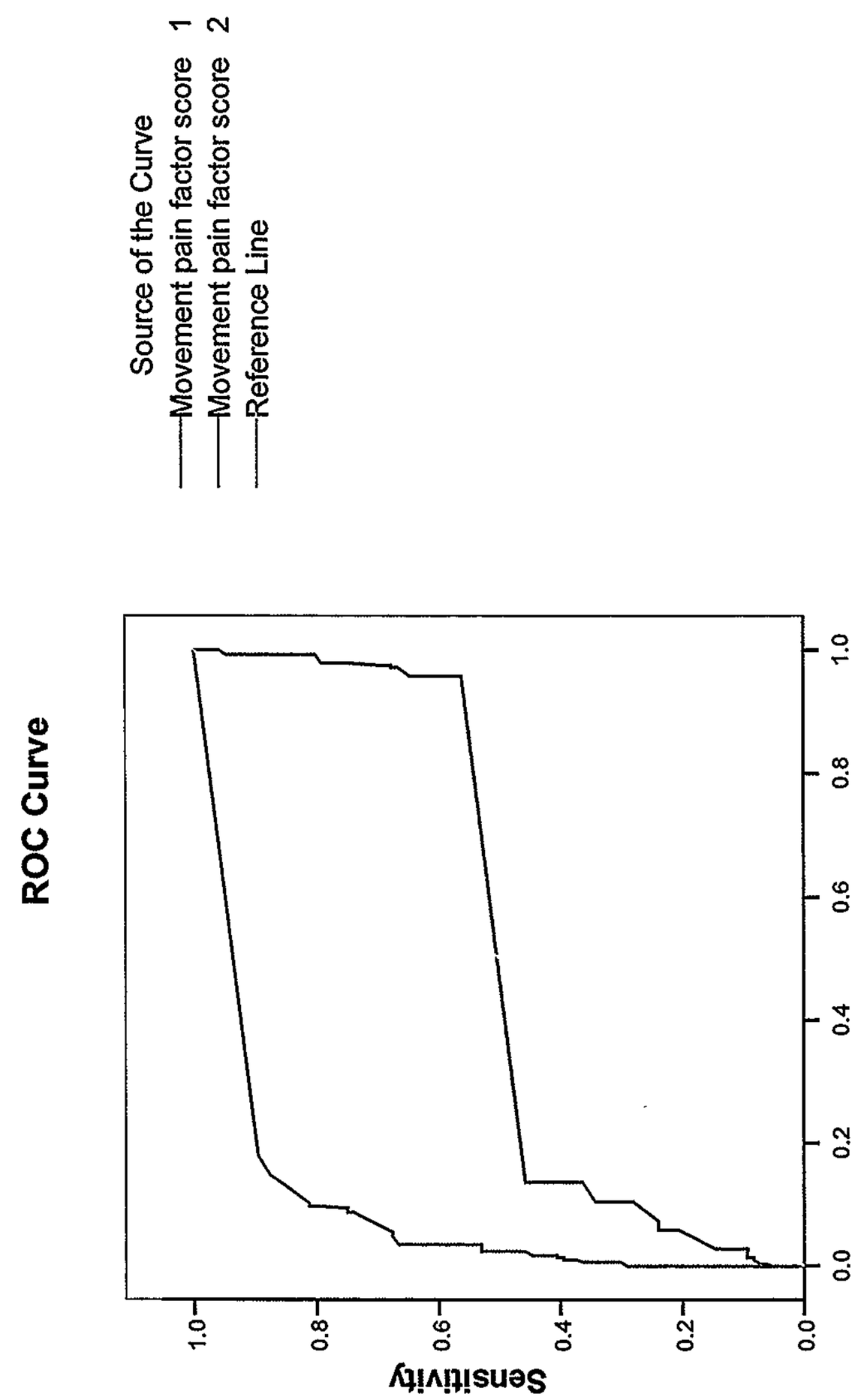


Fig.7 ROC curve of movement pain variable group

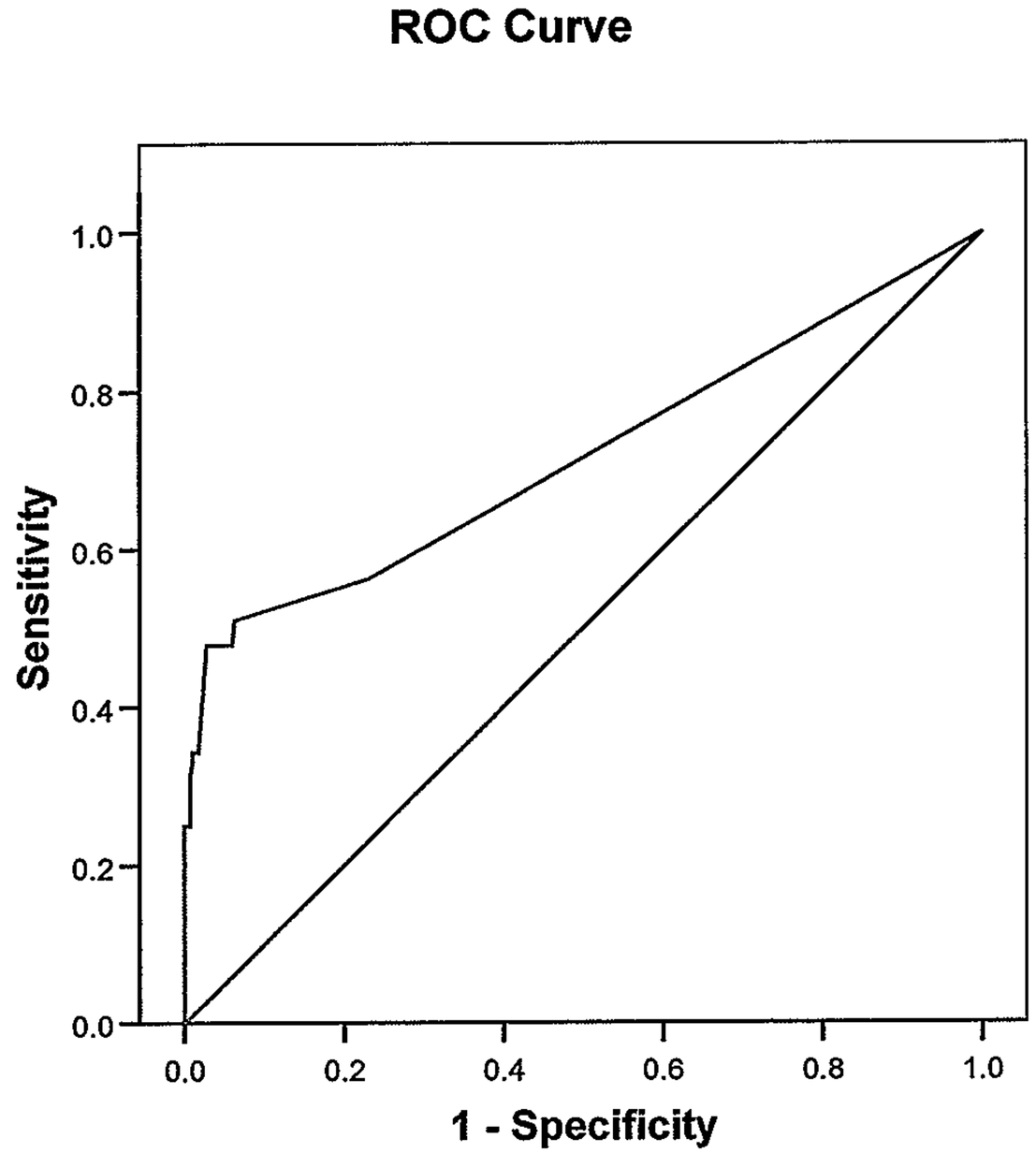


Fig.8 ROC curve of joint sound variable group

Table 8.9 Component matrix (a) of palpation pain variable group

	Component				
	1	2	3	4	5
Right posterior mandibular region pain	0.782				
Left posterior mandibular region pain	0.761				
Left submandibular region pain	0.752			-0.369	
Left masseter pain (interior)	0.737			-0.318	
Right masseter pain (superior)	0.734				0.348
Right tendon of temporalis	0.695		0.319		
Right submandibular region pain	0.686				
Left tendon of temporalis	0.676				-0.3
Left Temporalis pain (anterior)	0.673				
Left masseter pain(middle)	0.666		-0.368		
Right masseter pain(middle)	0.66				
Left masseter pain (superior)	0.648	0.355	-0.359		
Right masseter pain(interior)	0.634			-0.387	
Left lateral pterygoid area	0.617	0.468			-0.327
Left lateral pole pain	0.615	0.381	-0.367		
Left Temporalis pain (middle)	0.615	-0.38		0.332	
Right Temporalis pain (anterior)	0.613	-0.454			
Right lateral pterygoid area	0.611		0.435		-0.33
Right Temporalis pain (posterior)	0.597				
Left Temporalis pain(posterior)	0.591	-0.391		0.305	
Right lateral pole pain	0.581		0.362	0.411	
Right Temporalis pain (middle)	0.515	-0.49		0.348	
Left posterior attachment pain	0.413	0.574			
Right posterior attachment pain	0.367	0.344	0.526	0.345	0.34

a 5 components extracted.

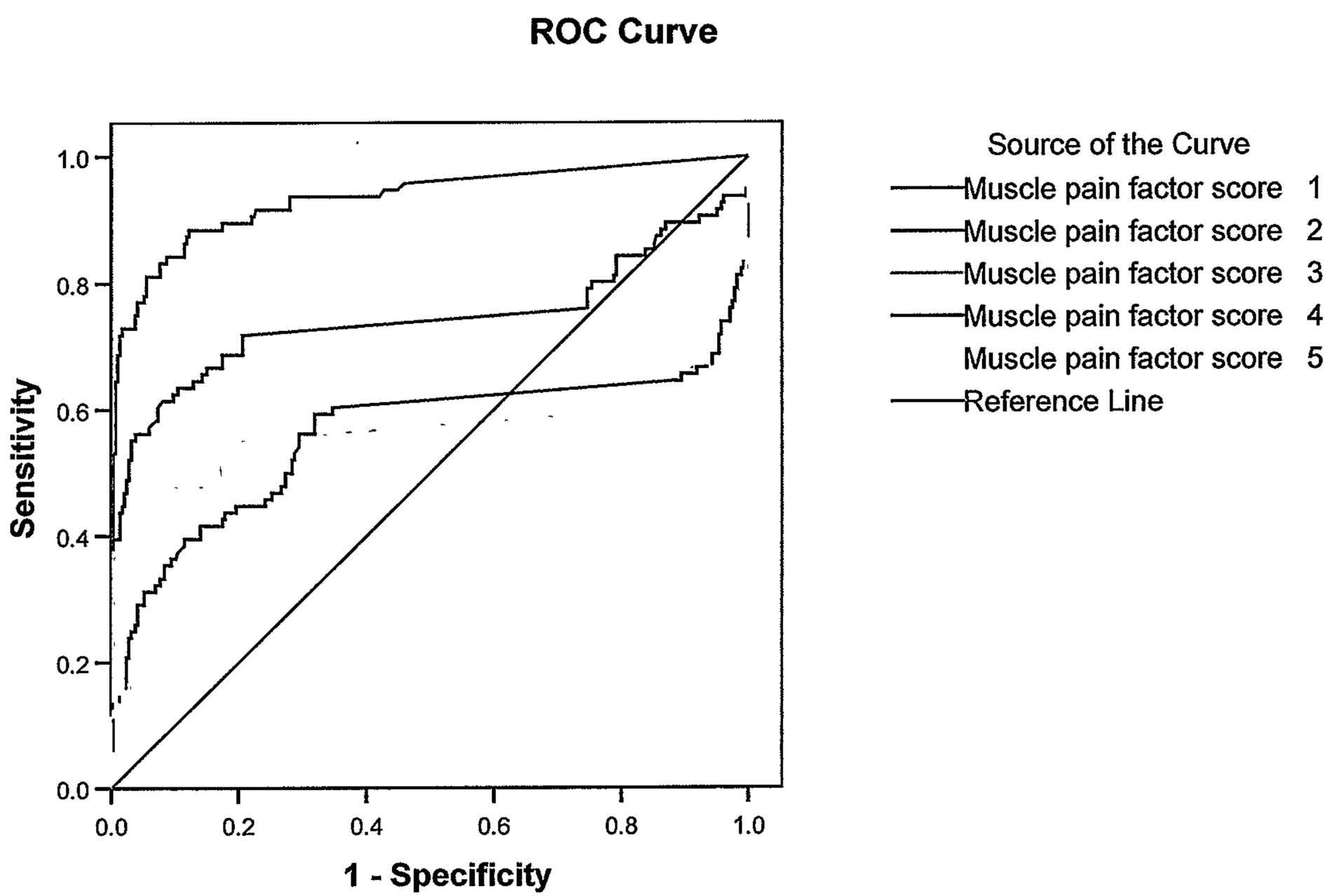


Fig.9 ROC curve of pain palpation variable group

Model One

After the dimensionality of the original variables was reduced by using the PCA, stepwise logistic regression analysis was carried out using those principal components, socio-demographic and general and oral health variables to identify the following predictive model for TMD (Table 8.10)

This predictive model comprised one self-report question (i.e. whether orofacial pain was experienced in the last month) and three groups of clinical exam variables (i.e. muscle pain palpations, pain during jaw movements and joint sounds on palpation). The ROC curve of this model clearly showed it was an excellent predictor for TMD (Fig. 10). The area under the curve was 0.978 (95% CI, 0.957 to 0.999) (Table 8. 11). Table 8.12 also showed the sensitivities of Model one were equal to, or more than 90% at different cut-off points. Cut-off points are the points to distinguish the positive and negative test results. Setting a cut off value too low may yield a very high sensitivity at expense of specificity. Setting a cut off value too high may yield a very high specificity at expense of sensitivity.

Table 8.10 Variables of Model One in the equation

	B	S.E.	P-value	Odds ratio	95.0% for OR	
					Lower	Upper
Orofacial pain in the past month	1.994	0.763	.009	7.346	1.648	32.746
Muscle pain factor score 1	5.507	1.258	.000	246.5	20.937	2902.6
Muscle pain factor score 2	2.046	0.551	.000	7.738	2.628	22.787
Movement pain factor score 1	1.099	0.413	.008	3.001	1.337	6.738
Movement pain factor score 2	-0.802	0.287	.005	0.449	0.256	0.787
Joint sound factor score 1	1.650	0.493	.001	5.205	1.982	13.667
Constant	-1.915	0.695	.006	0.147		

Table 8.11 Area under ROC curve of model one

Area	Std. Error	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.978	0.011	0	0.957	0.999

b Null hypothesis: true area = 0.5

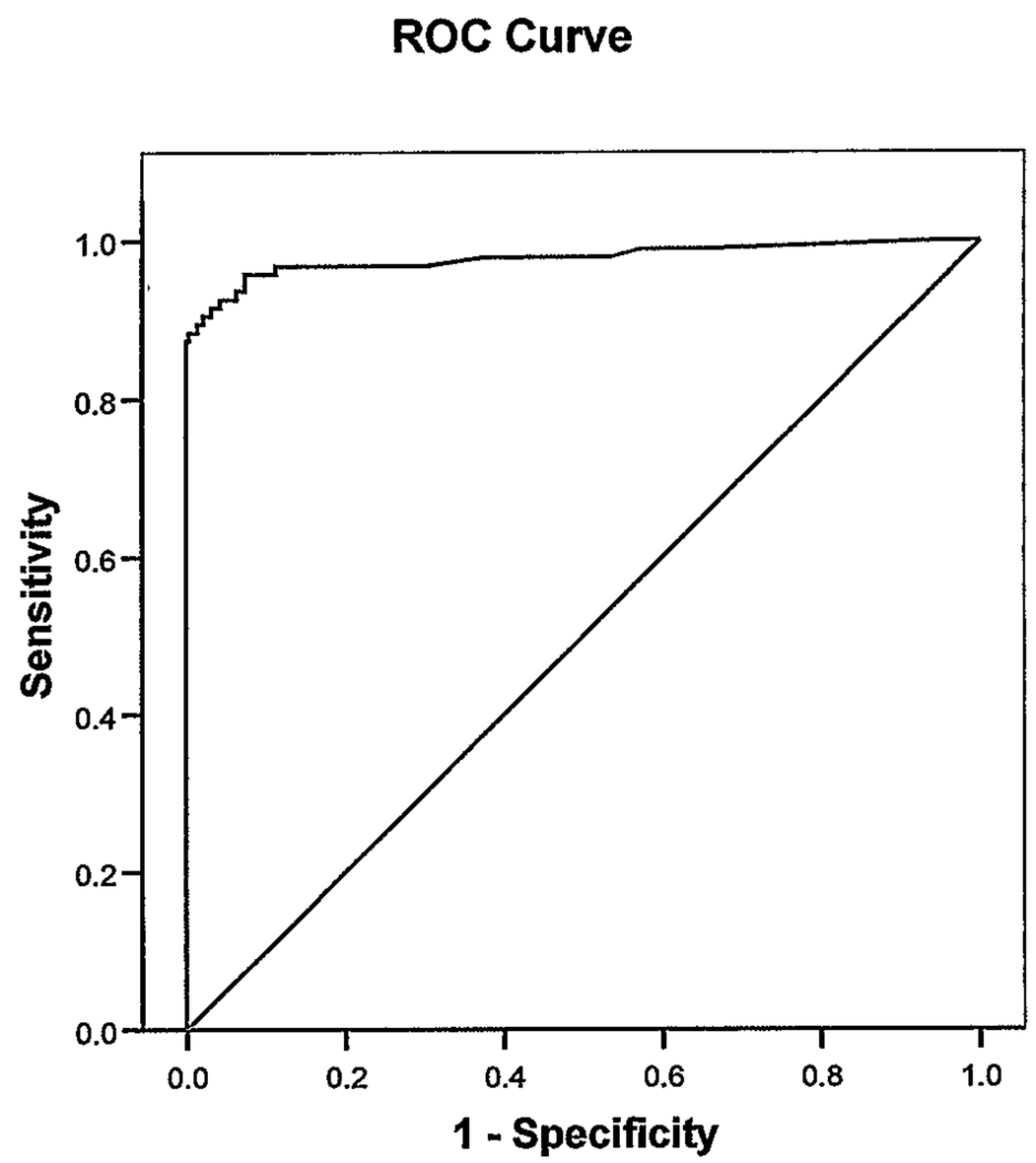


Fig 10. ROC curve of Model one

Table 8.12 Sensitivity & specificity achieved at different cutoff points of model one

Positive if Greater Than or Equal To	Sensitivity	1 - Specificity
-0.9992032	1	1
0.0009746	1	0.996
0.0024119	1	0.947
0.0026029	0.99	0.649
0.0060764	0.99	0.572
0.0062535	0.979	0.533
0.0178648	0.979	0.375
0.0181879	0.969	0.302
0.0991614	0.969	0.112
0.1036072	0.958	0.112
0.1356965	0.958	0.074
0.1386242	0.948	0.074
0.1426665	0.938	0.074
0.1487221	0.938	0.067
0.1546403	0.938	0.063
0.1722358	0.927	0.063
0.2378389	0.927	0.042
0.2444251	0.917	0.042
0.26099	0.917	0.032
0.275254	0.906	0.032
0.344243	0.906	0.021
0.3912883	0.896	0.021

Model Two

Although the previous Model showed its strong ability in predicting for TMD, it was primarily based on variables which can only be obtained from dental examination. Indeed, it required undertaking an almost full RDC/TMD examination protocol as a screen. The following model tried to exclude many subjects from being possible TMD patients before the clinical examination was required.

△Step one

In this step a classification tree analysis was carried out using variables available only from self-report questions (Fig.11)

Two variables (i.e. age>36 or experienced orofacial pain in the past month) quickly rule out 126 non-TMD subjects (almost 50% of non-TMD subjects in this data set) (Table 8.13). Those subjects (n=255) who are older than 36 or have experienced pain in the past month were selected for further investigation.

△Step two

A five-fold cross-validation study of the logistic regression models for TMD identified using stepwise variable selection from the self-report variables was conducted. The following independent predictors were included in at least 4 of the 5 models:

- V3 orofacial pain in the past month (positive association)
- V16 jaw click (positive association)
- V29 headache and migraines (negative association)
- V30 chewing limit because of jaw problem (positive association)
- V38 yawning limit because of jaw problem (positive association)
- V41 having usual facial appearance (positive association).

The detailed logistic regression model based on these independent predictors is shown in Table 8.14

For ease of use in clinical practice, instead of using the actual linear predictor coefficients which are shown in column B of Table 8.14, a simple score was developed, namely add 1 for each of V3, V16, V30, V38 and V41 that is positive, and subtract 1 if V29 is positive. This simplification was justified because the actual linear predictor coefficients of these variables are roughly equal 1. Except for V29, the other 5 variables are positively related to TMDs (Table 8.14).

The Roc curves of both the actual linear predictor score and the simple score are illustrated in Fig.12. The areas under the curves are shown in Table 8.15.

There is virtually no difference between the classification performance of the actual linear predictor score and its simplified version.

Table 8.16 shows that when simple score>=0, it ruled out another 31 subjects, although two of them actually had TMD. For those that were not ruled out (n=224) they proceeded to clinical examination.

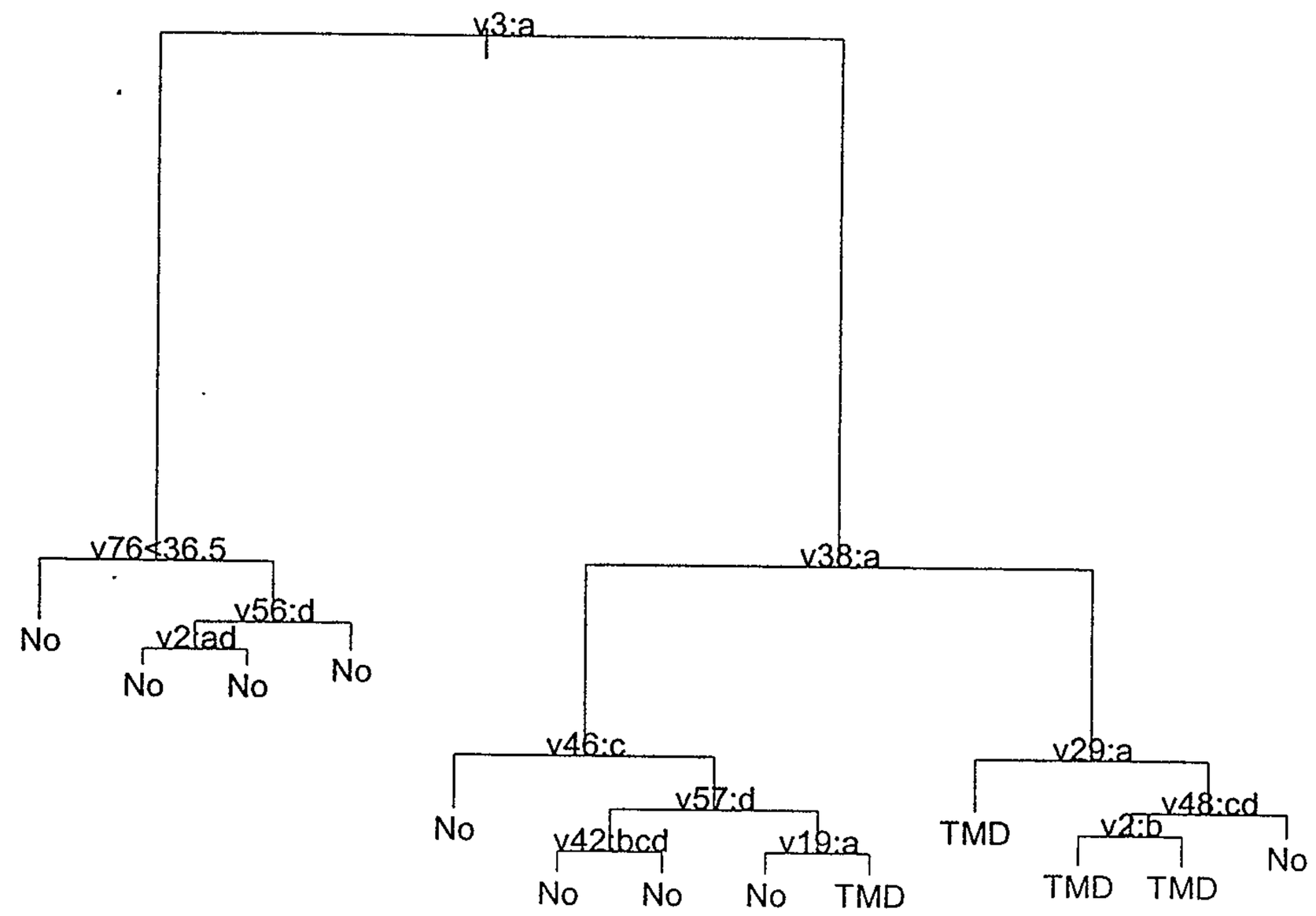


Fig 11 Classification tree analysis of self-report questionnaire variables

Table8.13 Predicted TMD based on oral facial pain in last month or age >36

			TMD		
			Absent	Present	Total
Predicted TMD based on oral facial pain or age >36	No	Count	126	0	126
		% within Predicted TMD	100.00%	0.00%	100.00%
	Yes	Count	159	96	255
		% within Predicted TMD	62.40%	37.60%	100.00%
Total		Count	285	96	381
		% within Predicted TMD	74.80%	25.20%	100.00%

Table 8.14 Variables of step two of Model Two in the Equation

					95.0% C.I.for OR	
	B	S.E.	Sig.	OR	Lower	Upper
V3	1.19	0.544	0.029	3.287	1.131	9.556
V16	1.109	0.361	0.002	3.031	1.495	6.147
V29	-1.24	0.415	0.003	0.289	0.128	0.653
V30	0.975	0.383	0.011	2.651	1.25	5.621
V38	1.524	0.384	0	4.593	2.165	9.743
V41	1.057	0.501	0.035	2.879	1.079	7.683
Constant	-2.452	0.509	0	0.086		

△Step three

Stepwise logistic regression identified five independent predictors among the clinical variables. The detailed logistic regression model based on these independent predictors is shown in Table 8.17. The actual linear predictor coefficient value of Masseter pain is roughly half of that of each other four variables (Table 8.17) Therefore, a simplified score (called final score rule) was recorded as follows:

- Joint pain on mouth opening score 2
- Muscle pain on protrusive jaw movement score 2
- Joint sound on mouth closing score 2
- TMJ pain score 2
- Masseter pain score 1

The ROC curves of both the actual linear predictor score and the Final score are illustrated in Fig.13. The areas under the curves are shown in Table 8.18.

Clearly, there is no appreciable difference between the actual linear predictor score and its simplified version.

From Table 8.19 we see that, when the Final score rule>=2, a further 113 subjects were ruled out including who 4 of them actually had TMD.

The overall performance of Model Two is shown in Table 20. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of model two for this particular sample were 93.8%, 92.6%, 81.1% and 97.8% respectively.

A flow diagram based on Model two shows how this screening procedure is carried out (Fig.14).

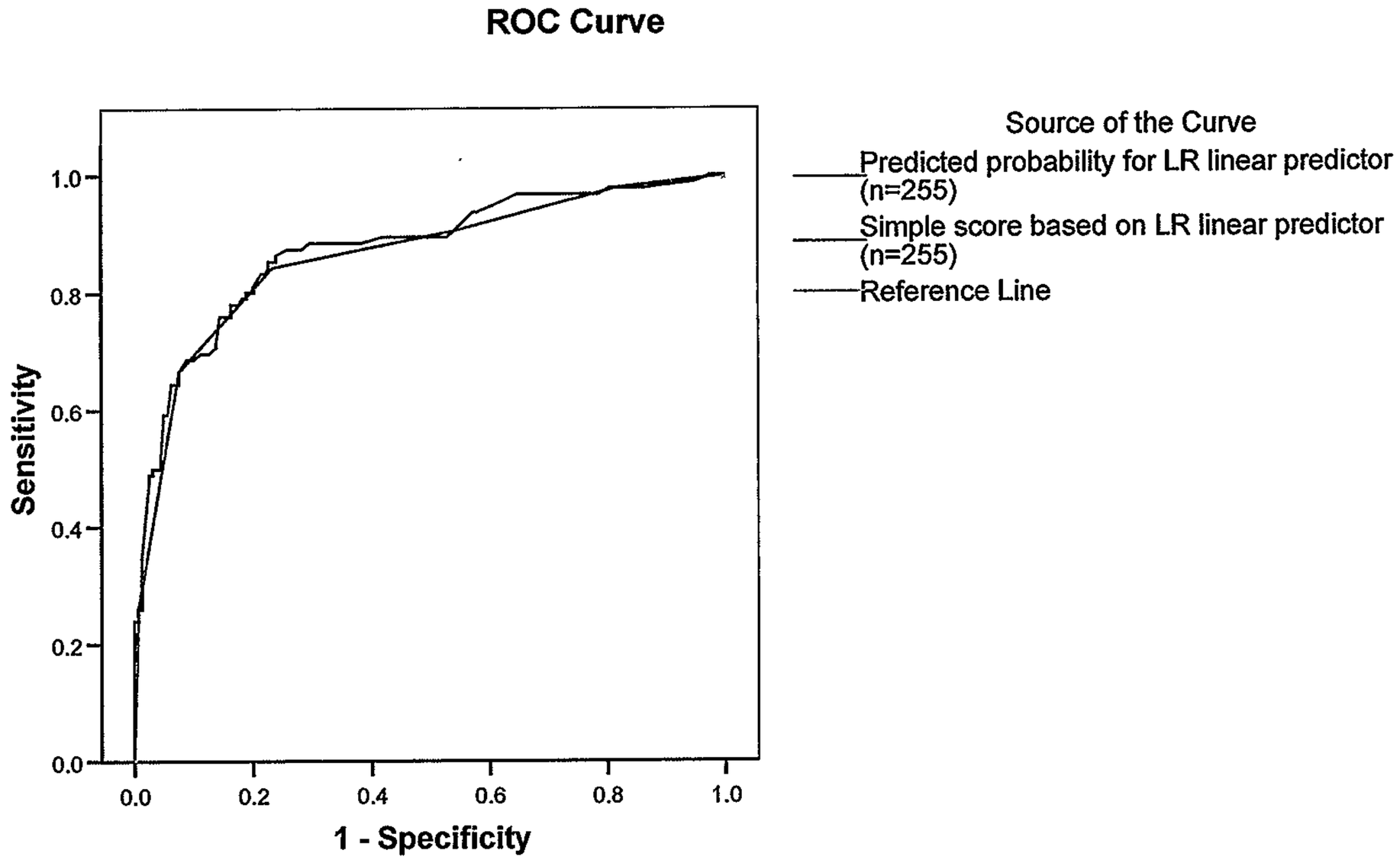


Fig.12 ROC curve of predicted probability and simple score

Table 8.15 Area under ROC curves of actual predicted score and simple score

Test Result Variable(s)	Area	Std. Error	p-value	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Predicted probability for LR linear predictor (n=255)	0.875	0.024	0	0.828	0.922
Simple score based on LR linear predictor (n=255)	0.863	0.025	0	0.813	0.912

Table 8.16 Simple Score >=0 * TMD Crosstabulation

		TMD		
		Absent	Present	Total
Simple Score >=0	No	29	2	31
	Yes	130	94	224
Total		159	96	255

Table 8.17 Independent predictors of clinical exam

	B	S.E.	Wald	df	p-value	OR	95.0% C.I.for OR	
							Lower	Upper
Joint pain on Opening	3.576	0.770	21.593	1	0.000	35.727	7.906	161.448
Muscle pain on protrusive jaw movement	3.219	1.076	8.950	1	0.003	24.999	3.035	205.942
Joint sound on closing	4.123	0.968	18.146	1	0.000	61.770	9.265	411.833
Masster pain palpation	1.526	0.551	7.672	1	0.006	4.600	1.562	13.541
TMJ pain palpation	3.352	0.633	28.039	1	0.000	28.549	8.257	98.710
Constant	-3.982	0.588	45.893	1	0.000	0.019		

Table 8.18 Area under ROC curves of actual predicted rule and final score rule

Test Result Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Predicted probability LR rule	0.967	0.012	0.000	0.943	0.990
Final Score rule	0.966	0.012	0.000	0.942	0.990

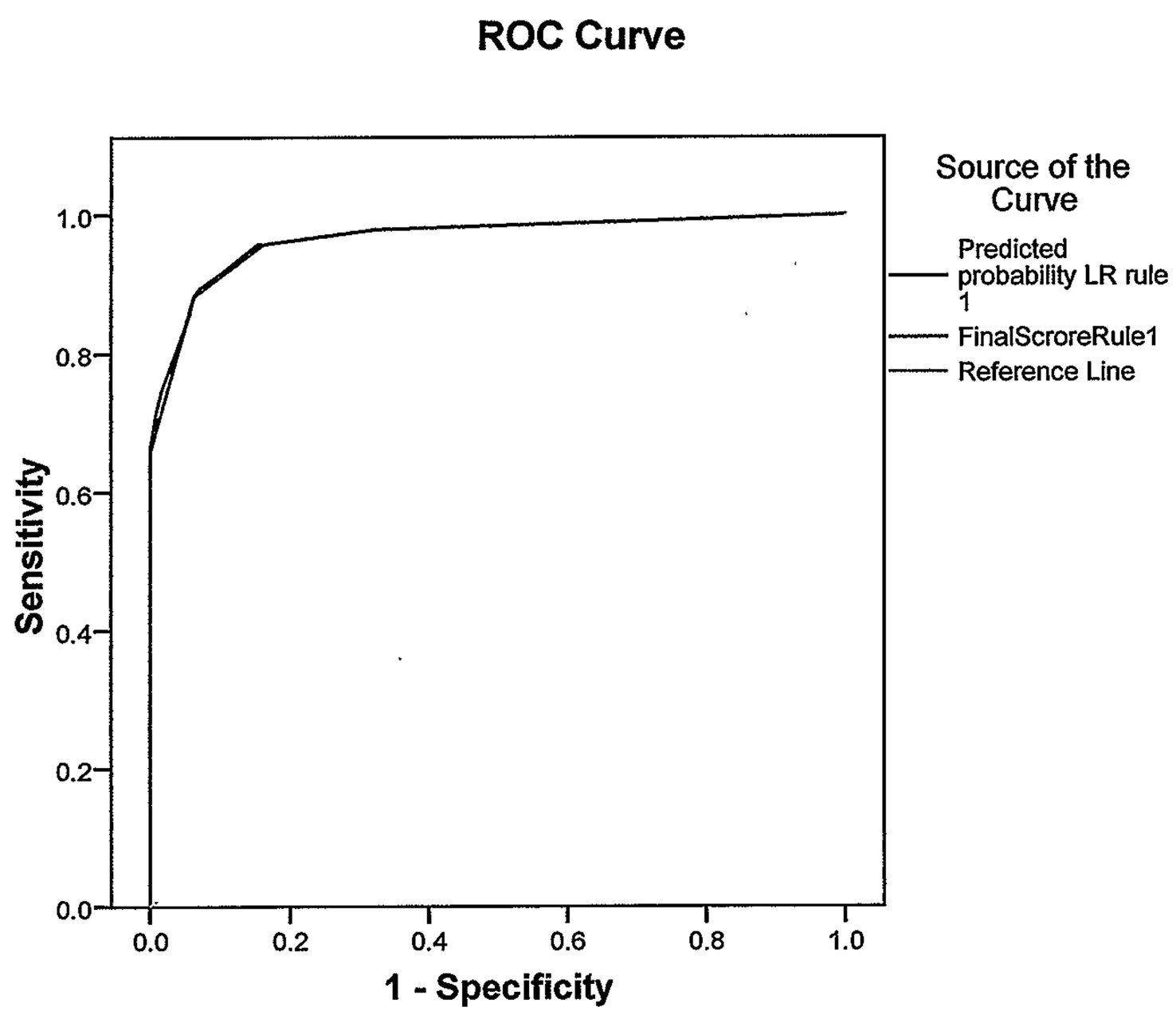


Fig. 13 ROC curve of Final score

Table 8.19 Final score Rule >=2 TMD Crosstabulation

		TMD		Total
		Absent	Present	Absent
Final score Rule >=2	No	109	4	113
	Yes	21	90	111
	Total	130	94	224

Table 8.20 Model two TMD Crosstabulation

		TMD		Total
		Absent	Present	Absent
Final score Rule >=2	No	264	6	270
	Yes	21	90	111
	Total	285	96	381

Sensitivity = 90/96 = 93.8%

Specificity = 264/285 = 92.6%

PPV= 90/111 = 81.1%

NPV= 264/270 = 97.8%

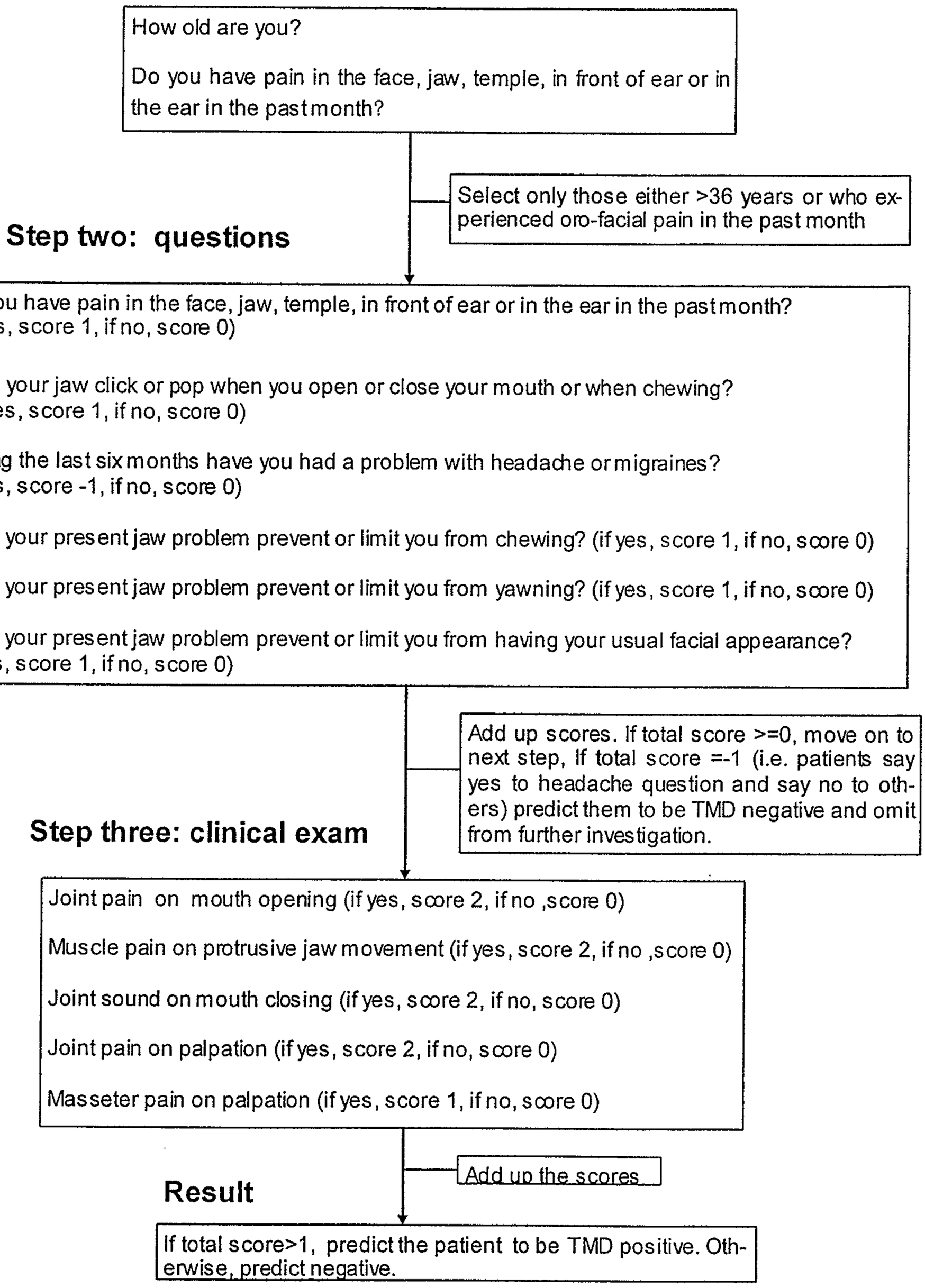


Fig .14 Screening procedure by using Model Two

Chapter 9: Discussion

Findings of present study

The main finding of the present study was that it was possible to reliably distinguish TMD patients from dental pain, headache and non-pain patients with a few simple questions and brief clinical exam. In this particular sample, nearly half of the non-TMD patients had been ruled out by using only two self-report questions before the clinical exam (model two) (Table 8.13). This is in agreement with previous studies (Unger et al., 1989, Gerstner et al., 1994, Nilsson et al., 2006)

Two predictive models have been developed in this study. Both of them achieved high levels of validity. However, the second model is recommended since it requires less clinic examination which suggests it is more efficient for screening purposes of TMD.

Interestingly, those under 36 years of age and without a history of face pain in the past month were automatically ruled out as having no TMD (Fig.14). In the TMDs sample, there were six subjects with a non-painful TMD diagnosis (disc displacements or osteoarthrosis). This low prevalence of non painful TMDs is likely one reason for step one questions ruling out subjects less than 36 years with non-painful TMDs. Although the sample may not be representative of non-painful TMD prevalence in the community (Yap et al., 2003 Rantala et al., 2003, Manfredini et al., 2006), the focus of the screen is to screen for painful TMDs since this is the group which demonstrates more disability and distress (McCreary et al., 1991, Glaros et al., 2005).

The relationship between age and TMD is still controversial. Pow and his colleagues reported the prevalence of TMD symptoms increased with age (Pow et al., 2001) whereas some other studies reported an opposite trend (Locker and Slade, 1988, Duckro et al., 1990). In the present study, age

over 36 years was identified as a predictor for TMD. Although this result differs from the findings of some previous studies which showed TMDs were more prevalent among people under 45 years (Locker and Slade, 1988, Duckro et al., 1990), the overlap of age group(36~45 year) between current and previous findings warrants further investigation in the future.

The question "Do you have pain in the face, jaw, temple, in front of ear or in the ear in the past month " was identified as a good predictor for TMD in this study and included in both step one primary selection and step two score system of the above model. This result was supported by a previous study which used a similar question for detecting TMD pain in an adolescent population. The reliability and validity were found to be very good (Kappa value: 0.83, test sensitivity and specificity: 98% and 90%, re-test sensitivity and specificity: 96% and 83%) (Nilsson et al., 2006).

The relationship between psychological factors and TMD has been well documented in many studies (Ferrando et al., 2004, Suvinen et al., 2005). Some previous studies indicated psychological distress was a good predictor for TMD related pain (Turner and Dworkin, 2004, Glaros et al., 2005). However, the role of such variables in screening for TMD in the present sample failed to predict those with TMDs from those with other orofacial and head pain. It suggests subjects with dental pain and headache may suffer similar emotional distress as TMD patients. In addition, since the present study recruited control pain-free subjects in the hospital environment, this may affect the emotional state of pain free subjects.

Joint sounds have been frequently reported in TMD patients as well as the general population (Duckro et al., 1990, Goulet et al., 1995, Otuyemi et al., 2000, Pow et al., 2001, de Felicio et al., 2006, Ozan et al., 2007). However, its diagnostic value for TMD is not clear (Stockstill and Mohl, 1991). A previous screening tool development study indicated that the presence of reciprocal clicking of the temporomandibular joint can distinguish headache patients from TMD patients (Schiffman et al., 1995). In the present study,

joint sounds on mouth closing were considered as a predictor for TMD. This supports the above studies that suggested that joint noise is a common finding in TMDs.

Validity of Model Two

Sensitivity and specificity are measures of a test's ability to correctly classify a person as having a disease or not having a disease. As TMDs are non-life-threatening, a screening tool for TMDs with high sensitivity but low specificity is not feasible. It is because many people who have a false positive diagnosis may consequently receive unnecessary management and treatment, and thus waste a lot of health care resources.

In the present study, the sensitivity and specificity of Model two are 93.8% and 92.6%, which means it correctly detected 93.8% of patients who truly had a TMD and correctly excluded 92.6% of the patients who truly did not have TMDs. At the same time, it may miss 6.2% of patients who truly have TMDs (false negative rate) and give TMD diagnosis to 7.4% of patients who actually do not have TMDs (false positive rate). Since studies on the development of a similar screening tool are rare to find, the comparison of results is difficult. Compared to a previous study which showed a brief questionnaire can reliably distinguish a non-TMD control group from a TMD group with 90.3%-97.7% sensitivity and 95.7%-100% specificity at cutoff values between 5 and 9 (Gerstner et al., 1994), the result of the present study is acceptable.

As population measures, sensitivity and specificity are conditional on knowledge of disease status. However, when tests are used clinically, the status of disease is unknown. Positive predictive value (PPV) and negative predictive value (NPV) are often used to evaluate the utility of screening tests in clinical practice. In the present study, the PPV and NPV of model two are 81.1% and 97.8%. It means 81.1% of those tested TMD positive actually have the disease, and 97.8% of those with a non-TMD test result are truly free of disease.

Statistical analysis

Most of other screening studies have a priori selected variables which were considered important in TMDs, based on clinical experience or previous epidemiological studies. In the present study, we decided to pick the complete variable set from the RDC/TMD assessment for analysis as possible predictors. We justified this because TMDs encompasses a broad range of painful disorders that can have quite diverse signs and symptoms.

Therefore, a large number of variables (151) were generated and broadly grouped into 9 variable categories. Principal Component Analysis (PCA) was chosen to reduce the dimensionality of the variable categories. Stepwise logistic regression was utilized to select the variables that differentiate TMDs from the other three control groups.

Limitations of the present study

There are some shortcomings that may affect the results of the current study.

First, the present study is based on a small sample size due to the limited time frame of data collection. Whether the model which we developed is applicable for the general population is unknown.

Second, compared to the other three groups, the mean age of the non-pain group is younger (Table.8.2). This is because subjects in this group were recruited from staff and students of Westmead Hospital and pain-free patients who attended the general dental clinic at the Centre for Oral Health. Finally, we received more responses from students during the recruitment phase.

Third, the clinical examination was performed by a single calibrated examiner for all subject groups, except the TMD group who were examined by calibrated clinicians in the Orofacial Pain Clinc. Although all examiners

have been calibrated, variability between the examiniers is inevitable.

Advantages of Model two

Although there are some potential shortcomings as mentioned above, model two does have some advantages as a screening tool for TMDs.

First, it can reliably distinguish TMDs from dental pain, headache and non pain subjects with a few simple questions and brief clinical exam in this sample, which meets the cost-effective criterion of a screening tool.

Second, its simple score rules which can be easily mastered and utilized in clinical practice, which fits the simple criterion of a screening tool.

Finally, since the clinical exam components of this model are generated from highly standardized clinical exam variables of the RDC/TMD, it allows comparison of findings among diverse clinical investigators

We believe this screening tool can be useful for two purposes. First, it would be useful for all patients attending the clinic as a basic assessment before carrying out any dental treatment which could potentially worsen a pre-existing TMD. Second, the TMD patients who are selected may benefit by earlier preventive intervention.

Future directions

Further investigations on reliability and validity of model two in a larger sample group would be advantageous. Furthermore, testing the model on different patient groups to determine its effectiveness as a screening tool is warranted.

Chapter 10: Conclusion

Both of two predictive models that were developed in this study can reliably distinguished TMD subjects from dental pain, headache and non-pain subjects. However, compared to the first model, the second model required less clinic examination suggesting it is more efficient for screening purposes of TMDs. This model has good clinical utility as the steps required need little training.

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Appendices

Appendix A: Ethical approval

Appendix B: Participant information

Appendix C: Consent form to participant

Appendix D: History questionnaire

Appendix E: Clinical exam questionnaire

Appendix F: Variables and Scoring

Appendix: A

SYDNEY WEST AREA HEALTH SERVICE (Westmead Campus)

HUMAN RESEARCH ETHICS COMMITTEE

Research Office, Clinical Sciences
Westmead Hospital Campus
Westmead NSW 2145

Telephone: 02 9845 8183
Facsimile: 02 9845 8352
Email: researchoffice@westgate.wh.usyd.edu.au

In reply please quote:

JH/pme HREC2007/2/4.19(2585)

18 July, 2007

A/Prof Christopher Peck
Professorial Unit
Westmead Centre for Oral Health

Dear Professor Peck

Research Proposal: The development of a screening assessment for Temporomandibular Disorders (TMD)

Thank you for your letter dated 10 July 2007 forwarding your revised Participant Information and Consent Forms Version 2 dated 10 July 2007 together with the signed letter of acceptance, all in accordance with the requests of the Human Research Ethics Committee letter dated 15 May 2007.

As the Committee's ethical concerns have now been satisfied, **final approval** of the study is confirmed and it may now commence. A copy of the approved Participant Information and Consent Forms Version No. 2 dated 10 July 2007 is attached for your records.

The Committee wishes you well with the study and looks forward to receiving progress reports in due course.

Yours sincerely,

Dr Jim Hazel
Secretary
Sydney West Area Health Service
Human Research Ethics Committee

Appendix: B

PARTICIPANT INFORMATION

Study Title: The development of a screening assessment for Temporomandibular Disorders

Short Title: Screening for Jaw Pain and Disorders

Chief Investigator: Dr Chris Peck **Department of** Oral Restorative Sciences

What is the purpose of the study?
The purpose of this study is to develop a brief, valid and reliable screening tool to screen for jaw pain or impaired function, as this occurs in approximately 10% of the population. This tool should be able to discriminate patients with these problems from those with headaches, dental pain and without pain.

Who will be invited to enter the study?
You have been invited to enter the study because you have been diagnosed with dental pain, headache or no pain in or around your mouth and face.

What will happen on the study?
You will be invited to attend the dental clinic at Westmead Centre for Oral Health for an assessment of your jaw. You will be asked to complete a questionnaire about face pain and your jaw function. Your jaw will be examined. The questionnaire and examination are routinely used in the Orofacial Pain Clinic at Westmead. The complete assessment will take 30 minutes.

Are there any risks?
There are no risks involved in the study. Your participation in the survey will not physically harm you. It is not anticipated that the survey will not involve any psychological distress to you.

Are there any benefits?
You will be given the results of your assessment, once it is complete. If needed, you will be provided with appointments in the Orofacial Pain Clinic for further assessment and treatment.

Confidentiality / Privacy
All aspects of this study, including results, will be strictly confidential and only the researchers will have access to your personal information. Any publication of the results from this study will use only de-identified information.

What will happen at the conclusion of the study?
The survey results will be published and the publications will be made available to you at your request.

Do you have a choice?
Your participation in this study is entirely voluntary. If you choose not to join the study, or you wish to withdraw from it at any time, your medical care will not be affected.

Complaints
If you have any concerns about the conduct of the study, or your rights as a study participant, you may contact
Westmead Hospital Patient Representative, Ms Jillian Gwynne Lewis, Telephone No 9845 7014 or email jillian_lewis@wsahs.nsw.gov.au

Contact details
If you have any problems while on the study, please contact Dr Christopher Peck,
Working Hours Telephone No – 9845 7821
For After Hours, contact the switchboard 9845 5555, and ask for Dr Peck to be paged on pager 22931

Participant's Name Signature Date

Version No 2 dated 19th July, 2007

Appendix: C

SYDNEY WEST

Area Health Service

CONSENT TO PARTICIPATE IN RESEARCH

Study Title: The development of a screening assessment for Temporomandibular Disorders

Name of Researcher:

1. I understand that the researcher will conduct this study in a manner conforming with ethical and scientific principles set out by the National Health and Medical Research Council of Australia and the Good Clinical Research Practice Guidelines of the Therapeutic Goods Administration.

2. I acknowledge that I have read, or have had read to me the Participant Information Sheet relating to this study. I acknowledge that I understand the Participant Information Sheet. I acknowledge that the general purposes, methods, demands and possible risks and inconveniences which may occur to me during the study and I, being over the age of 16 years acknowledge that I understand the general purposes, methods, demands and possible risks and inconveniences which may occur during the study.

3. I acknowledge that I have been given time to consider the information and to seek other advice.

4. I acknowledge that refusal to take part in this study will not affect the usual treatment of my condition.

5. I acknowledge that I am volunteering to take part in this study and I may withdraw at any time.

6. I acknowledge that this research has been approved by the Sydney West Area Health Service Human Research Ethics Committee.

7. I acknowledge that I have received a copy of this form and the Participant Information Sheet, which I have signed.

Before signing, please read 'IMPORTANT NOTE' following.

Name of participant _____ Date of Birth _____

Address of participant _____

Name of parent or person responsible (where applicable) _____

Address of parent or person responsible (where applicable) _____

Signature of participant _____ Date: _____

Signature of parent or person responsible (where applicable) _____Date: _____

Signature of researcher _____ Date: _____

Signature of witness _____ Date:_____

IMPORTANT NOTE

This consent should only be signed as follows:

1. *Where a participant is over the age of 16 years, then by the participant personally.*
2. *Where a participant is between the age of 14 and 16 years, it should be signed by the participant and by a parent or person responsible.*
3. *Where a participant is under the age of 14 years, then the parent or person responsible only should sign the consent form.*
4. *Where a participant has impaired capacity, intellectual disability or is unconscious, then specific approval for the*

Appendix: D

RDC/TMD HISTORY QUESTIONNAIRE

Date:_____
ID. _____

Please read each question and respond accordingly.

For each of the questions below circle only one response.

1. Would you say your health in general is:

Excellent Very good Good Fair Poor

2. Would you say your oral health in general is:

Excellent Very good Good Fair Poor

3. Have you had pain in the face, jaw, temple, in front of the ear or in the ear in the past month?

No
Yes

[If no pain in the past month SKIP to question 14]

If Yes,

4.a. How many years ago did your facial pain begin for the first time? _____years ago

[If one year ago or more SKIP to question 5]

4.b. How many months ago did your facial pain begin for the first time? _____months ago

5. Is your facial pain persistent, recurrent or was it only a one-time problem?

Persistent
Recurrent
One-Time

6. Have you ever gone to a physician, dentist, chiropractor or other health professional for facial ache or pain?

No
Yes, in the last six months
Yes, more than six months ago

7. How would you rate your facial pain on a 0 to 10 scale at the present time, that is right now, where 0 is "no pain" and 10 is "pain as bad as could be"?

NO PAIN PAIN AS BAD AS COULD BE

0 1 2 3 4 5 6 7 8 9 10

8. In the past six months, how intense was your worst pain rated on a 0 to 10 scale where 0 is "no pain" and 10 is "pain as bad as could be"?

NO PAIN PAIN AS BAD AS COULD BE

0 1 2 3 4 5 6 7 8 9 10

9. In the past six months, on the average, how intense was your pain rated on a 0 to 10 scale where 0 is "no pain" and 10 is "pain as bad as could be"? [That is, your usual pain at times you were experiencing pain].

NO PAIN 0 1 2 3 4 5 6 7 8 9 PAIN AS BAD AS COULD BE 10

10. About how many days in the last six months have you been kept from your usual activities (work, school or housework) because of facial pain? _____DAYS

11. In the past six months, how much has facial pain interfered with your daily activities rated on a 0 to 10 scale where 0 is "no interference" and 10 is "unable to carry on any activities"?

NO INTERFERENCE 0 1 2 3 4 5 6 7 8 9 UNABLE TO CARRY ON ANY ACTIVITIES 10

12. In the past six months, how much has facial pain changed your ability to take part in recreational, social and family activities where 0 is "no change" and 10 is "extreme change"?

NO CHANGE 0 1 2 3 4 5 6 7 8 9 EXTREME CHANGE 10

13. In the past six months, how much has facial pain changed your ability to work including housework) where 0 is "no change" and 10 is "extreme change"?

NO CHANGE 0 1 2 3 4 5 6 7 8 9 EXTREME CHANGE 10

14.a. Have you ever had your jaw lock or catch so that it won't open all the way?

No
Yes

[If no problem opening all the way SKIP to question 15]

If Yes,

14.b. Was this limitation in jaw opening severe enough to interfere with your ability to eat?

No
Yes

15. a. Does your jaw click or pop when you open or close your mouth or when chewing?

No
Yes

b. Does your jaw make a grating or grinding noise when it opens and closes or when chewing?

No
Yes

c. Have you been told, or do you notice that you grind your teeth or clench your jaw while sleeping at night?

No
Yes

d. During the day, do you grind your teeth or clench your jaw? No Yes

e. Does your jaw ache or feel stiff when you wake up in the morning? No Yes

f. Do you have noises or ringing in your ears? No Yes

g. Does your bite feel uncomfortable or unusual? No Yes

16.a. Do you have rheumatoid arthritis, lupus, or other systemic arthritic disease? No Yes

16.b. Do you know of anyone in your family who has had any of these diseases? No Yes

16.c. Have you had or do you have any swollen or painful joints) other than the joints close to your ears (TMJ)? No Yes

[If no swollen or painful joints, SKIP to question 17.a]

If Yes,

16.d. Is this a persistent pain which you have had for at least one year? No Yes

17.a. Have you had a recent injury to your face or jaw? No Yes

[If no recent injuries SKIP to question 18]

If Yes,

17.b. Did you have jaw pain before the injury? No Yes

18. During the last six months have you had a problem with headaches or migraines? No Yes

19. What activities does your present jaw problem prevent or limit you from doing?

a. Chewing	No Yes	g. Sexual activity	No Yes
b. Drinking	No Yes	h. Cleaning teeth or face	No Yes
c. Exercising	No Yes	i. Yawning	No Yes
d. Eating hard foods	No Yes	j. Swallowing	No Yes
e. Eating soft foods	No Yes	k. Talking	No Yes
f. Smiling/laughing	No Yes	l. Having your usual facial appearance	No Yes

20. In the last month, how much have you been distressed by:

	Not At All	A Little Bit	Moderatelv	Quite A Bit	Ex-tremelv
a. Headaches	0	1	2	3	4
b. Loss of sexual interest or pleasure	0	1	2	3	4
c. Faintness or dizziness	0	1	2	3	4
d. Pains in the heart or chest	0	1	2	3	4
e. Feeling low in energy or slowed down	0	1	2	3	4
f. Thoughts of death or dying	0	1	2	3	4
g. Poor appetite	0	1	2	3	4
h. Crying easily	0	1	2	3	4
i. Blaming yourself for things	0	1	2	3	4
j. Pains in the lower back	0	1	2	3	4
k. Feeling lonely	0	1	2	3	4
l. Feeling blue	0	1	2	3	4
m. Worrying too much about things	0	1	2	3	4
n. Feeling no interest in things	0	1	2	3	4
o. Nausea or upset stomach	0	1	2	3	4
p. Soreness of your muscles	0	1	2	3	4
q. Trouble falling asleep	0	1	2	3	4
r. Trouble getting your breath	0	1	2	3	4
s. Hot or cold spells	0	1	2	3	4
t. Numbness or tingling in parts of your body	0	1	2	3	4
u. A lump in your throat	0	1	2	3	4
v. Feeling hopeless about the future	0	1	2	3	4
w. Feeling weak in parts of your body	0	1	2	3	4
x. Heavy feelings in your arms or legs	0	1	2	3	4
y. Thoughts of ending your life	0	1	2	3	4
z. Overeating	0	1	2	3	4
aa. Awakening in the early morning	0	1	2	3	4
bb. Sleep that is restless or disturbed	0	1	2	3	4
cc. Feeling everything is an effort	0	1	2	3	4
dd. Feelings of worthlessness	0	1	2	3	4
ee. Feeling of being caught or trapped	0	1	2	3	4
ff. Feelings of guilt	0	1	2	3	4

21. How good a job do you feel you are doing in taking care of your health overall?

Excellent
Very good
Good
Fair
Poor

22. How good a job do you feel you are doing in taking care of your oral health?

Excellent
Very good
Good
Fair
Poor.

23. When were you born? Month_____Day_____Year_____

24. Are you male or female? Male Female

25. In what country were you born? _____

26a. Does this country best represent your race, national origin or ancestry?

Yes
No

If No,
26b. What is your country of national origin or ancestry?

_____

27. What is the highest grade or year of regular school that you have completed?

Never attended or Kindergarten
Primary School
High School
University

28.a. During the past 2 weeks, did you work at a job or business not counting work around the house (include unpaid work in the family farm/business)?

Yes
No
N/A

[If Yes SKIP to question 29]

If No,
28b. Even though you did not work during the past 2 weeks, did you have a job or business?

Yes
No
N/A

[If Yes SKIP to question 29]

If No,

28c. Were you looking for work or on layoff from a job during those 2 weeks?

Yes, looking for work
Yes, layoff
Yes, both on layoff and looking for work
No
N/A

29. Are you married, widowed, divorced, separated or never been married?

Married / spouse or defacto in household
Married / spouse or defacto- not in household
Widowed
Divorced
Separated
Never Married

30. Which of the following best represents your total **combined household income** during the past 12 months?

$0-$14,999	$25,000-$34,999	$50,000 or more
$15,000-$24,999	$35,000-$49,999	

Appendix: E

CLINICAL HEALTH QUESTIONNAIRE No. 3

Date _____

ID _____

CLINICAL RESEARCH DIAGNOSTIC CRITERIA (RDC) EXAMINATION

1. Do you have pain on the right side of your face, the left side or both.

None	0
Right	1
Left	2
Both	3

2. Could you point to the areas where you feel pain?

Right		Left	
None	0	None	0
Jaw Joint	1	Jaw Joint	1
Muscles	2	Muscles	2
Both	3	Both	3

(Examiner feels area subject points to, if it is unclear whether it is joint or muscle.)

3. Opening Pattern

Straight	0
Right Lateral Deviation (uncorrected)	1
Right Corrected ("S") Deviation	2
Left Lateral Deviation (uncorrected)	3
Left Corrected ("S") Deviation	4
Other	5

Type(specify) _____

4. Vertical Range of Motion

Maxillary incisor used	(8)	1.1
	(9)	2.1

(a) Unassisted opening without pain _____ mm

	MUSCLE PAIN				JOINT PAIN			
	None	Right	Left	Both	None	Right	Left	Both
(b) Maximum unassisted opening _____ mm	0	1	2	3	0	1	2	3
(c) Maximum assisted opening _____ mm	0	1	2	3	0	1	2	3
(d) Vertical incisal overlap _____ mm								

5. Joint Sounds (palpation)

		RIGHT	LEFT
(a) Opening	None	0	0
	Click	1	1
	Coarse Crepitus	2	2
	Fine Crepitus	3	3
	Measurement of Opening	_____mm	_____mm
(b) Closing	None	0	0
	Click	1	1
	Coarse Crepitus	2	2
	Fine Crepitus	3	3
	Measurement of Closing	_____ mm	_____ mm

(c) Reciprocal click eliminated on protrusive opening

No	No
Yes	Yes
NA	NA

6 Excursions

		MUSCLE PAIN				MUSCLE PAIN			
		None	Right	Left	Both	None	Right	Left	Both
(a) Right Lateral Excursion	_____mm	0	1	2	3	0	1	2	3
(b) Left Lateral Excursion	_____mm	0	1	2	3	0	1	2	3
(c) Protrusion	_____mm	0	1	2	3	0	1	2	3

(d) Midline Deviation _____mm RIGHT LEFT NA

7. Joint Sounds on Excursions

Right Sounds:	None	Click	Coarse Crepitus	Fine Crepitus
Excursion Right	0	1	2	3
Excursion Left	0	1	2	3
Protrusion	0	1	2	3

Left Sounds:	None	Click	Coarse Crepitus	Fine Crepitus
Excursion Right	0	1	2	3
Excursion Left	0	1	2	3
Protrusion	0	1	2	3

DIRECTIONS FOR ITEMS 8-10

The examiner will be palpating (touching) different areas of your face, head and neck. We would like you to indicate if you do not feel pain of just feel pressure (0), or pain (1-3). Please rate how much pain you feel for each of the palpations according to the scale below. Circle the number that corresponds to the amount of pain you feel. We would like you to make a separate rating for both the right and left palpations.

0 = No Pain/ Pressure Only

1 = Mild Pain

2 = Moderate Pain

3 = Severe Pain

PLEASE GIVE PATIENT RATING CARD

8. Extraoral muscle pain with palpation:

	RIGHT	LEFT
a. Temporalis (posterior) "Back of temple"	0 1 2 3	0 1 2 3
b. Temporalis (middle) "Middle of temple"	0 1 2 3	0 1 2 3
c. Temporalis (anterior) "Front of temple"	0 1 2 3	0 1 2 3
d. Masseter (superior) "Cheek/under cheekbone"	0 1 2 3	0 1 2 3
e. Masseter (middle) "Cheek/side of face"	0 1 2 3	0 1 2 3
f. Masseter (inferior) "Cheek/jawline	0 1 2 3	0 1 2 3
g. Posterior mandibular region (Stylohyoid/posterior digastric region) "Jaw/throat region"	0 1 2 3	0 1 2 3
h. Submandibular region (Medial pterygoid/Suprahyoid/anterior digastric region) "Under chin"	0 1 2 3	0 1 2 3
i. Stemocleidomastoid (origin) "Under ear"	0 1 2 3	0 1 2 3,
j. Sternocleidomastoid (body) F "Side of neck"	0 1 2 3	0 1 2 3
k. Trapezius (origin) "Back of head"	0 1 2 3	0 1 2 3
1. Trapezius (body and insertion) "Neck and shoulders	0 1 2 3	0 1 2 3

9. Joint pain with palpation:

a. Lateral pole "Outside"	0 1 2 3	0 1 2 3
b. Posterior attachment "Inside ear"	0 1 2 3	0 1 2 3

10. Intraoral muscle pain with palpation:

a. Lateral pterygoid area "Behind upper molars"	0 1 2 3	0 1 2 3
b. Tendon of temporalis "Tendon"	0 1 2 3	0 1 2 3
c. Tongue "Tongue"	0 1 2 3	0 1 2 3

Appendix: F

		Variables and scoring	
		History questionnaire	
		Variable	**Score**
V1	Q1	Self perception of general health	5-1 (excellent /very good/ good/ fair/ poor)
V2	Q2	Self perception of oral health	5-1 (excellent /very good/ good/ fair/ poor)
V3	Q3	Orofacial pain experience in the past month	0/1 (no/yes)
V4	Q4	The first time facial pain happened	Months
V5	Q5	Frequency of pain	3-1 (persistent/recurrent/one-time)
V6	Q6	Treatment sought	0-2 (no/yes, in the last six months/ yes, more than six months)
V7	Q7	Intensity of present pain	0~10
V8	Q8	Intense of worst pain in the past six months	0~10
V9	Q9	Intense of usual pain in the past six months	0~10
V10	Q10	Days of activity limitation due to the pain in the past six months	Days
V11	Q11	Severity of pain interference with daily activity in the past six months	0~10
V12	Q12	Severity of recreational, social and family activity related disability in the past six months	0~10
V13	Q13	Severity of work related disability in the past six months	0~10
V14	Q14a	Jaw lock	0/1 (no/yes)
V15	Q14b	Ability interference to eat because of jaw lock	0/1 (no/yes)
V16	Q15a	Jaw click	0/1 (no/yes)
V17	Q15b	Jaw grating or grinding noise	0/1 (no/yes)
V18	Q15c	Grating or grinding teeth during sleep	0/1 (no/yes)
V19	Q15d	Grinding teeth or clench jaw during the day	0/1 (no/yes)

V20	Q15e	Jaw ache or feel stiff when wake up	0/1 (no/yes)
V21	Q15f	Noise or ring in the ear	0/1 (no/yes)
V22	Q15g	Bite uncomfortable	0/1 (no/yes)
V23	Q16a	Systemic arthritic disease	0/1 (no/yes)
V24	Q16b	Family member who have systemic arthritic disease	0/1 (no/yes)
V25	Q16c	Swollen and painful joint	0/1 (no/yes)
V26	Q16d	persistent pain on joint at least one year	0/1 (no/yes)
V27	Q17a	Recent injury on face and jaw	0/1 (no/yes)
V28	Q17b	Jaw pain before injury	0/1 (no/yes)
V29	Q18	Headache and migraines	0/1 (no/yes)
V30	Q19a	Chewing limit because of jaw problem	0/1 (no/yes)
V31	Q19b	Drinking limit because of jaw problem	0/1 (no/yes)
V32	Q19c	Exercising limit because of jaw problem	0/1 (no/yes)
V33	Q19d	Eating hard food limit because of jaw problem	0/1 (no/yes)
V34	Q19e	Eating soft food limit because of jaw problem	0/1 (no/yes)
V35	Q19f	Smiling/laughing limit because of jaw problem	0/1 (no/yes)
V36	Q19g	Sexual activity limit because of jaw problem	0/1 (no/yes)
V37	Q19h	Cleaning teeth or face limit because of jaw problem	0/1 (no/yes)
V38	Q19i	Yawning limit because of jaw problem	0/1 (no/yes)
V39	Q19j	Swallowing limit because of jaw problem	0/1 (no/yes)
V40	Q19k	Talking limit because of jaw problem	0/1 (no/yes)
V41	Q19l	Having usual facial appearance	0/1 (no/yes)
V42	Q20a	In the last month ,distress by headaches	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V43	Q20b	In the last month ,distress by losing sexual interest	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)

V44	Q20c	In the last month ,distress by faintness or dizziness	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V45	Q20d	In the last month ,distress by pains in the heart or chest	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V46	Q20e	In the last month ,distress by feeling low in energy or slowed down	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V47	Q20f	In the last month ,distress by thoughts of death or dying	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V48	Q20g	In the last month ,distress by poor appetite	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V49	Q20h	In the last month ,distress by crying easily	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V50	Q20i	In the last month ,distress by blaming yourself for things	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V51	Q20j	In the last month ,distress by pains in the lower back	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V52	Q20k	In the last month ,distress by feeling lonely	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V53	Q20l	In the last month ,distress by feeling blue	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V54	Q20m	In the last month ,distress by worrying too much about things	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V55	Q20n	In the last month ,distress by feeling no interest in things	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V56	Q20o	In the last month ,distress by nausea or upset stomach	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V57	Q20p	In the last month ,distress by soreness of your muscles	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V58	Q20q	In the last month ,distress by trouble falling asleep	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V59	Q20r	In the last month ,distress by trouble getting breath	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V60	Q20s	In the last month ,distress by hot or cold spells	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V61	Q20t	In the last month ,distress by numbness or tingling in parts of body	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V62	Q20u	In the last month ,distress by a lump in throat	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V63	Q20v	In the last month ,distress by feeling hopeless about the future	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V64	Q20w	In the last month ,distress by feeling weak in parts of body	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V65	Q20x	In the last month ,distress by heavy feelings in arms or legs	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V66	Q20y	In the last month ,distress by thoughts of ending life	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V67	Q20z	In the last month ,distress by overeating	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)

V68	Q20aa	In the last month ,distress by awakening in the early morning	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V69	Q20bb	In the last month ,distress by restless or disturbed sleep	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V70	Q20cc	In the last month ,distress by feeling everything is an effort	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V71	Q20dd	In the last month ,distress by feelings of worthlessness	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V72	Q20ee	In the last month ,distress by feeling of being caught or trapped	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V73	Q20ff	In the last month ,distress by feelings of guilt	0-4 (not at all/ a little bit/ moderately/quiet a bit/ extremely)
V74	Q21	Self care of general health	5-1 (excellent /very good/ good/ fair poor)
V75	Q22	Self care of oral health	5-1 (excellent /very good/ good/ fair poor)
V76	Q23	Age	years
V77	Q24	Gender	0/1 (male/female)
V78	Q25	Country of birth	0/1 (Australian born/ oversea)
V79	Q26	Does this country best represent your race, national origin or ancestry	0/1 (no/yes)
V80	Q26b	County of national origin or ancestry	0/1 (Australia / oversea)
V81	Q27	Education level	1-4 (never/ primary school/ high school/ university)
V82	Q28a	Work in the past 2 weeks	0/1 (no/yes)
V83	Q28b	Have a job or business	0/1 (no/yes)
V84	Q28c	Looking for a job or lay off	0-3(no/yes, looking for work/ yes, lay off/ yes, both on layoff and looking for work)
V85	Q29	Marital status	1-6(married, spouse in household/ married, spouse not in household/widowed/ divorced/ separated/never married
V86	Q30	Income	1-5 (0-14999/15000-24999/25000-34999/35000-49999/50000 or more)

		Clinic examination	
		Variable	**Score**
V87	Q1	Painful side of face	0-3(no/right/left/both)
V88	Q2	Painful area on right side	0-3(no/jaw joint/muscle/both)
V89	Q2	Painful area on left side	0-3(no/jaw joint/muscle/both)
V90	Q3	Opening pattern	0-5(straight/right uncorrect/right correct/left uncorrect/left correct/other)
V91	Q4a	Unassisted opening without pain	mm
V92	Q4b	Maximum unassisted opening	mm
V93	Q4b	Pain on muscle when doing maximum unassisted opening	0-3 (no/right side/left side/ both)
V94	Q4b	Pain on jaw joint when doing maximum unassisted opening	0-3(no/right side/left side/ both)
V95	Q4c	Maximum assisted opening	mm
V96	Q4c	Pain on muscle when doing maximum assisted opening	0-3 (no/right side/left side/ both)
V97	Q4c	Pain on jaw joint when doing maximum assisted opening	0-3 (no/right side/left side/ both)
V98	Q4d	Vertical incisal overlap	mm
V99	Q5a	Right joint sound when opening	0-3 (no/click/coarse crepitus/fine crepitus)
V100	Q5a	Measurement of right side opening sound	mm
V101	Q5a	Left joint sound when opening	0-3 (no/click/coarse crepitus/fine crepitus)
V102	Q5a	Measurement of left side opening sound	mm
V103	Q5b	Right joint sound when closing	0-3 (no/click/coarse crepitus/fine crepitus)
V104	Q5b	Measurement of right side closing sound	mm
V105	Q5b	Left joint sound when closing	0-3 (no/click/coarse crepitus/fine crepitus)

V106	Q5b	Measurement of left side closing sound	mm
V107	Q5c	Reciprocal click eliminated on protrusive opening(right)	0/1 (no/yes)
V108	Q5c	Reciprocal click eliminated on protrusive opening(left)	0/1 (no/yes)
V109	Q6a	Right lateral excursion	mm
V110	Q6a	Pain on muscle when doing right lateral excursion	0-3 (no/right side/left side/ both)
V111	Q6a	Pain on jaw joint when doing right lateral excursion	0-3 (no/right side/left side/ both)
V112	Q6b	Left lateral excursion	mm
V113	Q6b	Pain on muscles when doing left lateral excursion	0-3 (no/right side/left side/ both)
V114	Q6b	Pain on jaw joint when doing left lateral excursion	0-3 (no/right side/left side/ both)
V115	Q6c	Protrusion	mm
V116	Q6c	Pain on muscles when doing protrusion	0-3 (no/right side/left side/ both)
V117	Q6c	Pain on jaw joint when doing protrusion	0-3 (no/right side/left side/ both)
V118	Q6d	Midline deviation (side)	1-2 (right/left)
V119	Q6d	Midline deviation (value)	mm
V120	Q7	Right joint sound on right excursion	0-3 (no/click/coarse crepitus/fine crepitus)
V121	Q7	Right joint sound on left excursion	0-3 (no/click/coarse crepitus/fine crepitus)
V122	Q7	Right joint sound on protrusion	0-3 (no/click/coarse crepitus/fine crepitus)
V123	Q7	Left joint sound on right excursion	0-3 (no/click/coarse crepitus/fine crepitus)
V124	Q7	Left joint sound on left excursion	0-3 (no/click/coarse crepitus/fine crepitus)
V125	Q7	Left joint sound on protrusion	0-3 (no/click/coarse crepitus/fine crepitus)
V126	Q8a	Right Temporalis pain (posterior)	0-3 (no pain/ mild/moderate/severe)
V127	Q8a	Left Temporalis pain(posterior)	0-3 (no pain/ mild/moderate/severe)
V128	Q8b	Right Temporalis pain (middle)	0-3 (no pain/ mild/moderate/severe)
V129	Q8b	Left Temporalis pain (middle)	0-3 (no pain/ mild/moderate/severe)

V130	Q8c	Right Temporalis pain (anterior)	0-3 (no pain/ mild/moderate/severe)
V131	Q8c	Left Temporalis pain (anterior)	0-3 (no pain/ mild/moderate/severe)
V132	Q8d	Right masseter pain (superior)	0-3 (no pain/ mild/moderate/severe)
V133	Q8d	Left masseter pain (superior)	0-3 (no pain/ mild/moderate/severe)
V134	Q8e	Right masseter pain(middle)	0-3 (no pain/ mild/moderate/severe)
V135	Q8e	Left masseter pain(middle)	0-3 (no pain/ mild/moderate/severe)
V136	Q8f	Right masseter pain(interior)	0-3 (no pain/ mild/moderate/severe)
V137	Q8f	Left masseter pain (interior)	0-3 (no pain/ mild/moderate/severe)
V138	Q8g	Right posterior mandibular region pain	0-3 (no pain/ mild/moderate/severe)
V139	Q8g	Left posterior mandibular region pain	0-3 (no pain/ mild/moderate/severe)
V140	Q8h	Right submandibular region pain	0-3 (no pain/ mild/moderate/severe)
V141	Q8h	Left submandibular region pain	0-3 (no pain/ mild/moderate/severe)
V142	Q9a	Right lateral pole pain	0-3 (no pain/ mild/moderate/severe)
V143	Q9a	Left lateral pole pain	0-3 (no pain/ mild/moderate/severe)
V144	Q9b	Right posterior attachment pain	0-3 (no pain/ mild/moderate/severe)
V145	Q9b	Left posterior attachment pain	0-3 (no pain/ mild/moderate/severe)
V146	Q10a	Right lateral pterygoid area	0-3 (no pain/ mild/moderate/severe)
V147	Q10a	Left lateral pterygoid area	0-3 (no pain/ mild/moderate/severe)
V148	Q10b	Right tendon of temporalis	0-3 (no pain/ mild/moderate/severe)
V149	Q10b	Left tendon of temporalis	0-3 (no pain/ mild/moderate/severe)
V150	Q10c	Right side of tongue	0-3 (no pain/ mild/moderate/severe)
V151	Q10c	Left side of tongue	0-3 (no pain/ mild/moderate/severe)