SUMMARY

The majority of disorders of the TMJ and associated masticatory muscles are characterized by the following triad of symptoms:
- pain in and around the TMJ and in the masticatory muscles
- joint sounds (clicking, crepitation)
- restriction of mandibular movement

Two major problem areas preclude comparison between the abundance of investigations regarding TMDs. The first involves the large variation of terms still in use to designate problems of pain and dysfunction related to the TMJ, and the lack of agreement on the symptoms and signs needed to establish a correct diagnosis (diagnostic assessment). The second problem area relates to measures that are most suitable to be used to evaluate treatment outcome (outcome assessment). Obviously, there is a need for a framework for diagnostic and therapeutic outcome assessment of temporomandibular disorders. In this thesis, osteoarthrosis was chosen as the 'target disorder' for the development of such a framework. Osteoarthrosis is a degenerative disorder of synovial joints that commonly affects the TMJ. The articular cartilage probably is initially affected, and during its course the disorder elicits responses in adjacent tissues that may give rise to clinical symptoms and signs. Radiographic changes are detected after a certain period of clicking, pain and restriction of movement.

The aim of diagnostic assessment is to identify a disorder by its diagnostic term, based on its defining criteria. Although the term temporomandibular disorders is now generally accepted to represent the collective mandibular musculoskeletal disorders, there is still no generally accepted classification of these disorders. The relative contribution of clinical symptoms and signs to establish a particular diagnosis must be known before specific diagnostic criteria can be defined. This has not yet been accomplished for most temporomandibular disorders. In this thesis, these problems are addressed in relation to TMJ osteoarthrosis and internal derangement.

Therapeutic outcome assessment requires a priori definition of outcome criteria, addressing both the physical damage and its functional and psychosocial consequences. Despite its importance, the latter aspect is frequently neglected when assessing the outcome of TMD treatment. Improvement of pain and mandibular function are the major objectives of treatment of TMDs from the patient’s point of view. Therefore, subjective assessment instruments are potentially powerful in outcome research. Nevertheless, clinimetrically tested instruments of this kind are not available in this field. In this thesis, several areas are explored in the search for objective or subjective assessment instruments.

The literature review presented in chapter 2 suggests that in many cases of craniofacial pain and dysfunction, TMJ osteoarthrosis is the basic disorder.

Basic characteristics of osteoarthrosis in general, and of TMJ osteoarthrosis in particular are reviewed in section 2.1. In the TMJ, like in all other synovial joints, shifting equilibria exist between form and function. The integrity of the joint is maintained as long as the joint's adaptive capacity is not exceeded. However, degenerative alterations, i.e. osteoarthrosis, may develop if the adaptive capacity is exceeded. Osteoarthrotic changes in the TMJ and in other synovial joints show a similar course, on a clinical, microscopic, and ultrastructural level. Initially, cartilage changes and maybe also changes in the synovial
membrane set up a vicious cycle of cartilage breakdown accompanied by attempts at repair. When the degradation exceeds the response of repair, the osteoarthrotic disorder progresses into clinically detectable stages.

In early osteoarthrotic changes, the articular cartilage is affected first. Degenerative changes of cartilage alter its physical properties and, as a result, its ability to withstand compressive and shearing stresses is also affected. Increased friction between the articular surfaces may impair joint movement and elicit compensatory or pathologic responses in the cartilage and adjacent tissues, such as capsule and ligaments, synovial membrane, subchondral bone, and associated musculature. Frequently, smooth gliding of the articular disc is impaired which may give rise to internal derangements. Progressive cartilage breakdown and subsequent subchondral bone changes may lead to radiographically detectable alterations. After a certain period of remodelling, predominantly of the bony parts of the joint, the osteoarthrotic process 'burns out' and clinical symptoms tend to subside. In section 2.2, these structural changes are described and related to common symptoms and signs of craniomandibular dysfunction, such as clicking, locking and instability, pain and tenderness, restricted ranges of mandibular motion, crepitation, deformity, muscle wasting, and changes of occlusion.

In chapter 3, temporomandibular disorders in general, and TMJ osteoarthrosis and internal derangements in particular are classified as a basis for diagnostic assessment.

Classifying temporomandibular disorders is essential for descriptive and diagnostic reasons. The etiology of many TMJ disorders is unknown and lack of scientific agreement about etiologic concepts contributes to controversies about the real nature of TMJ disorders. Although many classifications have been suggested, mostly based on etiologic assumptions, a generally accepted classification is not yet available. The TMJ is a true synovial joint comparable to all other joints in the body. This implies that the classification of disorders of the masticatory system should be consistent with the approach to musculoskeletal disorders in other parts of the body. Primarily based on this criterium and on the current state of knowledge, a classification of TMDs is proposed in section 3.1. The place of TMJ osteoarthrosis within the field of TMDs is discussed.

In the clinical setting, diagnosis primarily depends on the history and present status of the patient, and on the examiner's expertise in physical examination and interpretation of conventional radiographs. In section 3.2, the diagnostic significance of clinical and radiographic variables is evaluated, using magnetic resonance (MR) imaging as 'golden standard' for articular disc position. A total of 90 TMJs was available for the study. Eight joints (8.9%) showed a 'normal' disc position on the MR images in both the closed and open mouth situation (group I), 34 joints (37.8%) showed a 'normal' disc position only on the open mouth MR image (representing reducing disc displacement, group II), and a non-reducing disc (anterior position in both the closed and open mouth situation, group III) was present in 48 joints (53.3%). Out of a large pool of variables, nine anamnestic, fifteen clinical, and three radiographic variables obeyed predefined univariate selection criteria. Relatively high sensitivities were found for clicking-related variables in MR-group II, and for variables related to movement restriction in MR-group III. None of the symptoms or signs appeared to be pathognomonic for either one of the diagnostic groups. Discriminant analyses showed that symptom-combinations which included clinical variables related to
Summary

Joint mechanics appeared to provide the most useful diagnostic information. From this study, it can be concluded that reducing and permanent disc displacement can be distinguished in many cases using clinical and radiographic variables. However, there is considerable variability within these groups. To establish a specific clinical diagnosis, a more detailed classification of osteoarthrosis and internal derangement is desirable. A proposal for classification and operational definition of specific entities of temporomandibular joint osteoarthrosis and internal derangement is presented in section 3.3. The diagnostic criteria are based on the relative diagnostic significance of symptoms and signs (section 3.2), principles of synovial joint pathology in general (chapter 2), and on therapeutic considerations. The primary goal was to enable identification of characteristic stages of osteoarthrosis and internal derangement using diagnostic tools readily available in practice.

In chapter 4, instruments and methods that are potentially useful to assess pain and function impairment associated with TMJ osteoarthrosis are explored and evaluated.

Pain is a common reason for many patients with temporomandibular disorders to seek treatment. Any pain complaint seems to involve at least a sensory and a reactive component. Therefore, it is important to distinguish between diagnostic pain assessment and evaluation of the impact of pain. The aim of the study reported in section 4.1 was to evaluate characteristics of patients with temporomandibular joint (TMJ) related pain, and to propose a rationale for the assessment of this pain and its impact in the patients. Based on anamnestic information, the patients of our sample (n=88) could be classified according to the following grading of pain: grade 1 (acute/subacute nonrecurrent or recurrent pain) n=41 (46.6%), grade 2 (persistently recurring pain in relatively high frequency, or non-severe persistent pain) n=32 (36.4%), grade 3 (persistent and impairing pain) n=8 (9.1%), grade 4 (persistent and disabling pain) n=7 (7.9%), grade 5 (persistent and handicapping pain) n=0. Regarding TMJ pain provoked during the clinical examination there was a significant difference between diagnostic subgroups, subgroups with different subjective pain intensity levels, subgroups of patients classified according to their pain grade. No significant differences in clinical pain could be found between subgroups based on the duration of the pain symptoms since the onset. In addition, patient subgroups did not significantly differ in scores on the scales of the Multidimensional Pain Inventory (MPI) and of the General Health Questionnaire (GHQ), no matter according to what characteristic (diagnostic category, intensity, duration of pain, or grade) subgroups were classified. Based on the results of this study, the assessment of non-chronic TMJ pain may generally be limited to an accurate description of the pain complaint and thorough clinical assessment. Multidimensional assessment may be useful when the TMJ pain persists or is persistently recurring. Depending on the individual circumstances additional assessment procedures may prove to be useful.

The role of a variety of emotional, cognitive, and behavioral coping strategies in patients with temporomandibular joint (TMJ) pain is evaluated in the study reported in section 4.2. A group of 53 patients with TMJ osteoarthrosis and internal derangement completed the Coping with Specific Symptoms Questionnaire (CSSQ). To assess the relationship of coping strategies with pain suffering and psychological distress, pain was assessed using the West Haven-Yale Multidimensional Pain Inventory (MPI) and Visual Analogue Scales (VAS), and
psychological distress was assessed by the General Health Questionnaire (GHQ) and the Symptom Check List (SCL-90R). The patients of the study sample did not show a higher level of psychological distress than a normal (non-patient) population. Pain severity as assessed with the MPI was rather low and there was little interference of pain with daily life situations. While none of the coping strategies assessed by the CSSQ were frequently used, these strategies did explain a significant proportion of the variance in pain and psychological distress measures (27 to 68% of the variance). Stepwise regression analysis revealed that the coping strategies expression of emotions and wishful thinking were the main predictors. Patients scoring high on these coping strategies had significantly higher levels of pain and psychological distress.

Psychophysical studies of bite force perception have been proposed to provide data that might be readily applied clinically. The clinical relevance of measuring bite force reproduction ability is evaluated in section 4.3. This parameter was measured at reference force levels of 2, 10, and 50 N in a group of seven patients with articular and non-articular temporomandibular disorders and in a control group. The ability to reproduce the reference forces was measured at four equidistant occasions. All subjects poorly and imprecisely reproduced the reference force levels. A trend in the matches or in their imprecision could not be found. Bite force reproduction ability did not differ between the patient group and the control group. Therefore, we concluded that measurement of bite force reproduction ability does not provide a useful clinical assessment tool.

The aim of the study reported in section 4.4 was to investigate the potential clinical relevance of testing bite force endurance in patients with articular temporomandibular disorders. The endurance time of a 50 N bite force was measured in 51 patients with painful temporomandibular joint disorders. The results were compared to those of a control group of 20 subjects. During this test, the force exerted was sustained until this task could not be continued anymore because of intolerable pain or fatigue. The endurance test was repeated following therapy. Testing bite force endurance could be reliably carried out (paired t-test not significant, product-moment correlation coefficient 0.87). The mean endurance time in the patient group was significantly different from that of the control group. The 95% intervals of the mean endurance time for patients and controls did not show any overlap. No difference in endurance time between diagnostic subgroups could be detected, however. Following treatment, all patients showed a significant increase in endurance time, and reported a decrease in post-test pain. The mean difference between pre- and post-treatment endurance was 60 seconds. Subjects of the control group stopped the biting effort predominantly because of muscle fatigue. By contrast, TMJ pain was the main reason to cease the effort. The results of this study indicate that the discriminatory power of the test is sufficient to justify its utility as a complementary tool in assessing the functional capacity of the masticatory system, and alterations of this capacity after treatment.

In clinical practice, signs and symptoms needed for diagnosis, often combined in a 'dysfunction index', are frequently used as the only basis for mandibular function assessment. From the patient's point of view, however, characteristics of 'dysfunction' become really symptomatic when they interfere in some way with daily mandibular activities. Therefore, comprehensive assessment of function impairment associated with temporomandibular disorders should comprise diagnostic assessment of symptoms and signs, as well as functional tests.
and the

ly used,
ological

ered that

ruction

clinical

hedral

n pre-

power

function

between jaw function impairment and measures of pain, movement restriction, and psychological distress was also assessed. Joint pain reported in response to clinical examination procedures appeared to explain a striking proportion of the variance in function impairment. The lack of a relationship between perceived function impairment and measures of psychological distress provides support for the system-specific nature of mandibular functioning. The results indicate that the MFIQ appears to be a reliable and valuable complementary tool for assessing mandibular function impairment.

In chapter 5, the sensitivity for change of potentially useful outcome measures in response to treatment of TMJ osteoarthrosis is evaluated in a controlled clinical trial. In this trial, we compared arthroscopic surgery with non-surgical treatment for specific subgroups of TMJ osteoarthrosis and internal derangement, characterized by joint pain and restricted mobility. Twenty-one patients with TMJ pain and restriction of movement were randomly assigned to receive arthroscopic surgery followed by post-operative physical therapy (ASURG, n=9), or non-surgical treatment (NONSURG, n=12). Of the latter group, seven patients received physical therapy alone, and five patients did not receive treatment in addition to the exercises that were instructed to all patients. The measures used for treatment outcome evaluation were grouped in four categories (i.e. TMJ pain, movement restriction, mandibular function impairment, and impact on daily life and well being). Prior to treatment, outcome criteria were defined for each of their component variables. Assessments were carried out at baseline, immediately following treatment, and six months following treatment. The results of the study indicate that most of the assessment methods appear to be sufficiently sensitive for changes in pain, mobility, and functional ability. Patients treated with arthroscopic surgery reported a more rapid reduction of pain, and a higher subjective overall improvement. More formal assessment revealed comparable results in the two groups, however. Owing to our strict criteria for inclusion, we obtained a relatively small though homogenous sample. Because of the limited sample size, our results must be interpreted with care. Nevertheless, our findings support the importance of and the need for controlled outcome studies. Since they suggest a risk of over-treatment with arthroscopic surgery, our results need to be confirmed in a larger study.

Summary

as well as its consequences for the patient's ability to function properly in daily life. In section 4.5, both aspects are addressed.

Regarding the former aspect, restriction of the range of opening is most frequently considered an indicator of 'dysfunction'. However, this variable does not distinguish between articular and muscular causes of the restriction. Our results show that a combination of indirect and direct assessments, including the range of opening movement after passive stretch, the range of horizontal excursion towards the opposite side, and the condylar translatory capacity by palpation, is sufficiently reliable to assess TMJ mobility, and to differentiate between the other potential causes of its restriction.

The second element, i.e., assessment of mandibular function impairment in the patient's value system, is a neglected area. The main objective of the study reported in section 4.5, therefore, was to design a mandibular function impairment questionnaire (MFIQ). The total score of the questionnaire appears to represent an overall function impairment. The questionnaire consists of two scales, which are represented by separate analytic factors. These scales reliably assess the degree of masticatory and non-masticatory impairment. The relationship between jaw function impairment and measures of pain, movement restriction, and psychological distress was also assessed. Joint pain reported in response to clinical examination procedures appeared to explain a striking proportion of the variance in function impairment. The lack of a relationship between perceived function impairment and measures of psychological distress provides support for the system-specific nature of mandibular functioning. The results indicate that the MFIQ appears to be a reliable and valuable complementary tool for assessing mandibular function impairment.
Summary

In this investigation, a two-track dynamic framework for assessment of temporomandibular disorders is proposed. The first track concerns detailed operational definition of the different temporomandibular disorders by means of specific criteria. The second track concerns assessment of symptoms and signs and their impact that can be used to characterize individual patients with a particular diagnosis and for therapeutic outcome assessment.

Regarding diagnostic assessment, symptom combinations including clinical variables related to joint mechanics provide the most useful information. Based on clinical and radiographic variables, subgroups of osteoarthritis and internal derangement can be distinguished in many cases by applying specific diagnostic criteria.

Clinical assessment methods evaluated in this study were primarily focused on pain and movement restriction. An important finding was that pain associated with TMJ osteoarthritis and internal derangement consistently responds in proportion to mechanical stimuli. Thus, with the method we used for clinical pain assessment an important characteristic of musculoskeletal pain could be operationalized. Patients with osteoarthritis and internal derangement did not have a higher level of psychological distress than a normal (non-patient) population. Moreover, specific coping strategies were not frequently used by these patients.

Our efforts to develop simple instrumental methods that could contribute to assessment of jaw function impairment were only partly successful. This illustrates the problems that arise when it is attempted to objectively measure variables that intrinsically have a considerable subjective element. More extensive research is, therefore, necessary to develop and evaluate proper subjective assessment instruments. The good clinimetric properties of the MFIQ are encouraging in this respect.

To allow comparison of results of treatment outcome studies, criteria for patient selection and treatment outcome must be operationally defined. Treatment outcome measures can be grouped in four categories, i.e. pain, movement restriction, mandibular function impairment, and impact on daily life and well-being. The former three categories appear to be sufficiently sensitive for change in response to treatment of TMJ osteoarthritis and internal derangement. The framework proposed in this thesis forms a good basis for extensive research regarding treatment outcome with clinically useful results.