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Continuing diagnostics of the temporomandibular and musculoskeletal system (TMS/MSS)

Key words *TMD, temporomandibular system, musculoskeletal system, temporomandibular disorder (TMD), temporomandibular joint (TMJ)*

The starting point for any orthodontic occlusion diagnostics, treatment planning and subsequent therapy should be the physiological mandibular position. A possible discrepancy between maximal intercuspation and occlusion in the physiological mandibular position should be carefully investigated. An unrecognised and therefore untreated temporomandibular dysfunction (TMD) nullifies the success of orthodontic treatment. If there are signs of a TMD in the short screening test, the following detailed functional diagnosis, possibly including the musculoskeletal system (MSS), is necessary. This also includes the diagnosis of analogue or virtual models mounted in a physiological condylar position. Cone beam computed tomography (CBCT) and sometimes also an MRI scan is needed to specify the diagnostics in some patients.

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Introduction

In issue 2/2018 of the Journal of Aligner Orthodontics (JAO) Professor Meyer presented the "Short Clinical Screening Procedure for Initial Diagnosis of Temporomandibular Disorders"[1]. This short screening should generally be performed before any dental treatment begins. It should also be considered for preliminary diagnostics in orthodontics for both adults and children[2-4]. Unrecognised and untreated temporomandibular dysfunction (TMD) does not only affect the course of orthodontic treatment unfavourably, but may ultimately lead to a high probability of failure[5].

If the short screening test[1] is positive, detailed functional diagnostics and analysis of the occlusion are performed using analogue or virtually mounted models in the physiological mandibular position, if necessary supported by cone beam computed tomography (CBCT) or magnetic resonance imaging (MRI). In case of a pathological finding, a reversible pretreatment with an occlusal splint is usually necessary.

Discussion

According to Beyer[6], even very brief stimulation of motor neurons or inter-neurons can lead to a long-lasting change of the motor unit, which itself evokes changes in muscle tension and body posture, as well as asymmetry, impaired

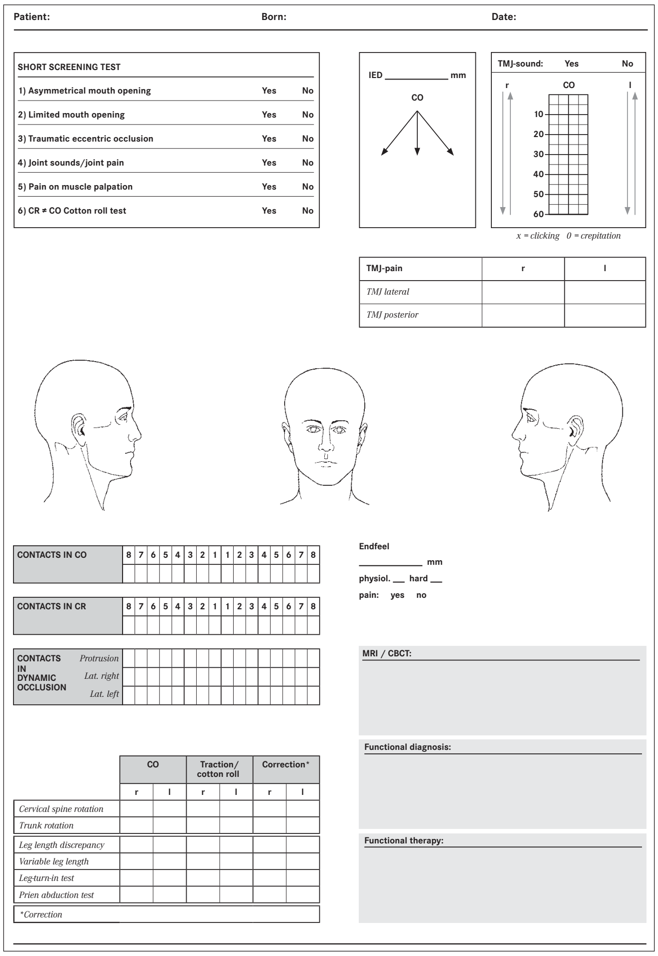

Fig 1 Diagnosis sheet of the temporomandibular and musculoskeletal system.

SHORT SCREENING TEST		
1) Asymmetrical mouth opening	Yes	No
2) Limited mouth opening	Yes	No
3) Traumatic eccentric occlusion	Yes	No
4) Joint sounds/joint pain	Yes	No
5) Pain on muscle palpation	Yes	No
6) CR ≠ CO Cotton roll test	Yes	No

Fig 2 Short screening test; red marks show the individual findings also in the following figures.

movement and pain. As he points out, the origin of the painful stimulus (source of pain) and the region where the pain occurs (site of pain) do not necessarily coincide. If one part of the segment is disturbed over a longer period, the dysfunction disperses first in the segment itself, then over the segments along to the cranial and caudal, as well as over the muscular, fascial and articulation chains, giving rise even to disturbances of stereotypes. Thus, even the non-painful, but dysfunctional, temporomandibular joint (TMJ) can transmit referred pain into the adjacent muscles.

If the chewing muscles are painful (site of pain), often the origin of pain is the dysfunction of the TMJ (source of pain).

Due to the concatenation of the temporomandibular system (TMS) with the musculoskeletal system (MSS), from our experience both systems and their concatenation should be investigated. For this purpose, together with manual physicians, we have developed the examination sheet presented here. Whenever there is a discrepancy between maximum habitual intercuspation and intercuspation in a physiological condylar position (termed CO ≠ CR), an accurate diagnosis should be made. This then results in the function-oriented treatment planning.

The starting point of the orthodontic aligner therapy is then not the habitual intercuspation, but the corrected mandible position in a physiological TMJ position.

1. Anamnesis

The dental anamnesis is broadly designed to detect dental problems, but also typical key symptoms that go beyond the TMS and may be associated with disorders in the MSS. The anamnesis includes family medical history, patients' prehistory, medication, risk factors, and the patient's expectation of the treatment. Depending on the medical history, a physiological screening should be carried out.

2. Examination of disorders in the temporomandibular system (TMS)

The diagnosis sheet of the temporomandibular and musculoskeletal system (Fig 1) is divided into the part "Short Screening Test" (Fig 2)[1] and the following part "Continuing Diagnosis". If two or more findings are positive in the short screening test, the continuing diagnosis is immediate.

The findings from the short screening test are yes/no findings and can be entered immediately in the extended part of the continuing diagnosis. If, for example, a deviation is detected in the short screening test, it can also be entered immediately into the extended "Continuing Diagnosis" sheet.

2.1 Examination of mandibular mobility

During examination of the mandibular mobility, the following parameters should be documented (Fig 3):

- Incisal edge distance (IED), specified in mm;
- Lateral movement of the mandibular jaw to the right and left, specified in mm;
- Protrusion of the mandibular jaw, specified in mm;
- Mouth opening symmetry/asymmetry;
- Deviation;
- Deflection.

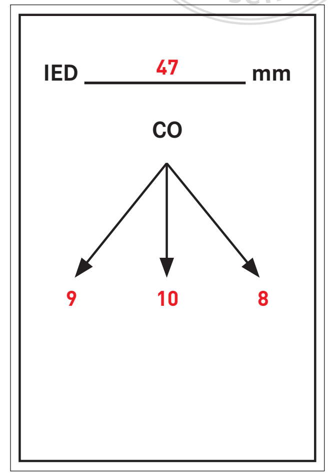

Fig 3 Mandibular mobility: IED, lateral movement, protrusion; deviation – see Figure 4.

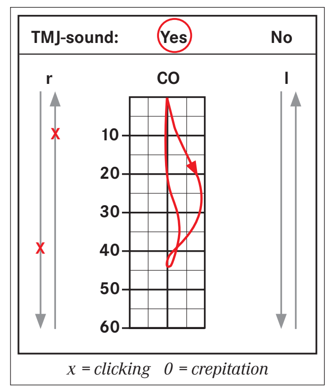

Fig 4 TMJ sound, clicking, deviation.

The active movement, carried out by the patient without the instructor's help, is observed and measured. The maximal range of motion and mandibular gait (deviation/deflection) are of special interest. For the clinical examination of the mouth-opening movement, the patient should be instructed to open his/her mouth several times consecutively.

The incisal edge distance (IED) is an individual value; therefore there it is no standard dimension that can be referred to. According to Rocabado, the functional part of the TMJ is 70% to 80% of the maximum possible area, when also considering the viscoelastic properties of the connective tissue and the stable relation of the joint[7]. For a maximum opening movement of 50 mm, the functional value of the opening movement is therefore 70% to 80%, or 35 mm to 40 mm, which should be a minimum.

In the case of an acute anterior disc displacement without reposition, the opening movement is always limited, and the movement pattern is a deflection. In a TMJ with anterior disc position with repositioning, the movement pattern is a deviation.

According to Siebert, with an IED of approximately 10 mm it should be possible to make pain-free excursions of the mandible of more than 7 mm, otherwise the lateral movement can be considered as limited. As with the opening movement, this is a very individual value, which is very hard to define[8].

A movement restriction in the lateral movement can be observed in the case of the disposition of an anterior disc, limiting the movement to the healthy side.

Deviation and deflection during the opening movement and protrusion tend to the side of the damaged joint. In laterotrusion, the movement to the healthy side is restricted. For example, laterotrusion to the healthy side is limited in acute anterior disc displacement without reposition. There is a deflection to the damaged side during mouth opening.

2.2 The temporomandibular joints (TMJs)

During examination of the TMJs, the following parameters should be documented:

- TMJ sound (Fig 4);
- Clicking;
- Crepitation;
- Pain with palpation lateral/intraauricular, specification x moderate pain, xx pain, xxx severe pain (Fig 5).

TMJ pain	r	l
TMJ lateral	XX	
TMJ posterior	X	

Fig 5 TMJ pain: lateral and posterior (intraauricular palpation).

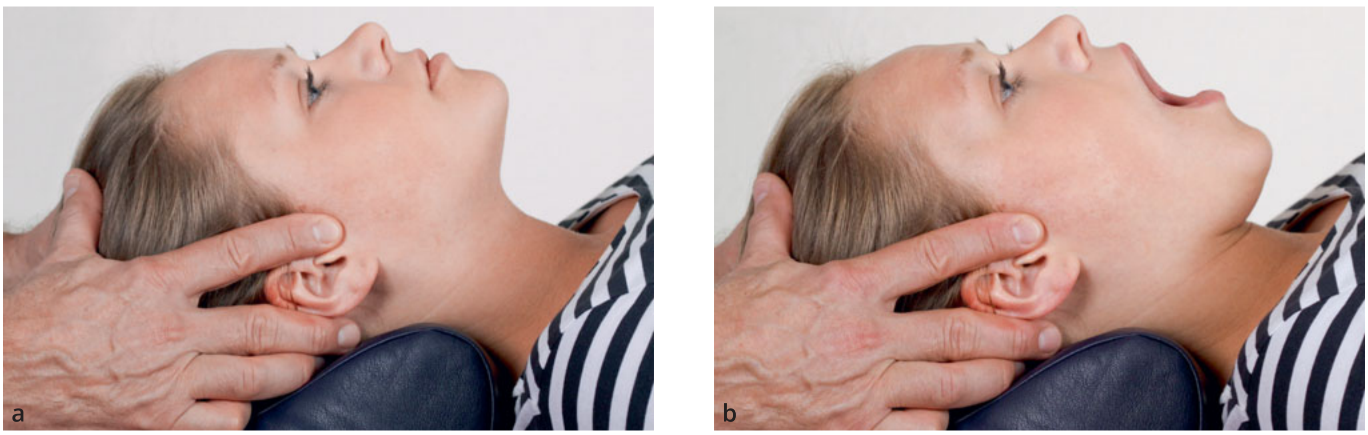

Fig 6a and b Palpation of the TMJ on the lateral aspect – closed and open.

2.2.1 Lateral palpation of the TMJs

The examiner's finger is used to locate the lateral condylar pole immediately anterior to the tragus (Fig 6).

Starting from habitual intercuspation, the patient is then instructed to carry out:

- Opening and closing movements;
- Protrusion and retrusion motions;
- Excursion movements to the right and left.

The lateral and also the intraauricular palpation is accomplished by low local pressure to obtain sensitivity in the receptors of the fingertips. When applying too much pressure, sensitivity decreases.

The lateral palpation enables us to make statements regarding:

- Pain and pain localisation, especially of the joint capsule;
- TMJ noise (clicking, crepitation);
- Mobility of the condyles (simultaneous or staggered start of movement and limitation, unilaterally or bilaterally).

2.2.2 Intraauricular palpation of the TMJs

In our experience, with intraauricular palpation we are able to make better statements than with lateral palpation.

With the tip of the little fingers we palpate bilaterally in the external acoustic porus. By doing so, we pull the little fingers in the direction of the cranial, posterior condylar poles (Fig 7), allowing us to palpate the posterior aspect of the condyle with the bilaminary zone.

Starting from habitual intercuspation, the patient is then instructed to carry out:

- Opening and closing movements;
- Protrusion and retrusion motions;
- Excursion movements to the right and left;
- Protrusion and retrusion motions with teeth in contact; protrusion and retrusion approximately 2 mm.

The palpation enables us to make statements regarding:

- Pain and pain localisation, especially of the bilaminar zone;
- Swelling;
- TMJ sounds (clicking, crepitation);

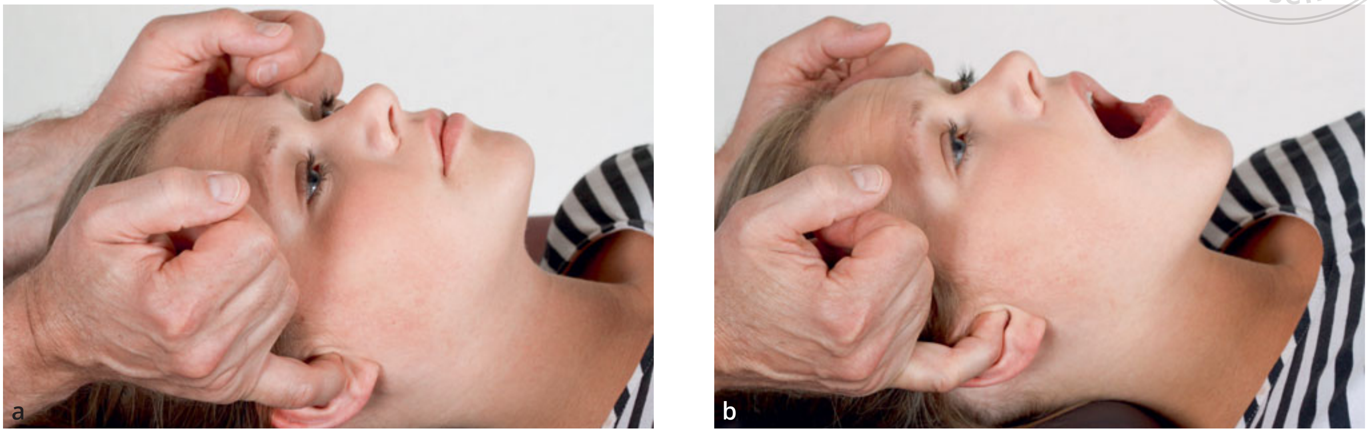

Fig 7a and b Intraauricular palpation of the TMJs – closed and open.

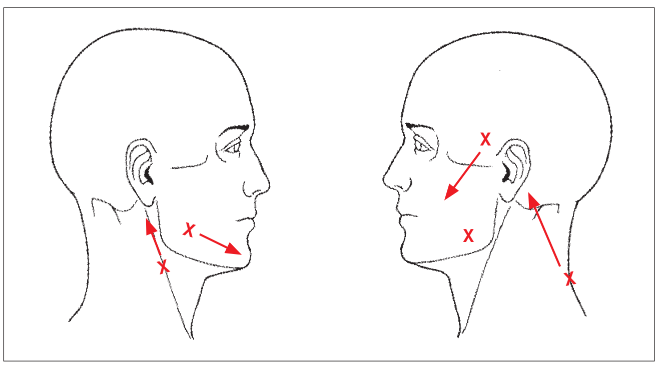

Fig 8 Examination of the musculature of the TMS. Existing muscle pain can be entered on the sheet (x moderate pain, xx pain, xxx severe pain). The referred pain is drawn into the relevant area with an arrow.

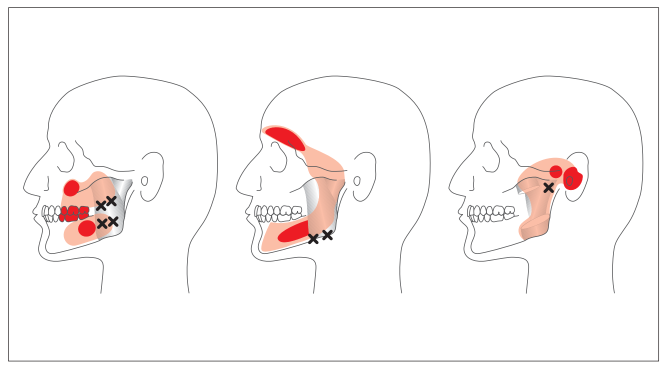

Fig 9 Trigger points of the masseter muscle. The left and centre graphic show the trigger points of the superficial part; the graphic on the right shows the trigger points of the deep part. (x = trigger point; red = areas of radiating pain with an intense pain pattern; orange = areas of radiating pain with a less intense pain pattern).

- Mobility of the condyles (simultaneous or delayed/staggered start of movement and limitation unilaterally or bilaterally);

Note the anterior/posterior position of the condyles in habitual intercuspation and then with protrusion and retrusion motions with teeth in light contact, protrusion and retrusion of approximately 2 mm.

2.3 Examination of the musculature of the TMS

When diagnosing chewing muscles, the following parameters should be documented:

- Muscle pain (Fig 8);
- Graduation: x = discomfort, minor pain, XX = distinct pain, xxx = severe pain, possibly with radiation;
- Trigger points (Figs 9 and 10);
- Localisation;
- Referred pain.

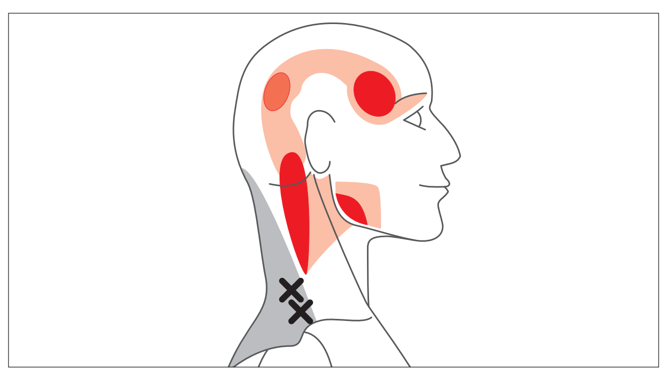

Fig 10 Trigger points of the trapezius muscle (upper compartment) (x = trigger point; red = areas of radiating pain with an intense pain pattern; orange = areas of radiating pain with a less intense pain pattern).

CONTACTS IN CO	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
		X	X	X	X	X	X	X	X	X		X	X			

CONTACTS IN CR	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
						X	X	X	X	X						

CONTACTS IN DYNAMIC OCCLUSION																	
	Protrusion								X	X							
	Lat. right					X	X					X	X				
	Lat. left					X	X					X	X				

Fig 11 Occlusal contacts: occlusal contact points in maximum habitual occlusion (CO), occlusal contact points in a more physiological condyle position (CR) (cotton roll test), occlusal contact points in dynamic occlusion: protrusion, laterotrusion to right and left.

As a standard, we examine the following chewing muscles:

- Masseter muscle;
- Medial (internal) pterygoid muscle;
- Tendon of the temporalis muscle in front of lateral (external) pterygoid muscle;
- Temporalis muscle;
- Anterior;
- Medialis;
- Posterior;
- Digastric muscle;
- Sternocleidomastoid muscle;
- Trapezius muscle.

Mandatory palpatory findings are essential for assessing the functional state of temporomandibular structures. For palpation of the muscles, a good cooperation between dental practitioner and patient is essential. Therefore, it is recommended to instruct patients about the upcoming examination and encourage them to provide precise information about the pain intensity and the referred pain of the individual palpation areas. Sometimes it is best to first demonstrate the palpation on the palm of the hand of the patient in order to convey the feeling of pressure.

The musculature is first examined by the palpation of the individual muscles of the entire TMS, including the neck muscles. Special attention should be paid to the assessment of trigger points. Trigger points are small, ischemic areas in a shortened muscle that transfer pain into neighbouring areas. They should always be treated first[9-11].

In order to palpate different structures, various techniques[12] are used. In the case of superficially running muscles and tendons, the palpation is generally transverse to the course of the fibre.

Depending on the position and size of the muscle, different techniques are used. They either follow the course of the muscle or grip the muscle between the thumb and the fingertip of the second finger. For the palpation of deeper muscles, the muscle above it must be pushed aside or palpated through it. This allows for a differentiation between muscle and tendon, for example, through active flexion of the muscle by the patient.

These different palpation methods allow for a complementary diagnosis of the masticatory muscles and the TMJ. The only exception is the lateral pterygoid muscle, which is hardly palpable due to its location, thus making it very difficult to distinguish it from the neighbouring structures. Tuerp and Minagi therefore recommend omitting the palpation of the lateral pterygoid muscle as a diagnostic criteria[13]. In front of the internal pterygoid muscle we can palpate the tendon of the temporalis muscle, which is important because of the often-found trigger points. These trigger points can be treated immediately.

The palpation starts in the tendon (origin of the muscle) because of the trigger points often located there. Within the muscle, we palpate transversally to the fibre orientation. The individual muscles are identified symmetrically on each side in the appropriate order and palpated. During palpation, a continuous pressure needs to be maintained for a certain period of time. Gradually, the pain builds up to a maximum, which remains constant for about 5 s.

2.4 Occlusal contacts in habitual intercuspation, in centric occlusion and in dynamic occlusion

When examining the occlusal contact points (Fig 11), the following parameters should be documented:

- Occlusion contacts in maximum habitual intercuspation;
- Contacts in a more physiological condyle position;
- Contacts in dynamic occlusion;
- Protrusion;
- Excursion to right;
- Excursion to left.

2.4.1 Contacts in habitual intercuspation

The evaluation of proximal contacts is done with Shimstock foil in Miller holders, with the patient in an upright position, without manipulation. The static occlusion can also be analysed by using ultra-fine block marking tapes (12 µ).

The tooth contacts can provide information about habitual occlusion. In functional and parafunctional activity, a broad distribution of tooth contacts disperses force vectors over many teeth and reduces force concentration on a limited number of teeth. The pronounced contacts and wear on anterior teeth is an indication of the lack of posterior teeth support, overloading the front and possibly leading to a deflection of the mandible.

2.4.2 Contacts in a more physiological condyle position

The analysis of occlusal contacts in maximum habitual intercuspation vs contacts in a "more" physiological condyle position can be combined with the short screening test. We analyse the single contacts and write them down onto the diagnosis form. Next, we place the cotton rolls between the first premolars[1] and ask the patient to bite on the cotton rolls for 2 min while maintaining a normal head position. The cotton rolls are then removed and the patient is asked to bite into the first contacts with ultra-fine marking tapes (12 µ) between the maxillary and mandibular dentition. The patient is either sitting upright or standing. Now we can mark the contact points on the diagnosis form to see whether or not there is a difference between habitual occlusion and a more physiological condyle position.

Any dental treatment, including orthodontic treatment, is based on the centric relation and not on the habitual intercuspation[1].

2.4.3 Contacts in dynamic occlusion

The dynamic guidance is analysed in different steps, during both protrusion and excursion movements to the right and to the left. For this analysis, ultra-fine marking tapes (12 µ) in different colours are used. The incisors should guide the protrusion, and the canines may be included. In protrusion, there should not be any contact points on premolars and molars. The canines, and perhaps the premolars, should also guide the laterotrusion. In laterotrusion, there should be no contacts on premolars and molars on the contralateral side.

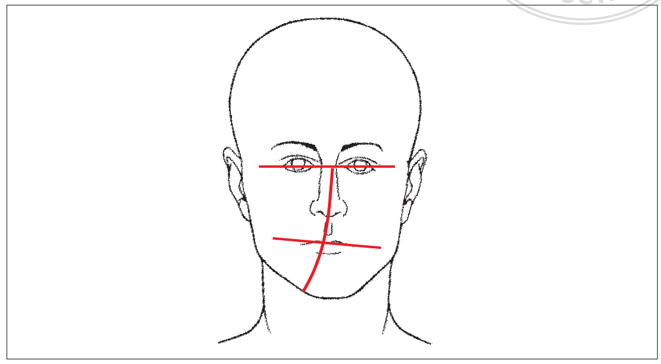

Fig 12 Frontal extraoral view for the assessment of vertical and horizontal facial symmetry. Diagnosis sheet with marked facial scoliosis; in this patient it represents a left convex face and the inclination of the occlusal plane with a shortened right face. Mostly, the functional problems and pain are on the shortened side.

2.5 Facial symmetry

When examining the facial symmetry, the following parameters should be documented:

- Symmetry of the face (Fig 12);
- Vertical;
- Horizontal.

An accurate assessment of facial symmetry is necessary for the development of a dentofacial diagnosis and begins with the inspection. The precise side comparison of the facial skull structures should be the focus. We also diagnose if the musculature of the TMS is hypertrophied on one or both sides.

A frontal visual inspection of the face (Fig 12) often provides valuable indications of a possible one-sided loss of height or a lack of vertical support in the posterior region with a difference between right and left. In most patients, the shorter side of the face is associated with a loss or lack of posterior support. From our experience, these patients show a displaced condyle position to posterior-cranial, with compression of the condyle into the bilaminar zone.

On the shorter side, with the compression of the TMJ, the temporal bone responds with an inflare[14-19].

The TMJ is a stress-loaded joint. The force from the TMJ gets into the temporal bone and from there into the skull. Figure 13a shows the physiological position of the condyle and the temporal bone in physiological occlusion. Figure 13b shows the physiological position of the condyle and the temporal bone in centric occlusion contact on the right

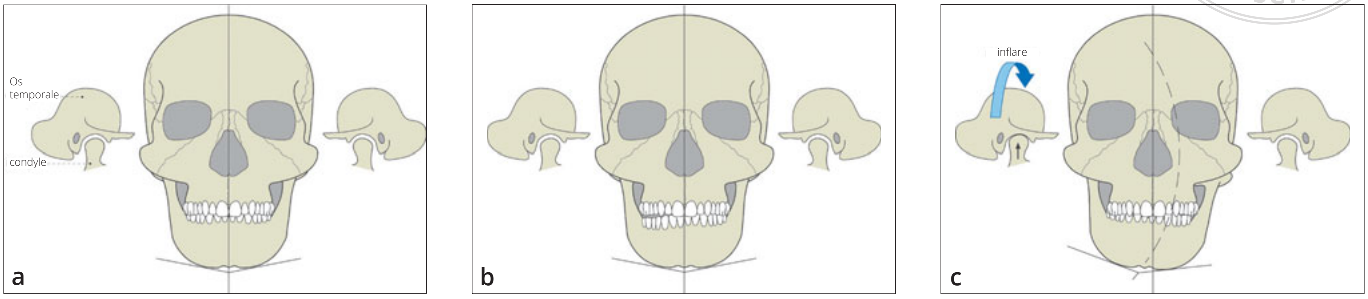

Fig 13 a) The occlusal contacts are equal on both sides with a physiological TMJ and temporal bone; **b)** Occlusal contact in a physiological condyle position only on the left, with a lack of posterior support on the right; **c)** In habitual occlusion, the patient has occlusal contacts on the right and left, with a compression of the TMJ on the right and an inflare of the temporal bone.

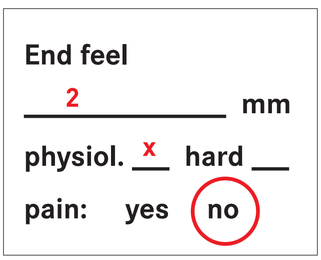

Fig 14 End feel test of the TMJ: quantity in millimetres, quality – physiologic or hard, pain yes/no.

side. On the left side there is a lack or loss of posterior support. Figure 13c shows the same patient in habitual occlusion with a pathological position of the condyle and with an inflare of the temporal bone due to the compression on the right.

According to Roccabado[20,21], the position of the TMJ in the sagittal plane has a "range of motion", meaning that we have some leeway in the anterior-posterior direction. On the other hand, in the vertical plane and also the transversal plane, slight errors can have more consequences[22].

Attention is paid to the parallelism of eye level, auditory canal level, lip closure line, and occlusion level. The mandible should be central to the face. The centre of the chin and the maxillary midline should always be evaluated in relationship to the philtrum, not the tip of the nose, since the nose is frequently asymmetrical. Facial scoliosis based on findings should be drawn onto the examination form. The examination sheet shows a left convex face with an inclination of the occlusal plane of a face shortened to the right. The mandible is shifted to the right. The cause can be a loss or absence of vertical dimension on the right side, with potential TMJ compression on the right side[14,23].

2.6 Clinical examination of the joint play of the TMJ

2.6.1 End feel test

During examination of the end feel (Fig 14), the following parameters should be documented:

- Quantity (extent) of the end feel;
- Quality of the end feel – physiological or hard;
- Pain.

Every joint has an active and a passive movement. The examiner can increase the active, maximal mouth opening movement by applying force passively and carefully. This difference, which is usually between 1 mm and 2 mm in the TMJ, is the ligamentous end feel. Any healthy joint shows an increased active movement when guided passively by the examiner. If a passive movement is not possible, this demonstrates a malfunction in the joint.

In a healthy joint, the end feel is ligamentally limited and can only be achieved with a greater effort. The end feel, described for range of motion limited at the end by the joint capsule, is ligamentally limited and can only be achieved by applying a considerable amount of pressure. In healthy joints the end feel is soft and painless.

In female subjects, it was possible to increase the end feel of the TMJ up to 4 mm. If the end feel is hard and the maximum mouth opening cannot be increased, a mechanical blockage is probable, such as an anterior disc displacement without reposition or, less commonly, a capsulitis.

In cases of disc displacement, the end feel can be described as "rebounding", according to Hansson and Hesse, as well as Bumann et al[24-26]. If the elastic resistance of the

Fig 15 Testing of the end feel of the TMJ: passive opening by the examiner, executed after the final active movement (mouth opening).

Fig 16 Investigation of the joint play.

mouth opening can be increased with pain, the limitation is pain-reflexive, that is, it has a muscular origin. In a healthy joint, the passive end feel at the end of the active mouth opening is ligamentous and not painful. It is about 2 mm (Fig 15).

2.6.2 Joint play test for traction and compression

The joint play test is an additional diagnosis and not a part of the diagnosis form. In some patients the joint play test is useful and sensitive to diagnose joint pathology.

"Joint play" is defined as small movements in a synovial joint that are independent of voluntary muscle activity and cannot be triggered by it. The joint play is an expression of the biomechanics and refers to the normal, physiological movement of two joint partners. The shape of the joint surfaces determines the range of movement. The joint play is indispensable for a painless and free movement of all joints. A dysfunction will restrict normal voluntary movements that are often associated with pain. The loss of joint play can be referred to as "joint dysfunction". The joint play cannot be restored by the patient's voluntary muscle activity. As a result, a joint dysfunction always means a loss of joint play. This rule also applies to the TMJ. Flexibility and function need to be restored by therapeutic measures[27].

This joint play is first tested by performing a traction movement[28,29]. In this case, the quality of the translatory sliding movement is more important than the quantity of movement. The end feel should be soft and elastic, never too firm. However, a barrier can frequently be observed at the end of the movement. With little force, it is often not possible to get beyond this barrier. As a practitioner, it feels as if it would "crack" with further passive movement.

The therapy of choice is to restore the translatory sliding movement to normalise the joint function. The translatory traction and sliding movements are also used therapeutically. This results in a release of the articular surfaces, to tighten the joint capsule and its reinforcing bands and to stretch the shrunken portions of the capsular ligament of the hypomobile joint. The starting point of traction treatment is not the physiological resting position, but always the end point of the mobility of the joint[30].

The assessment of the joint play in traction is followed by the joint play in compression[28]. The painful structures are selected by guiding the mandible with one hand, as shown in Figure 16, and palpating the joint with the other. While in compression, the condyle is guided into all directions of movement, i.e. anterior/posterior and lateral/medial. To reinforce this movement, the condyle is slightly rotated.

3. Examination of disorders in the musculoskeletal system (MSS)

A cluster of manual tests has been proposed to assess ascending or descending myofascial chains towards or originating from the TMJ and the TMS[31,32]. Data about the reliability of the test units are scarce. Studies about the validity

	CO		Traction/ cotton roll		Correction*	
	r	l	r	l	r	l
Cervical spine rotation	h		Φ			
Trunk rotation	h		Φ			
Leg length discrepancy		+3		+1		
Variable leg length	+2			+2		
Leg-turn-in test		h		Φ		
Prien abduction test		h		Φ		
**Correction*						

Fig 17 Examination of disorders in the MSS. The diagnostic form shows the different findings of the MSS between habitual intercuspation (CO) and in a more physiological condyle position (cotton roll) and, if desired, with correction with a bite registration.
h = hard end feel, +3 = left leg 3 cm longer than right leg.

and the reliability of the cluster are pending, although objectivity should increase with the whole of the examination procedures.

During examination of the musculoskeletal system (Fig 17), the following parameters should be documented:

1. Examination in habitual occlusion:

- Rotation of the cervical spine;
- Trunk rotation;
- Leg length discrepancy;
- Variable leg length (long sitting test);
- Leg turn-in test;
- Prien abduction test.

2. Examination with cotton roll test in a more physiological condyle position:

- Rotation of the cervical spine;
- Trunk rotation;
- Leg length discrepancy;
- Variable leg length (long sitting test);
- Leg turn-in test;
- Prien abduction test.

Rotation of the cervical spine

The patient sits upright and actively rotates the head to the right and left (Fig 18), followed by passive rotation by the examiner to assess the end feel (Fig 19). In the case of the active movement, care must be taken that a pure rotational movement takes place.

Repetitive compensating movements are noted. If the passive end feel is hard and not physiological, this is recorded. The extent of the active rotation should be between 70 and 75 degrees in the case of a physiological movement.

The assessment of the cervical spine mobility with a "cervical range of motion devices" proved exact and reliable. Excellent intraclass correlations (ICC for CI of 95%) between 0.94 and 0.98 are published[33]. Even visual estimation gained a good ICC of 0.7 for left rotation and of 0.82 for right rotation[34].

Trunk rotation

The patient sits on the examination table, with the soles placed firmly on the floor to ensure pelvic fixation. The patient's hands lie on the opposite shoulders ("pharaoh grip"). The patient actively rotates the upper body to one side and is turned further passively up to the point of a "final feeling". This examination is repeated for the other side and the findings are compared (Fig 20).

We find excellent intra- and interrater reliabilities for trunk rotation in scoliotic patients by means of scoliometric or iPhone-based devices and ICCs of about 0.95[35,36]. Another back range of motion (BROM) device in healthy volunteers showed good and very good intra- and interrater variability for flexion and side-bending (ICC range: 0.77 to 0.92), but only poor to moderate results for extension and rotation (ICC range: 0.35 to 0.63)[37]. There are no data available concerning visual estimates.

Leg length discrepancy

The patient lies on the table in a supine position and leg lengths are compared (Fig 21).

For this purpose, the patient pulls up the knees, and then stretches the legs again. Afterwards the examiner lifts the legs from underneath, and the patient is prompted to pull, lift, and lower the hip.

Without putting traction on the legs, the examiner compares the malleoli to see if a difference in position is present. It can be helpful to place the thumbs on the internal malleolus in order to have a better orientation during the evaluation.

Variable leg length (long sitting test)

The patient lies on the examination table in a relaxed supine position, with the arms next to the body. The examiner raises the stretched legs by about 20 degrees. The patient is instructed to sit up, and may also use the arms to do so (Fig 22 a to c). If there is a difference in leg length of at least

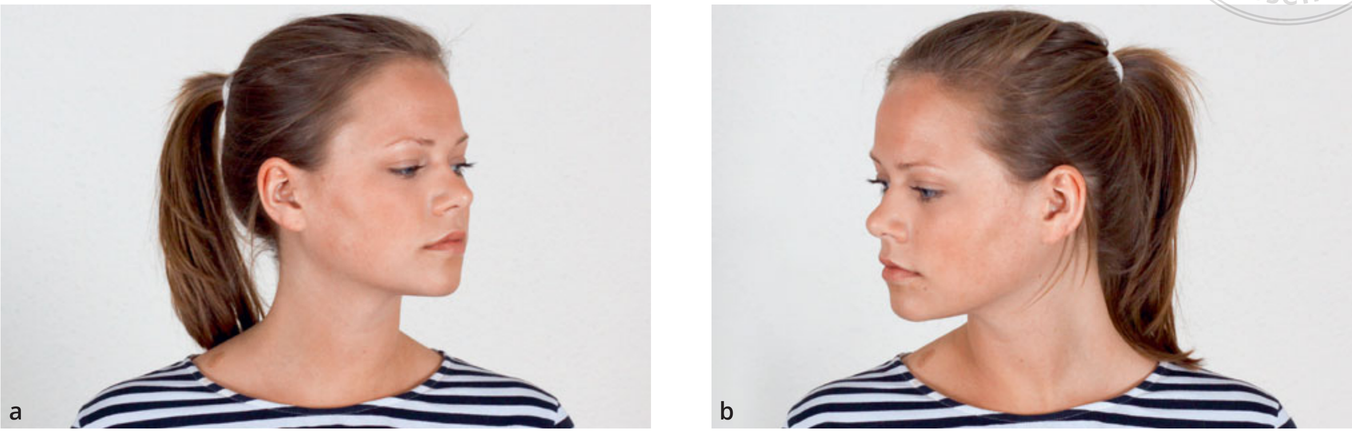

Fig 18a and b Active movement of the rotation of the cervical spine. The rotation should be between 70 and 75 degrees.

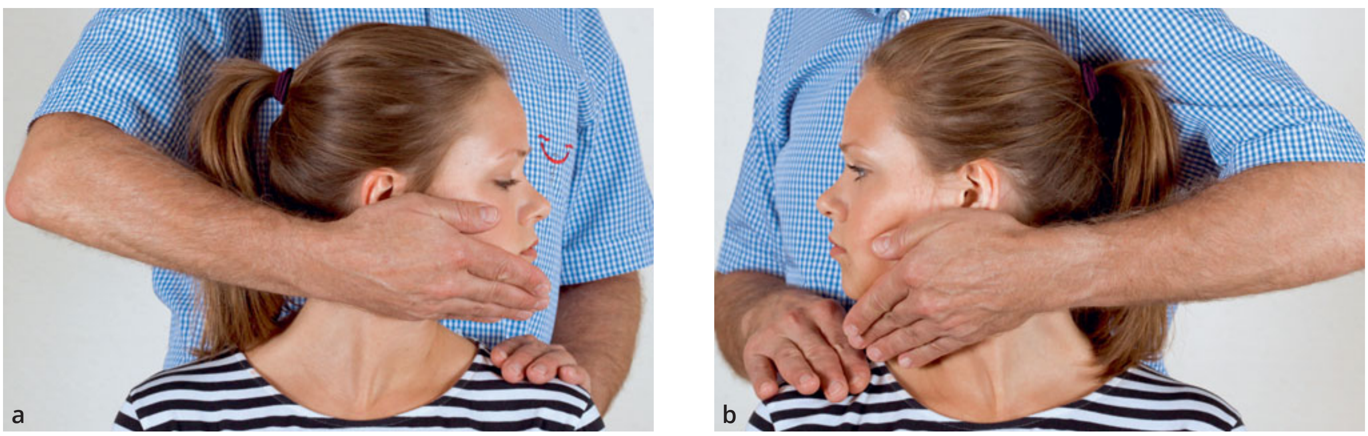

Fig 19a and b Passive movement of the rotation of the cervical spine by the examiner. The end feel should be soft.

Fig 20a and b The trunk rotation test shows the passive movement. The end feel should be soft.

Fig 21 The leg length discrepancy is shown in this photograph. The right leg is nearly 30 mm shorter than the left. This can be an anatomical leg length discrepancy or a functional leg length discrepancy.

Fig 22a to c Variable leg length (long sitting test).

Fig 23 The leg turn-in test shows a restricted passive movement on the left.

1 cm, this represents a variable length discrepancy. The result is again documented. A variable leg length is a sign of a functional pelvic tilt.

Data for the reliability of this manual test are not yet established. A validation study in asymptomatic patients from 1987 correlates its results to examinations that were subsequently found unreliable (like the standing and sitting flexion test or symmetry from landmarks). Sensitivity in the 51 subjects was only 17%, while specificity was 38%[38].

Leg turn-in test

The patient lies in a supine position with legs extended. The examiner gently presses both the lower limbs and the feet into an inner rotation by embracing the external corners of the ankle (Fig 23).

We examine quantity and quality of internal rotation in comparison to each side. A difference of the leg turn-in test right to left is a sign of fascial tension. Data about the reliability of this osteopathic manual test are not yet established.

Fig 24a and b Prien abduction test right and left in 90 degrees of hip flexion.

Prien abduction test

Marx described a connection between arthropathy of the temporomandibular region and hip abduction[39]. The patient lies in a supine position on the examination table. The examiner fixes the patient's pelvis on one side of the patient by putting pressure on the *Spina iliaca* anterior superior. The test is performed in 90 degrees of hip flexion, passively bending the leg into abduction to the passive physiological end of range. The angle between the upper thigh and bench is measured (Fig 24). Range of motion and quality of movement are assessed.

The Prien abduction test is a variation of the FABER or Patrick's test that assesses tenderness and pain. Contrary to this test, rotation of the hip joint is eliminated with the Prien abduction test, starting abduction from 90 degrees of hip flexion. It estimates range of motion, end feel and symmetry. Reliability for measurements of the hip abduction is good to very good (intra-rater examination: ICC 0.78 to 0.86)[40,41]. The visual estimate of symmetry, on the other hand, was rated poor (inter-rater examination: ICC 0.2, intra-rater examination: ICC 0.38 to 0.61)[42].

The results of the examinations of the MSS are entered on the findings sheet.

Conclusions

In the final habitual intercuspation, the occlusion dominates the positioning of the TMJ and thus also motor function. If there is a discrepancy between the central physiological TMJ positions in habitual intercuspation with existing malocclusion, the consequence is a displacement of the TMJ from the physiological position. Incorrect loading of the TMJ leads via proprioceptors, mechanoreceptors and nociceptors to stimulation in the trigeminal nerve with relaying via the caudal section of the spinal nucleus of the trigeminal nerve and the associated trigemino-cervical convergence. Within the *pars caudalis nucleus spinalis n. trigemini* is the cervico-trigeminal convergence between the:

- *N. trigeminus;*
- *N. facialis;*
- *N. glossopharyngeus;*
- *N. vagus;*
- *N. accessorius;*
- Cervical afference of *radix dorsalis n. spinalis.*

The interconnection in the wide dynamic range (WDR) neurons leads to complex results in the central nervous system. This information reaches the basal ganglia (among other structures), which are directly involved in the planning of procedural learning and voluntary motor movement. The basal ganglia are involved in many processes, such as perception, learning, emotion, memory, attention and motor function. They select central signal input and output of both a motor cognitive and emotional nature. Malocclusion can change these processes if there is a need for the basal ganglia to keep the allodynia in balance[43].

If there are any signs of pathology in the medical history, as well as in the examination of the MSS, we will prepare a therapeutic construction bite (see below). Herewith the question as to whether disturbances in the MSS or pain (headache, neck pain, back pain, dizziness, etc.) are related to the malocclusion (and if treatment seems to make sense) can be answered. The ultra-hard wax construction bite cooled in ice water (Miltex – Beauty Pink Wax, extra hard, DeLar – Bite-Registration sheet wax) is used for the patient, who is asked to swallow and take some steps to neurologically reorganise the new bite situation to the MSS.

Immediately thereafter, the examinations of the MSS are repeated with the transcutaneous bilirubin (TcB) test. If an improvement of the peripheral findings is noticeable, there is a descending component, which indicates that the malocclusion is involved in the peripheral disorder.

For initial diagnostics, instead of the TcB, the cotton roll test is carried out for the sake of simplicity, similar to the procedure used for the short screening test. Instead of the TcB, cotton rolls are placed between the first premolars before the patient is asked to bite on them for about 2 to 3 min. To adapt the musculoskeletal system to the new mandibular position, the patient should swallow and take a few steps (neurological reorganisation).

We then examine the musculoskeletal system again by means of the described tests.

The process in detail:

Anamnesis

↓

Examination of disorders in the TMS

↓

Examination of the MSS
Rotation of cervical spine
Trunk rotation
Difference in leg length
Variable leg length
Leg turn-in test
Prien abduction test

↓

Cotton roll test or TcB followed by neurological reorganisation

↓

Examination of the MSS
Rotation of cervical spine
Trunk rotation
Difference in leg length
Variable leg length
Leg turn-in test
Prien abduction test

↙ ↘

Improved findings

↓

Descending component likely

↓

Treatment with occlusal splint

↓

Orthodontic or restorative treatment or combination of both

Unimproved findings

↓

Descending component unlikely

↓

Further medical diagnostics/ Orthopaedic consultation is advised

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