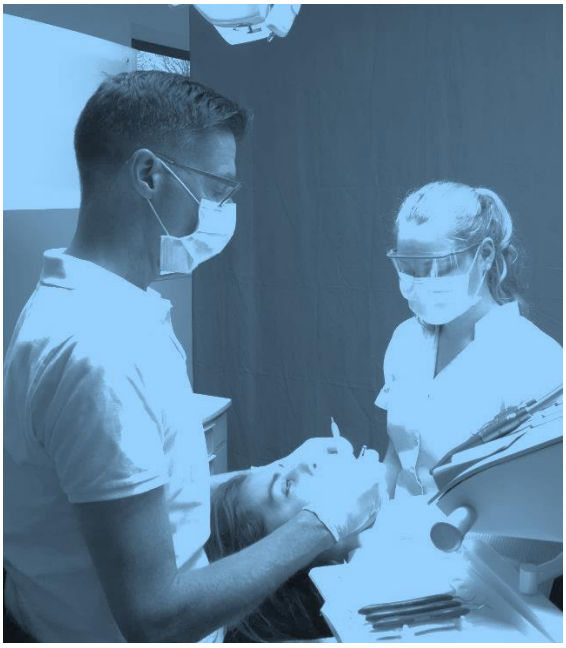
THEME DOCUMENT

An ergonomic approach to dental patient treatment



Oene (O.) Hokwerda MSc

Rolf (R.A.G.) de Ruijter MSc

Amber (A.) Denekamp

Expertise Center
Dental
Ergonomics

Physical, Social-organizational and Cognitive Ergonomics

KEM Foundation The Netherlands

Version Nr.	2
Date of revision	KEM 65 E 121220

Preface

The aim of this theme document from the Dutch Expertise Center for Dental Ergonomics (KEM) is to provide a brief description of important principles for a healthy, ergonomic working posture and to summarize these principles for handling in dental practice and in education.

The document is intended for:
- Dentists, dental hygienists, dental assistants charged with preventive treatments and dental assistants in dental practice who want to improve posture and work technique;
- It is also intended for use in training and refresher courses.

This document deals with:
Physical ergonomics and socio-organizational ergonomics.

Comments on the content or structure of the document
Anyone who has comments on the content and/or structure of this document is invited to inform the secretary of the KEM Foundation (Dutch Expertise Center for Dental Ergonomics), kemergonomics@gmail.com, who will be responsible for forwarding it to the author and discussing it at the KEM in a KEM meeting. Before revising a theme document, consultation takes place about the way in which it will be processed.

This theme document has been elaborated under the responsibility of the KEM Foundation by:

dr. Oene (O.) Hokwerda
Emeritus Professor dental ergonomics

Rolf (R.A.G.) de Ruijter MSc
dental ergonomist
Center for Dentistry and Oral Hygiene
University Medical Center Groningen

Amber (A.) Denekamp
occupational therapist

Special thanks to dr. Stefan Danylak. BDSc for his constructive criticism on the manuscript of this document.

Table of contents

1 Introduction

The human body is made to perform movements. However, the working method of the dental practitioner has a strongly static character. As a result, the physical effort required to perform tasks during patient treatment is extremely demanding. Unfortunately it is not always avoidable to adopt a wrong posture, due to various causes, such as ergonomically inadequate treatment equipment and patient conditions. In such cases, it is necessary to find the best possible solutions in full knowledge of the situation.

Work-related stress is also an important factor for an increase of muscle tension, resulting in an increase in physical strain on the body. Various causes can lead to work stress, such as a too tight work schedule, lack of opportunities to act at one's own discretion, unfavourable relationships in the oral health care team, etc. Then it is necessary to tackle the stress factors.

In this document the starting points for an ergonomically sound working posture are described in order to gain knowledge and insight into handling this, in order to prevent the development of postural abnormalities (musculoskeletal abnormalities). Because these can largely be prevented. However the description of the basic principles is based on the knowledge needed to understand an ergonomic working method, without going into the underlying anatomical and physiological knowledge.

In order to obtain an ergonomic working method, the following aspects are important:

- take care of a dynamic working posture by performing movements;
- varying in duration and types of treatments;
- planning shorter and longer breaks;
- performing firm movements or sports outside practice hours for relaxation and strengthening of muscles and also for a healthy functioning body.

In addition to the above there are also other factors that influence handling a dynamic way of working. These include the ergonomic layout of a practice, insight into the load of treatment activities and the load capacity of the body, awareness of one's own abilities and limitations, organization of practice activities, team cooperation and the ability to reflect on one's own way of working. This document does not elaborate further on these issues.

In Chapter 2 posture and postural load are discussed in relation to a static working posture. This is followed by a description of the way in which proprioception makes it possible to distinguish between an overloaded and a relaxed working posture. In Chapter 3 the starting points for a standing working posture are briefly discussed. Working in a standing position is suitable for various work situations and is also important as a variation for working in a sitting position. Chapter 4 contains a detailed explanation of the basic principles for ergonomically healthy sitting when treating patients This detailed description is intended to provide a good insight into a responsible way of sitting. This chapter also serves as a reference work for chapter 5 with the 'Key principles for an ergonomic way of working', in which the basic principles are summarized in the form of a checklist.

If you are already familiar with an ergonomic working method, you can also start by going through the checklist to test your own knowledge and look for missing knowledge.

2 Posture and postural strain

Posture can be defined as the relative ratio of the body segments to each other at a given moment in time. Good posture is based on a muscular and skeletal balance of the supporting structures of the human body, which protects the body against injury and deformity; independent of the basic position in which the body stands, sits and lies. Under such conditions, the muscles will function most efficiently and thoracic and abdominal organs will be in an optimal position. With a deviant posture, there is an imbalance of different body segments in relation to each other. This puts more strain on the body's supporting structures leading to a less efficient body balance.
Adopting an ergonomically correct posture can therefore be regarded as a good habit which contributes to the well-being of the individual. A deviant posture is a bad habit which, if maintained, can lead to discomfort, pain and abnormalities. Depending on the nature of the abnormality, muscles will shorten or lengthen and strengthen or weaken.

International research shows that 62-93% of oral health care workers experience musculoskeletal disorders. Common complaints are low back pain (36.6-60.1%) and neck and shoulder pain (19.8-85%). Important causes are prolonged sitting, working in unilateral, stressful positions and performing improper fine motor hand-arm tasks. A lot of work is done in static postures and the result of the static load on the muscles is a reduced blood flow to the tissues which leads to muscle tension. This reduces functioning of the tissues and increases the risk of injuries. The pain that arises then leads to adapted locomotor behaviour, which further increases the risk of strain on joints and muscles.
The NEN-ISO standard 11226 defines a static working posture as follows: there is a static working posture when a body part adopts the same posture for more than 4 seconds. Then the blood supply goes gradually from aerobic to anaerobic.
Furthermore, the mentioned standard contains guidelines for sitting and standing occupations which indicate the recommended limit values for safe working postures of the different parts of the body. These limit values are expressed in degrees and duration.
When operating with static working postures, the risk of overloading the musculoskeletal system is low concerning neutral posture zones. The more the working postures deviate from a neutral stand, the less time it takes to overload the body structures.

Proprioception is important for observing the strain on posture and for movements.
Proprioception provides the individual with information about his or her body’s sense of position and movement. The sense of position is the perception of the orientation of the different parts of the body in space. Sense of movement is the perception of speed and acceleration of the body during movement.
The proprioceptive system is a feedback system that consists of different proprioceptors located in capsules, ligaments, skin and muscles. These proprioceptors provide an afferent input along the nerve pathways to the brain to coordinate and adjust the movements of the different parts of the body in relation to each other. The function of these proprioceptors is to ensure that the body remains in balance. Without this balance one constantly loses balance. Proprioception functions in conjunction with the organs of balance and visual perception. When standing, one starts to perceive proprioception at the feet, because this is the basis for the support of the body and there are many receptors here. This is different when sitting. This will be discussed later.

In order to learn to work in an ergonomic working posture, it is necessary to distinguish between an overloaded and relaxed posture. By learning to experience proprioceptive behaviour, it is possible to determine whether the posture is relaxed or overloaded, i.e. unfavourable. This is a basic skill.
It can be trained by, for example, doing awareness exercises by making use of:

- Body scan: regular conscious observation of posture and movement. E.g. 'am I sitting symmetrically upright or do I lift my upper arms too much while working? Or do I have to reach too far towards my instruments to grasp these?'
- Making conscious adjustments or improvements of posture and movement, for training the experience of the use of a relaxed, correct posture and posture control. Based on the dentist's work, all kinds of exercises can be imagined, which can be used to train experiencing an overloaded posture, followed by replacing it with a relaxed posture.
- Carrying out balance and stability training with e.g. exercise materials.

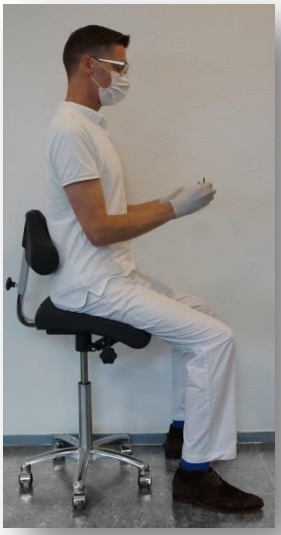


Fig. 1a Correct working posture

Control of postural load:
begin to determine what a relaxed posture upright feels like after some time
Continue with the assignment of fig.1 b and 1c.

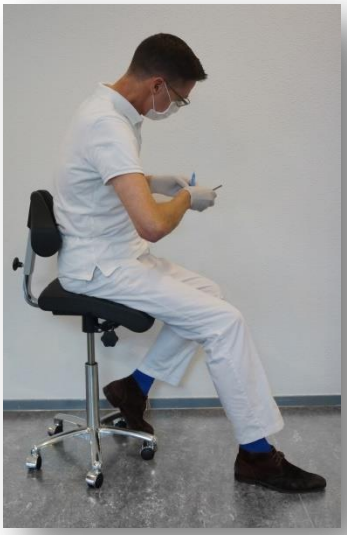


Fig. 1b Wrong posture (side view)

What is the difference, after some time, with a posture bent forward and sideways, with the right arm (and left arm) substantially raised?

Fig. 1c Wrong posture (rear view)
Continue with other burdensome postures for monitoring the effects after some time

Pictures: KEM, R. Wouters

In this way, the feeling of a correct posture and therefore of an ergonomically healthy working posture can be acquired and familiarized.

It should be borne in mind that attention to one's own working posture often is repressed by being occupied in the patient's mouth. Possibilities for solving this are:

- Interrupt the actions for a moment and check what strain is being felt;
- Make arrangements in the oral care team to warn each other by giving signals when a change of posture is desirable.

3 Working in a standing position versus working in a sitting position

First, working in a standing position is now explained as an important opportunity for alternating with working in a sitting position, which is then described in more detail. It has already been established that a dynamic working posture (i.e. a posture associated with constant movement) is necessary to counteract a static working method`. This has to be done by regularly alternating between tightening and relaxing muscles so that frequent movements are performed. To accomplish this, variation of a sitting position is also desirable in the form of standing and walking a number of steps, since when standing more movements can take place. Conversely, dentists who do a lot of work in a standing position are recommended to alternate sufficiently between standing and sitting, as the strain of adopting an ergonomically healthy seated working posture is less. This led to the introduction of the seated position, when ergonomics was introduced into dentistry some 70 years ago. However, because still many people work in unfavourable postures, the percentage of posture-related complaints remains considerable. It is therefore desirable to strive not only for an ergonomically healthy posture, but to introduce also sufficient variation in posture. It is also desirable to start from a suitable mix of short, longer lasting and time-consuming treatments. As well as a good distribution of easy and difficult tasks and finally, it is advantageous to look for variation with non-clinical work, organizationally.
The standing posture often offers a better starting position for different treatments, provided the patient is properly installed for this purpose. Examples are the extra-oral examination (including palpation), taking impressions, giving anaesthesia and performing extractions; sometimes also removing any tartar. Although, depending on the situation, these operations can also be carried out sitting down.
In view of the objections of prolonged standing, in the Dutch Working Conditions Directive for standing times has been included: prolonged standing work can lead to circulatory and foot problems. Guidelines have been drawn up to prevent complaints. TNO and the Health Council of the Netherlands therefore advise not to stand for more than 1 hour in sequence per 8-hour working day and not to stand for more than 4 hours in total. And, of course, to alternate between standing and sitting.

When standing, achieving a relaxed working posture is just as important as when sitting:

- Precise manipulation with instruments such as syringes, extraction pliers, ultrasonic tartar cleaning instruments and also an impression tray requires a relaxed working method;
- A higher workload as a result of an unfavourable posture has an unfavourable effect on precise manipulation with instruments. That is, with regard to coordination of actions and dosing of forces.
- A patient experiences a tense way of working by the practitioner as less pleasant and trustworthy. Because tension with the practitioner can create tension with the patient.

Starting points for adopting a correct standing posture are the following:

- The feet are flat on the ground for a balanced distribution of the load under the feet.
- The feet are further at hip width apart from each other or slightly beyond.
- The legs are spread out moderately while the knees are slightly bent. Due to this slightly bent position of the knees it is easily possible to make movements with the whole body, via the easily movable knee joint. This is not possible when the knee joint is stretched and certainly not when it is overstretched.
- Standing still at a fixed place for a long time should be avoided, because this will interfere with the operation of the muscle pump, which in the long run can lead to varicose veins /spatial veins.
- The upper body is upright in a symmetrical position as much as possible, so that the back muscles are tightened as little as possible.

- The head is slightly bent by means of a high neck flexion - by pulling back the chin - and the arms are positioned as much as possible next to the body and are not raised high, except for short periods or as part of a movement.

Furthermore, the same principles apply as described for working in a seated position.
Both standing and sitting require well supportive and comfortable shoes with flat heels.

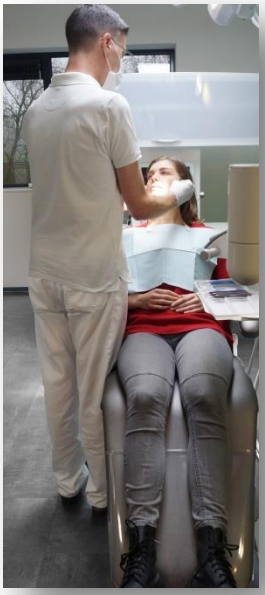


Fig. 2a Standing posture with patient when performing a palpation procedure

Fig. 2b Standing working posture, rear view

Fig. 2c Standing working posture seen from the side.
Balancing upright in the knees

Pictures: KEM, R. Wouter

An ergonomic working situation in relation to the standing posture is achieved as follows:

- Set the correct height of the work surface, with the forearms normally raised 10-15°. Only for certain actions in the lower jaw, e.g. when doing impressions or extractions, the forearms are held in a horizontal position.
- Obtain a favourable reach distance to the working field by positioning the patient's upper body and head.
- Use the three ways of rotating the head of the patient to direct the work field in the patient's mouth towards the practitioner's direction of vision. So that he is able to look perpendicular to the work field in the patient's mouth as much as possible.
- Provide good illumination by aligning the dental lamp with the direction of the light beam parallel to the viewing direction of the practitioner.
- When performing treatments of the teeth in the mouth with instruments: use the modified pen grip (see 4.11) and support with the hands using the ring finger and the little finger inside and/or outside the mouth.
- Sufficient space must be available for the feet, knees and body of the practitioner in order to be able to stand upright next to a patient sitting upright. For right-handed practitioners at the 8 o'clock location (for left-handed practitioners at the 4 o'clock location).

The dimensions of the patient chair can be problematic, as the patient chair is usually designed for sitting down by the practitioner. The dimensions may cause limitations due to the size or location of the base of the patient chair and a limited height range of the patient chair (especially for tall practitioners). This may also be due to the shape and size of the backrest and a too short a reach of

the dentist's lamp arm, while the placement of the armrests may be an impediment to standing sufficiently close to the patient.
It is desirable to look for solutions to ensure that restrictions are kept to a minimum.

In essence, the working field in the mouth needs to be:

- set up as much as possible in the plane of symmetry of the practitioner;
- located at a short distance from his body;
- positioned in such a way that the practitioner can look straight at it as much as possible, by turning the patient's head in 3 directions.

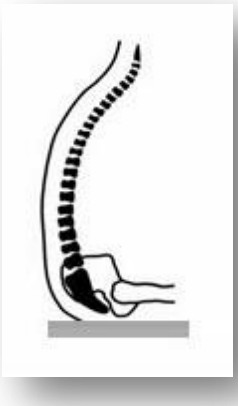
4 Explanation of basic principles for a healthy sitting posture

Below a detailed description is provided of the basic principles for all components of an ergonomic working method for the oral care provider. For getting to know the how and why of it. Those who are already familiar with this can first read the manual in chapter 5, which only contains a list of basic principles without explanation. If something is unclear, one can go back to the explanations in chapter 4. If already sufficient knowledge is gained, this can be used as a reference work. In both chapters, the subjects are included in the same order.

4.1 Ergonomic sitting posture

The following principles are important for an ergonomically healthy sitting posture:
Sitting in an active posture - as a basis for movement - and symmetrically upright - in order to achieve the most favourable load on the upper body's postural muscles (See fig. 3 b).
The spinal column must have the natural S-shape with:

- a slight hollow in the neck (cervical lordosis);
- in the upper back a slight bulging to the back (thoracic kyphosis);
- in the lower back a slight concave forward (lumbar lordosis, similar to the natural shape in the standing posture);



Bron: Anonymous modified by RdR

Fig. 3a The unfavourable C-shaped back Fig. 3b The natural S-shape back

- On fig. 3a the common unfavourable sitting posture, the C-shaped back, is depicted. This results in an undesired load of the intervertebral discs as well as an undesired extension of the back muscles, making it less efficient to tighten them. In the long run, the pectoral muscles are shortened by holding the shoulders forward. Breathing takes place high up in the chest, which is a less favourable way of breathing, i.e. superficial and shorter. This is due to the curved posture, which fixes chest and auxiliary breathing muscles and increases the pressure on the abdominal

cavity. The breathing then often moves to the top of the chest area, whereby the shoulders are usually pulled forward. This posture is common among oral care workers and monitor workers.

- To avoid this unfavourable posture, a standing and sitting posture with a natural S-shape of the back is recommended, as shown on fig.3b.
- To adequately perform fine-motor procedures in the mouth, the practitioner sits stably upright, with the sternum slightly raised. The shoulders remain relaxed and are not pulled forward or backward. Sitting upright is in the first place important for minimizing the strain on the postural muscles, as mentioned above. Secondly, it is a condition for being able to perform fine-motor actions adequately. However, in between performing actions it is desirable to strive to make movements.
- To achieve the natural S-shape of the back, with the pelvis in the middle position, the knee angle, i.e. the angle between upper and lower legs, must be between 110-125°. (The middle position of the pelvis means that the pelvis is neither tilted forward nor backward).
- The upper body may slightly come forward (about 10°) from the hip joints. Make sure that the back moves forward as a whole so that the natural S-shape is maintained (and the back does not bend in a C-shape).
- Sideways bends and rotations of the upper body should be avoided.
- The head should not bend forward more than 25°, with the chin always slightly retracted, so that the extension of the neck is maintained as much as possible.
- If the head is bent forward more than 25°, the load of the neck muscles and the load of the intervertebral discs of the cervical spine becomes too high.
  Avoid also a forward position of the head (anterior position), i.e. sticking the chin forward.
- The upper arms may be held forward with a maximum of 15° when assuming a position.
- The forearms are bent in the elbow and raised 10-15° above horizontal, with a maximum of 25°.
- When moving, the upper arms may come forward no more than 25° and sideways no more than 15-20°. Movements further forward and to the side result in lifting of the shoulder, which causes unfavourable strain on the shoulder.
- The thighs are slightly spread, up to about 40° (hip width) in order to achieve a stable seating position, with the least strain on the hip muscles. So that the strain on the muscles and hip joints is as low as possible. If the thighs are spread too widely, there is a tendency to overstretch the lower back (hyperlordosis), while too much tension arises in the muscles around the hip joint. This leads to fixation of the pelvis and makes movements more difficult. In this way a reduced balance of sitting is created.
- The lower legs are perpendicular to the floor, at the same distance for the body and the feet are in the plane of the legs. In this position the stability of the body is maximal and the operation of the foot switch is most subtle.
- When the feet are placed facing sideways, there is a risk of exo-rotation of the legs from the hips, i.e. the thighs move outwards, causing a higher muscle strain.
- When the lower legs are positioned perpendicularly to the floor, in line parallel to the upper body and when spread out by only 40°, they are sufficiently distant from the upper body to provide a stable seating position.
- When the feet are placed wider apart than 40°, then they are positioned too close to the upper body/work chair so that the support of the body by the feet is less stable.
- If the lower legs are placed too far forward, the lower back tends to tilt backward; if the lower legs are placed too far backward, a tendency to hyperlordosis occurs, resulting in a less favourable load on the lower back.
- If it is unavoidable to work in a correct posture, find a posture that is as favourable as possible and allow this posture to last for a short time or provide regular breaks to relax the muscles.

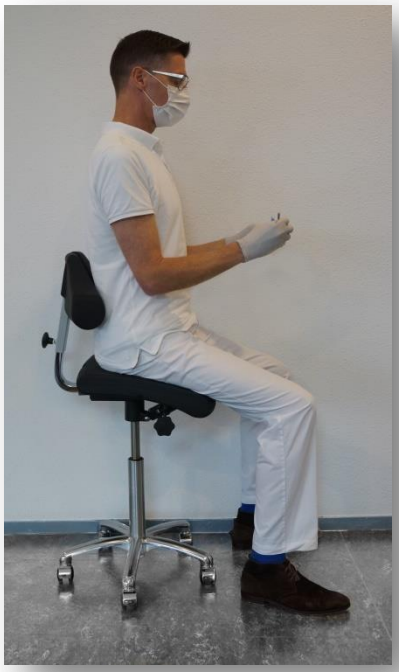


Fig. 4a Ergonomic sitting position (side view), with enlarged knee angle

- Head bent forward, with high neck flexion and chin retracted
- Forearms are raised 10-15°
- Back support against top/backside of pelvis

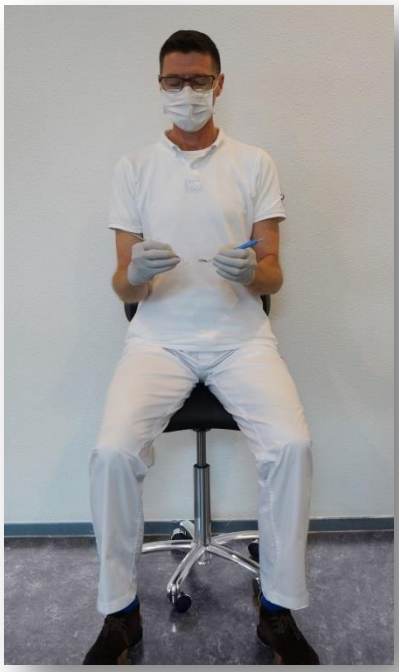


Fig. 4b Ergonomic sitting position (front …….view)

- Symmetrical posture with hands straight in front of upper body
- Upper legs spread 40°

Pictures: KEM, R. Wouters

4.2 Sitting on the work chair

- In order to sit in a stable upright position, with a knee angle of 110-125° between the lower and upper legs, a work chair is needed with a seat divided in 2 parts for obtaining a balanced sitting posture: a horizontal part at the rear (for supporting the buttocks, especially the ischial tuberosities or sit bones) and an oblique front part that slopes forward (for support of the forward sloping upper legs) (See fig. 4a and b).
- For an adequate support of the pelvis, a sufficiently hard and roughened upholstery of the seat is needed, depressing only slightly. If the upholstery is too soft it allows the pelvis to move into an incorrect and unstable position and that is tiring. The effect depends upon the weight of the practitioner.
  The soft tissues of the buttocks are less suitable for absorbing the weight of the upper body. If there is no sufficiently firm support of the sit bones the proprioceptive perception of the posture is limited. Receptors for proprioception are, except for the sit bones and in the area of the hip joints, not extensively present in the pelvic area. In this way, there is a less favourable basis for proprioceptive perception of sitting position than for standing.
  Note: The experience of seat hardness depends on body weight and size of the seat.
- The sides of the seat should not go up because, by doing so, the sides of the buttocks with their muscles are lifted upward and this reduces the fixing of the pelvis, particularly when the pelvis is not well supported. An ascending back has an upward force on the pelvis and can lead to tilting the pelvis too far forward. In addition, ascending sides obstruct the needed freedom of moving whilst sitting , whereas an all-embracing seat can also cause heat discomfort.
- For optimal support of the pelvis by means of the sit bones, it should be possible to tilt the entire seat forward by just a few degrees (2-3°).

- In order to support the buttocks and upper legs evenly, one takes place on the seat backward as far as possible.
- The backrest is used for 2 purposes:
    - as an indication that one sits upright, when one works without leaning against the backrest;
    - to support against when muscle fatigue occurs. This prevents the pelvis from tilting backward, causing the back to bend into an unfavourable C-shape.
- An elevated seating position with sloping thighs has further advantages: better possibilities to perform movements with the work chair, getting up and sitting down are easier and there are more possibilities to place the backrest of the patient chair with patient's body between thighs and forearms.
- Furthermore, the sloping thighs can be placed better under the backrest and the patient's mouth is more easily accessible. This also allows the practitioner and assistant to sit closer together.
- The back support of the work chair is placed against the lower back, just below the pelvic margin. It is precisely here that support must take place to prevent backward tilting of the pelvis.
- Positioning the back support against the lower buttock muscles and higher back muscles must be avoided, because this limits a good seating or mobility.
- Lying of the support above the pelvic rim is also undesirable, because the pelvis can then tilt backward under the back support.

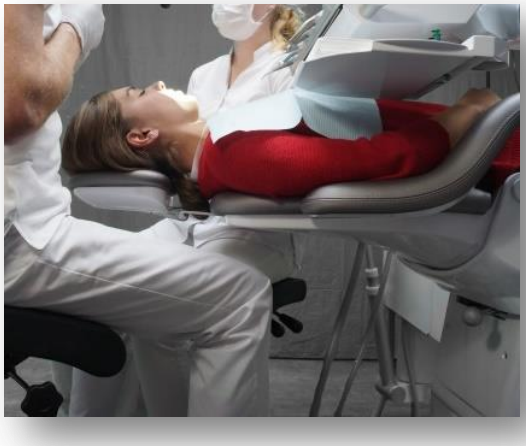
4.3 Sitting positions

- Right-handed practitioners from 9.00 - 12.00 hours with a starting position of 11.00 hours, left-handed practitioners from 15.00 - 12.00 hours with a starting position of 13.00 hours.
- Sitting lower than in the 9.00 position leads to an unfavourable asymmetrical posture of upper body and head and should therefore be avoided.
- The exact seating position is determined by being able to get a good view of the working field, i.e. by being able to look more or less perpendicular to it.
- If it is not possible to look as much perpendicular to the working field as possible, the eyes compulsively steer the body in a posture adapted to that, but less favourable.
- Adapt the seating position continuously during work when changing the approach of the working field, so that there is always a good view, working from a symmetrical posture with the upper arms closely to the body.
- When the drill head of the contra angle hand piece enters the viewing direction (eye-working field): turn the head of the patient and adjust the sitting position.
- At Four-Handed Dentistry, the dental assistant sits symmetrically upright, right in front of the practitioner in the zipper seat, so with the thighs of dentist (a) and dental assistant (b) in abab-position. Otherwise, the hands of the assistant are in an asymmetrical position in front of the upper body while further an asymmetrical posture arises in the assistant with bends forward and sideways, as well as rotations of the upper body. See further paragraph 4.12.
- An assistant may work in the zipper seat until about the 11.30 position of the dentist, but must stand up as soon as a good seating position is no longer possible. He or she will then stand at an angle to the dentist.
- If necessary, the right-handed practitioner can move beyond the 12.00 position; the dental assistant must then be on the other side of the patient chair.
- For the left-handed practitioner the above applies in mirror image.

4.4 Positioning patient body on patient chair

- The body of the patient is generally placed horizontally as much as possible, both for treatments in the lower jaw and upper jaw; and further on the level of the work plane height of the practitioner (this is the height of the practitioner's hands while performing a treatment). Certain medical situations can lead to oblique positioning of the backrest. Standing treatment is usually better in these situations.

- Horizontal placement of the body and head is necessary to direct the funnel-shaped opening of the mouth backward as much as possible, oriented towards the viewing direction of the practitioner. This also has the function of being able to move freely with the thighs under the backrest. If the backrest is angled, one quickly gets stuck with the legs, which leads to bending over of the practitioner to obtain sufficient visibility. This applies also to a large extent to the assistant who sits further away from the head of the patient chair.



Picture: KEM, R. Wouters

Fig. 5a Horizontal positioning of the patient by means of a horizontal position of the backrest of the patient chair, creating sufficient space for the upper legs of the practitioner and, above all, for the assistants upper legs.

- For treatments in the upper jaw, the patient's head is turned sufficiently far back: with the occlusion plane about 25° backward in relation to a vertical plane.
- For treatments in the lower jaw, the patient's head is turned more or less towards the chest when the patient is placed horizontally. This depends on the size of the mouth opening and obtaining an adequate vision. The working field is placed in the so-called book reading position, i.e. one places the working field as much as possible in the same way as you keep a book or newspaper in front of you while reading.
- During treatment in the lower jaw in the 9.00-10.00 sitting position, the lower jaw is placed horizontally as far as possible. If necessary, the backrest will be angled a little bit.
- It is often said that for treatments in the lower jaw the patients backrest has to be placed more or less obliquely, even if the practitioner sits behind the patient chair. This is not correct, because then the mouth opening of the patient turns forward so that the practitioner has to bend forward with his upper body to be able to look over the face of the patient for a good view in the mouth, which causes an overloaded work posture.
- Only for treatments in the occlusal plane of the lower jaw, from the 9.00-10.00 seating position, it may be necessary - in addition to tilting the patient's head forward - to place the backrest in an inclined position of 10-20° upwards in relation to the back of the patient chair.

4.5 Positioning of the working field in the patient's mouth in relation to the practitioner

- The working field is placed symmetrically straight in front of the upper body of the practitioner, at a distance of about 20 - 25 cm, in order to obtain the desired symmetrical posture, with the hands straight in front of the upper body in the plane of symmetry (= mid-sagittal plane).
- Further at working plane height, where the forearms are normally raised 10-15°.

- Distance from eyes or front of glasses to the working plane is 35 - 40 cm. At large lengths sometimes a little more.

4.6 Positioning the head of the patient for arrangement of the working field

- The patient's head is rotated for adequate positioning of the working field:
    - forward or backward;
    - obliquely to the right or left side, towards the shoulder (in lateroflexion);
    - to the right or left around the longitudinal axis of the head.
- In case of insufficient possibility of adjustment of the headrest to the desired positioning : try to find the best possible solution by additional support.

Pictures: KEM, R. Wouters

Fig. 5b Practitioner and assistant are sitting upright and facing each other in a zipper position.
Head patient rotated around 3 axes of rotation with upper jaw occlusion plane 20-25° backward from vertical for upper jaw treatment.
Instruments positioned within the viewing direction

4.7 Positioning dental light

- The light beam is approximately parallel to the direction of view, not deviating more than about 15°, in order to direct the light beam as much as possible perpendicular to the work in the mouth. This is necessary for shadow-free illumination of the working field including the surroundings and to prevent the emergence of skimming light, as a result of which less light is reflected.
- The lamp is placed just above the head of the practitioner; to the left or right of the head; when using a mirror slightly in front of it. Not further above the head, because then you have to reach too far upwards.
- Set up the lamp in such a way that it needs to be moved as little as possible, which by the way can often be done by the dental assistant.

Picture: KEM, R. Wouters

Fig. 5c Illumination beam dental lamp runs approximately parallel to the viewing direction of the practitioner.

4.8 Use of mirror

- A mirror is intended for indirect vision, lighting, screening of teeth and tongue retention. But not for holding off the cheek, what can be done better with a finger (finger is narrower, warm and easier to manoeuvre).
- When working with indirect vision, the mirror is placed in an inclined position, about 40°; when using a drill instrument it is often a bit more inclined.
- Point the light beam as much as possible perpendicular towards the mirror.
- For obtaining the desired position of the head of the patient for the purpose of an adequate mirror position: turn the patient's head in the 3 possible directions.

4.9 Placement of instruments

- Instruments should be placed within the field of vision, i.e. 30° to the right or left of the practitioner's plane of symmetry (mid-sagittal plane), to avoid undesired distant movements of the arms. This also prevents as much as possible tiring accommodation of the eyes (due to changed distance of eyes to object) and adaptation (= adaptation of the eye to the changed amounts of light). A whip unit/continental style fits best here.
- Hand instruments are placed at about 20 - 25 cm and dynamic instruments at 30 - 40 cm from the upper body of the practitioner.
- Rotating instruments connected to a whip arm (in the case of a whip/continental style unit) are inclined at an angle of 45° to a vertical plane.
- It is important that the traction of the hoses is minimal for limiting the load on hand and arm.

4.10 Positioning foot switch in relation to foot position

- Both feet are placed, starting from both upper legs at an angle of 40°, in front of the upper body in such a way that the feet point in the direction of the knees.

- The feet are hereby placed in a line parallel to the upper body in order to obtain a stable sitting position; and at a sufficient distance from the body.
- Placement of the foot switch is done in such a way that the foot stays as much as possible in the plane of the lower and upper leg when the foot switch is operated, because this gives the most subtle operation and a low strain.

4.11 Handling of instruments in modified pen grip

- The hand is used in a middle position of the wrist joint, up to a maximum of 15° upwards (dorsal flexion) (Fig.6).
- Avoid deviation of the hand (rotation of the hand towards the thumb or little finger), dorsal flexion (movement of the hand upwards) and palmair flexion (movement of the hand downwards) in the wrist joint.
- Bending in the wrist joint leads, among other things, to complaints in the carpal tunnel. Furthermore, the strength of the hand decreases with (major) wrist movements outside the neutral position.

Pictures: KEM, R. Wouters

Fig. 6 Required (√) and undesirable, extreme (X) positions of the hand

- The instrument is held in a three-point contact, with the tips of thumb, index finger and middle finger (Fig. 7).
- The thumb and index finger are approximately opposite each other, the index finger more at the active end of the instrument.
- The 3 fingers are held in a bended position around the instrument (i.e. not stretched, because then - in the end position of the joints - the force is less and the load is bigger).
- By using the modified pen grip, instead of the more strenuous ordinary pen grip, more strength, stability and dexterity are available and the wrist is loaded more favourably. Because this can then be handled as much as possible in a neutral position at which the force of the hand is greatest.

Picture: CTM UMCG

Fig. 7 Modified pen grip with proper support for ring finger and little finger

- Movements of instruments take place mainly by means of fingers and limited movements of the wrist joint; supplemented by movements of the forearm and to a limited extent of the upper arm; however, not of the upper body.
- With the ordinary pen grip, more deviating positions of the wrist joint are often used and therefore more strenuous movements take place within the wrist.
- When manipulating with an instrument in the mouth, the hand with the instrument is supported with the fourth and fifth fingers placed on a hard surface (dental arch or jaw or chin or cheek with bony support), inside and/or outside the mouth.
- The support can optionally take place through using a finger of the not active hand, which will provide the final support somewhere on a jaw arch.
- The right and left hand must be kept at the same height, otherwise the shoulder is raised on the side of the higher positioned hand, which causes an asymmetrical posture.
- For a right-handed practitioner, the support of the left hand (which often holds the mirror) is done in the same way as with the right hand: on the fourth and fifth finger and on a hard surface, and so on. Without support, the shoulder will be raised, which should be avoided.
  (With a left hand practitioner in the opposite way).
- If possible, the inside or ball of the hand is supported on the cheekbone, if necessary on the forehead of the patient, for stability and relief of the arms. This has the added advantage that patient's head can be maintained in a certain position or be turned when needed.
- Preferably use (hand) instruments with a thicker shaft of 7.5 mm to approximately 10 mm.

4.12 Posture dental assistant for Four-Handed Dentistry

For the prevention of postural abnormalities the dental assistant will have to sit in the same position as is healthy for the practitioner. So symmetrically upright with the arms next to the body and the head bent only slightly.
Horizontal placement of the patient is necessary not only for the posture and view of the practitioner in the mouth but also for the dental assistant. He/she usually sits at a somewhat greater distance from the top of the patient chair or patient's head than the practitioner. When the back of the patient chair is positioned obliquely than it is not possible for her to place especially her left upper leg (working together with a right handed practitioner) sufficiently far below the back of the patient

chair, sitting at the needed height and a reasonable distance from the patient's mouth. It is not possible in this way for her to adopt an ergonomically healthy sitting position. .

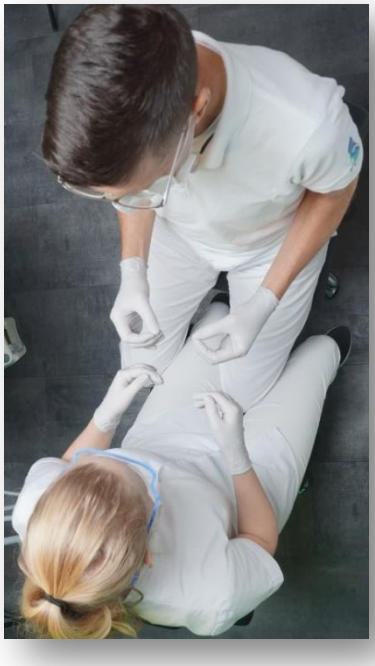


Fig. 8a Dentist and assistant in zipper position, symmetrically upright, with hands straight in front of body

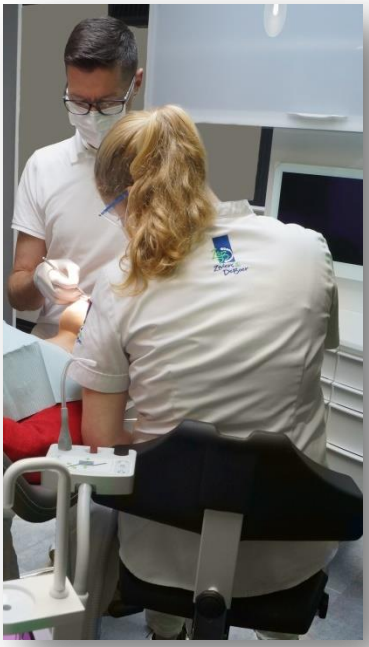


Fig. 8b Assistant in unfavourable non-symmetrical posture as her working field, the patient's mouth, is not in her symmetrical plane (because he/she is not sitting directly opposite the dentist).
NOTE: Unfavourable placement of high velocity and saliva ejector at 3 o'clock position

Pictures: KEM, R. Wouters

For adopting a symmetrical working posture by a dental assistant, the working field in the mouth must also be placed symmetrically right in front of him or her, so that necessary activities can be carried out with the hands around his/her plane of symmetry (= the mid-sagittal plane). Otherwise rotations and bends with the upper body forward and sideways will take place resulting in unfavourable asymmetrical working postures. Usually the assistant will also sit then with bent back apart from a supporting backrest.
This means that an assistant for the purpose of an ergonomically correct sitting position must be able to sit directly opposite the practitioner, with the legs of the practitioner and assistant in an abab-position (dentist a and assistant b or vice versa), in the so-called zipper position. Only then the working field can also be placed symmetrically in front of the assistant.
When the practitioner works in the 9.00-10.30 o'clock sitting position, it is not so difficult to sit down in the zipper position. Problems arise especially when the practitioner works in the 12.00 o'clock sitting position with his legs placed forward, because then the assistant is forced to sit with the legs parallel to the upper legs of the practitioner. This leads to rotations as well as forward and sideways bending of head and body, while the hands are placed to the left to perform activities. This results in an unfavourable asymmetrical posture.
Also when the assistant is forced by the position of the upper legs of the practitioner to sit in a wide spread seat, a corresponding bad posture arises.
When the practitioner works from the backside of the patient, about 10.30 to 12.00 o'clock, the practitioner should sit in the 11.00 position as much as possible. This requires turning the patient's

head sideways to the right (in lateral flexion), supplemented by tilting the head forward or backward and rotating the head to the right or left to obtain good vision; in the manner described earlier. For this purpose, however, a suitable head support is required, possibly with an additional pillow, for support.
The Dutch Occupational Health and Safety Act requires the employer to ensure healthy working conditions for the employee. It is therefore important to pay attention to an ergonomic working method.

For working in a zipper position, it is desirable that practitioner and assistant differ little in length from each other. Often a female assistant has to sit a bit higher working with a male practitioner, because she is often a bit shorter. This requires a work chair that can be used for this purpose. It is desirable to take this into account as much as possible when recruiting a feminine assistant.
In case of too large differences in height and in work situations where the assistant can't sit symmetrically opposite the dentist, the assistant has to shift to standing.

Finally, for an adequate way of grasping and placing instruments back, it is also required for the assistant that instruments are positioned within the field of vision, 30° to the left and to the right in relation to the plane of symmetry. This is often not the case (Fig 8b). Instead of repeatedly bending to the side and rotating with the upper body, it is then necessary to move the work chair backward for a moment and then turn with it in the direction of the required instrument, grasp the instrument and move back in the direction of the patient's mouth. The replacement of instruments is done in a corresponding manner. It takes some training to be able to do this quickly at all times.

Placement of instruments for handling by the dental assistant

In order to work ergonomically, it is necessary to set up instruments:

- in the field of vision, i.e. within an angle of 30° left and right to the median = plane of symmetry of the assistant's upper body;
- at working height, i.e. the height at which the work is carried out in the mouth;
- at a distance of 20 cm to a maximum of 25 cm from the assistant's body in the case of hand instruments;
- at a distance of 30 cm to a maximum of 40 cm from the assistant’s body in the case of dynamic instruments, i.e. instruments connected to a hose.

In this way, instruments can be picked up and placed back again with a favourable , natural way of reaching for the instruments while unfavourable torso twists and bends, both forward and sideways, are prevented. As well as the lifting of the shoulders which takes place when the instruments are placed too high and too far away.
If an assistant is forced to make the above mentioned unfavourable movements due to incorrect positioning of the instruments, then they will occur frequently during the work and therefore contribute to shoulder, upper back and neck complaints.
With regard to the handling of instruments while working with the practitioner during patient treatment, there are 3 situations:

1. Handing over hand instruments to the practitioner and taking them back after using.
   The most favourable place for the tray with hand instruments is between assistant and patient or - by using a body tray - on the patient's chest.

   NOTE. If the tray is placed above the patient, connected to the dynamic instruments holder or to a separate supporting arm, the placement is usually too high for the assistant. This is because the tray is soon placed approximately 10 cm above the patient's chest. If the tray is placed too high in front of the assistant, the upper arm and shoulders must be raised when

grasping and returning instruments and this will cause an unfavourable strain on the shoulder region.

2. Use of a high velocity suction unit or dental assistant's unit by the assistant.
   The best solution is a suction unit or assistant's unit coming from behind the patient's head. This can be placed in a good position for both the assistant and the practitioner.
   An effective solution can also be a suction unit that is attached to the side of the dynamic instrument console with a movable bracket.
   Good use requires a working height adjustment in relation to sitting or standing use.

   NOTE. Although frequently used, placement of a suction unit or assistant unit on the left side of the patient (so left of an assistant working on the left side of the patient chair) causes concerning posture and the way of grasping instruments. Forced lateral and backward gripping and repositioning of instruments results in an undesirable lateral bending and rotation of the upper body and head, i.e. of the entire spine; as well as an exorotation of the wrist. Sometimes there is not enough room for the suction unit between assistant and spittoon and then it stands more or less behind the assistant.
   As previously described: a solution for preventing these repetitive, unfavourable movements is: move the work chair backward for a moment and then turn with it in the direction of the instrument needed. Subsequently take the necessary instrument and move the work chair back in the direction of the patient's mouth. These movements also contribute to a regular alternation of the load of the working posture.

3. Handing over multifunctional syringe or dynamic instruments to the practitioner and replacing these.
   This requires an instrument holder or console that is positioned above the patient and in such a way that the instruments are easily accessible for the assistant. Sometimes the assistant only uses the instrument holder's multifunction syringe, so that accessibility is limited to the multifunction syringe.

   NOTE. If a separate multifunction syringe is included in the suction unit or assistant unit, then the same objections apply to use as stated in the previous point regarding the placement of the suction unit.

If there are problems with the height adjustment, then sometimes an improvement can be achieved by adjusting the seat height.
When using the aspiration cannula the hand , with which it is used, should rest on the patient's head as well as possible. Otherwise, the arms and hands will be subjected to prolonged static strain.
The above is a brief description of the ergonomic working method of the assistant as to Four-Handed Dentistry.

5 Key principles for an ergonomic way of working

5.1 Basic Criteria

The following five criteria are the basis for achieving an ergonomically healthy working posture, whereby by performing sufficiently movements during activities, the most favourable load can be achieved, so that physical complaints are prevented or limited. Furthermore, work can be done more efficiently. It also forms the basis for a healthy working posture of the assistant, if applicable.

The five basic criteria form the summary of the fundamental principles for a healthy way of working.

1. The working posture is symmetrically upright and the head is bent slightly forward.
2. The working field lies in the plane of symmetry and is directed towards the viewing direction of the practitioner.
3. The light beam of the lamp is parallel to the direction of the practitioner's viewing direction gaze.
4. Instruments are handled in the modified pen grip.
5. Ensure an active working posture by making movements as variety for performing actions in the mouth of the patient.

Fig. 9a Symmetrical upright

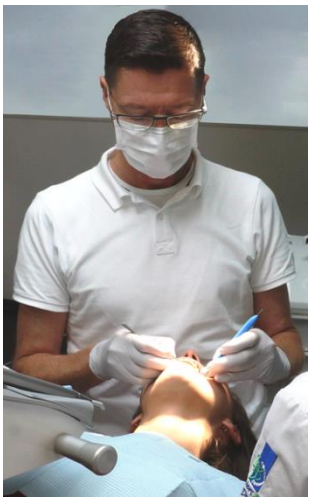


Fig. 9b Working field in plane of symmetry

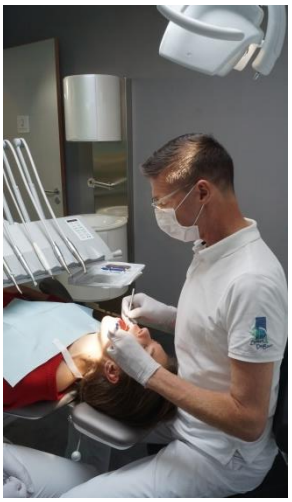


Fig. 9c Light parallel to the viewing direction

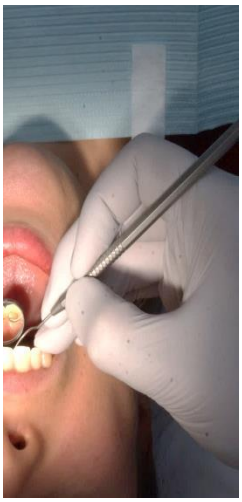


Fig. 9d Modified pen grip

Pictures: KEM, R. Wouters

5.2 Checklist Ergonomic Handling for the dental practitioner

In the checklist below, step by step, based on the five basic ergonomic criteria, the starting points for a healthy, ergonomically well considered working posture are listed, but now without explanation. The numeration below corresponds with the numeration in the previous chapter, in which explanations are given.

A. The working posture is symmetrically upright and the head is bent slightly forward

Working posture

- Sit symmetrically upright in an active sitting posture with the back relaxed stretched and with the spine following the S-shape. The leg angle (between upper and lower leg) is between 110-125°.
- When performing actions in the mouth, sit steadily upright with the sternum pulled a little forward and upward. But try to make movements between performing actions.
- Move the upper body as a whole not more than 10° forward in the hip joints.
- Move the head at most 25° forward with the chin retracted.
- Avoid sideways bent postures and rotations of the upper body.
- With a static position of the arms - Keep upper arms max. 15° forward and lift forearms 10-15°.
- When moving the arms - Move upper arms not more than 25° forward and 15-20° sideways.
- Spread the upper legs about 40° and place the lower legs perpendicular to the floor; the feet are not turned out or inward in relation to the upper legs. The feet are then automatically placed sufficiently far in front of the upper body.
- When it is unavoidable to adopt an unwanted posture: look for the best possible posture and let it last as short as possible or interrupt this posture from time to time.

Sitting on the work chair

- Sit on a horizontal rear part of the seat, with the front part of the seat inclined forward, parallel with the sloping down thighs.
- Sit on the seat as far back as possible.
- Only when necessary: tilt the seat a few degrees forward. More is undesirable to prevent slipping off the seat.
- Use the backrest to guide you to a correct sitting posture or to lean against it.
- To do this, place the backrest at lower back level just below the pelvic edge, without pressure on buttock or back muscles.

Sitting positions

- For right-handed practitioners the 9-12 o'clock sitting positions, with the 11 o'clock sitting position as a starting point. (For left-handed practitioners the 3-12 o'clock sitting positions, with the 1 o'clock sitting position as a starting point).
- Choose the exact sitting position depending on the possibility to look perpendicularly to the working field as much as possible.
- If the approach to the working field has changed, adjust the sitting position always in such a way that it is possible to look perpendicularly to the working field as much as possible.
- If the drill head of the angle piece enters the viewing direction: turn the head of the patient and adjust the sitting position.
- For performing Four-Handed Dentistry, the assistant sits opposite the practitioner in the zipper position. If this is not possible, he or she will stand.

B. The working field lies in the plane of symmetry and is directed at the viewing direction of the practitioner

Positioning body patient

- For treatments, in both the lower and upper jaw, place the patient's body horizontally.
- Then, from the obtained position of the mouth opening, provide the desired view of the working field by turning the head in 3 directions (see next 2 items).

Placement of the working field in the patient's mouth in relation to the practitioner

- Place the working field right in front of the upper body of the practitioner, about 20-25 cm away, in the plane of symmetry.
- The viewing direction must be perpendicular to the working field as much as possible.
- Distance from the eyes, or front glasses, to the working field is 35-40 cm, sometimes a little more.

Turning of the head of the patient for positioning the working field

- For adequate positioning of the working field, turn/ or tilt the head of patient:
    - forward or backward;
    - obliquely to the left or right towards the shoulder; and
    - along the longitudinal axis of the head to the left and to the right.

  Mostly a combination of the 3 turnings of the head of the patient is necessary, in connection with determining a good sitting position.
- The working field in the lower jaw is set up in the book reading position. In the upper jaw, starting from placement of the occlusion plane about 25° backward from the vertical, the correct positioning of the working field depends on whether the patient treatment is done with direct or indirect vision.

C. Light beam of the lamp is parallel to the direction of view of practitioner's gaze

Positioning dental lamp

- Position the light beam of the lamp as parallel as possible to the viewing direction of the practitioner, not deviating by more than 15°.
- Position the lamp just above the practitioner's head, to the left or right of the head. When using a mirror slightly in front of it.
- Adjust the lamp in such a way that it needs to be moved as little as possible.

Usage of mirror

- For indirect vision place the mirror at an angle of approximately 40°. When using an angle piece often slightly more inclined.
- Place the light beam of the dental lamp as much as possible perpendicular to the mirror.
- For an adequate mirror position, rotate the patient's head to match the desired mirror position.

Positioning instruments

- Place instruments as far as possible within the field of view, i.e. 30° to the right or left of the plane of symmetry.

- Place hand instruments about 20-25 cm and dynamic instruments about 30-40 cm from the upper body.
- Rotating instruments are at an angle of 45°.
- Use hoses with minimal traction.

Foot switch positioning

- Position the footswitch in such a way that the foot stays in the plane of the lower and upper leg as much as possible during operation.

D. Instruments are manipulated in the modified pen grip

Handling instruments in modified pen grip

- Hold instrument with three-point contact with thumb, index finger and middle finger: thumb and index finger approximately opposite each other, the index finger more at the active end of the instrument.
- The three fingers are held in a bended position around the instrument, while the hand is in a middle position of the wrist joint, up to about 15° to dorsal (top).
- Support the hand with the instrument with the fourth and fifth fingers on a hard surface (jaw arch, jaw or chin/ cheek with bony support).
  Support can also be obtained through using of a finger of the non-working hand which is placed on a jaw arch.
- Support, if possible, with the inside or ball of the hand on the cheek bone or head of the patient.
- Support also the non-working hand, with an instrument (mirror), in the same way, using the fourth and fifth fingers. Both hands are at the same height in front of the upper body.
- Carry out movements of the instrument mainly with the fingers and to a limited extent using the wrist joint around the neutral position; supplemented with movements of the forearm and to a limited extent of the upper arm.

E. Ensure an active posture by making movements as a variety for performing actions in the mouth of the patient

Dynamic sitting / standing behaviour

- Take care of making movements during patient treatment as a variety for performing actions in the mouth of the patient, to relieve the muscles. Keep moving also by the way of working around the patient chair.

6 Concluding remarks

In relation to the frequent occurrence of posture problems, it is important to pay a lot of attention to the prevention of posture disorders by starting from an ergonomic working method. This requires a twofold approach, because the dental practitioner works in a human-machine system. To begin with it is about the human being: every person is unique. He distinguishes himself in e.g. physique, body proportions, habitual posture, motor skills and physical conditions. Subsequently the different characteristics should guide the workplace ergonomics so that the working conditions become appropriate for the user. It means that these must match the physical characteristics and also the possibilities and limitations of a practitioner for an ergonomic way of working. In other words treatment equipment, the machine side, must be adequately attuned to the variety of requirements of the dental practitioner to make ergonomically working possible. For example, a practitioner of 1.85 metre will have to use the dental equipment in a different way to sit and work in a responsible way than a practitioner of 1.60 metre. An example can be the adjustment of the height of the patient chair in relation to the practitioner's own height.

For prevention of postural disorders, knowledge and training is required regarding a healthy way of working and a proper use of treatment equipment.

Existing complaints concerning posture and musculoskeletal disorders or problems with sharp vision may require appropriate measures to arrive at an ergonomic working method.

In some cases, ergonomic workplace advice is recommended to prevent posture-related complaints.

References / consulted sources

This theme document is based on:

- Ruijter RAG de. ABC-checklist Ergonomie, Kenniscentrum Tandheelkundige Ergonomie UMCG. Available at: www.tandheelkundigeergonomie.umcg.nl. Consulted 1 September 2017.

  This checklist has been in use for many years in education and also in ergonomics education in oral care practice, but has been updated and better substantiated for use as a theme document.

  The ABC checklist Ergonomics provides summaries from:
  - Hokwerda O. Syllabus Ergonomie in de tandheelkunde, CTM, Universitair Medisch Centrum Groningen;
  - Syllabus Arbeid en gezondheid. Ergonomie in de tandheelkunde, Studiejaar 2016-2017, ACTA, Academisch Centrum Tandheelkunde Amsterdam;
  - Hokwerda O, Ruijter RAG de. Innemen van een gezonde zittende werkhouding bij de patiëntbehandeling. Kenniscentrum Tandheelkundige Ergonomie UMCG. Available at: www.tandheelkundige ergonomie.umcg.nl. Consulted 1 September 2017;
  - Ruijter RAG de. Wijze van hanteren van instrumenten voor het uitvoeren van tandheelkundige verrichtingen, Kenniscentrum Tandheelkundige Ergonomie UMCG. Available at: www.tandheelkundige ergonomie.umcg.nl. Consulted 1 September 2017.

These documents are related to:

- Delleman NJ, Haslegrave CM, Chaffin DB. Working Postures and Movements. Tools for Evaluation and Engineering. London, New York, Washington; CRC Press LLC, 2004
- ISO Standard 11226 Ergonomics – Evaluation of static working postures
- Hokwerda O, Ruijter RAG de, Wouters J, Shaw S. Ergonomic Requirements For Dental Equipment, 2007 UMCG. Available at: www.tandheelkundige ergonomie.umcg.nl. Consulted 1 September 2017
- Bos-Huizer JJA, Bolderman FW. Gezond bewegen in de tandheelkunde. Ned Tijdschr Tandheelkd 2014; 121: 106-110
- Demeulenaere S. De invloed van de gewoontehouding op de uithoudingscapaciteit van spieren van de dorsale keten. Gent: Faculteit Geneeskunde en Gezondheidswetenschappen, Revalidatiewetenschappen en Kinesitherapie; Academiejaar 2009-2010: 4.
- Hayes MJ, Cockrell D, Smith DR. A systematic review of musculoskeletal disorders among dental professionals. Int J Dent Hyg 2009; 7: 159-165
- Peereboom KJ, Scheijndel PAM, Red. Handboek Ergonomie/ Human Factors 2015. Alphen aan den Rijn: Vakmedianet: 2014
- Saer L De, Matthijs S. Een cross-sectionele studie naar de invloed van de gewoontehouding op proprioceptie en posturale controle bij asymptomatische jong volwassenen. Gent: Faculteit der Geneeskunde en gezondheidswetenschappen, Revalidatiewetenschappen en Kinesitherapie; Academiejaar 2010-2011: 18
- Sociaal Fonds Particuliere Beveiliging. Fysieke belasting: stabelasting (met advies TNO en Gezondheidsraad). In: Korte E de, c.s. Veilige grenzen voor statijden. Gorinchem: Sociaal Fonds Particuliere Beveiliging; 2016: 5