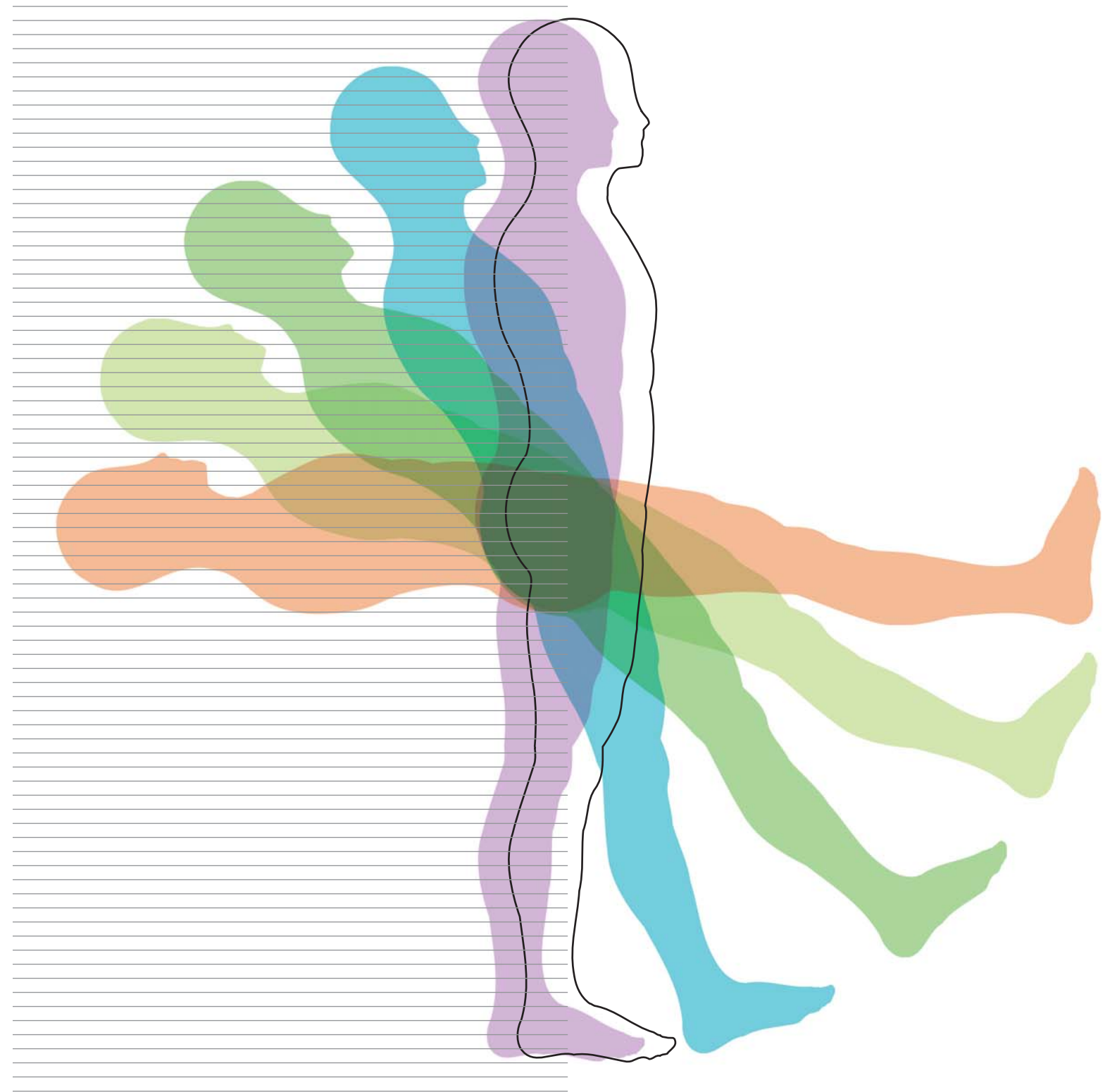


Human-Centered
Dental Treatment System
Interface

HUMAN CENTERED SYSTEM FORMATION



Human-Centered
Dental Treatment System
Interface

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Tools that are useful to users

Tools in general need to be comfortable, easy and simple to use, and to help reduce the time needed to get work done. Safety and overall economy are also considered in selecting tools, and a good appearance or "being with-it" must not come first. These considerations should be kept in mind, particularly in selecting tools that have a significant impact on work productivity and quality and are intended to be used for a long period of time.

No automobiles are equipped with a left-foot accelerator pedal

A wide variety of automobiles are in the market such as Japanese cars, imported cars, luxury model cars, light motor vehicles, cars with right-hand drive and those with left-hand drive. However, have you ever seen any cars with a left-foot accelerator pedal?

In principle, equipment around the driver's seat is arranged in the same manner regardless of the automobile type.

Why?

The left and right feet have a different sense from each other and the left foot is not suitable for delicate control of an accelerator or brake pedal. That is why accelerator and brake pedals are designed for operation with the right foot.

Automobiles are thus made based on senses common to all people and natural motions of the human body, and automobiles of different types share the same arrangement of equipment around the driver's seat.

In other words, automobiles are made to suit human anatomy and function.

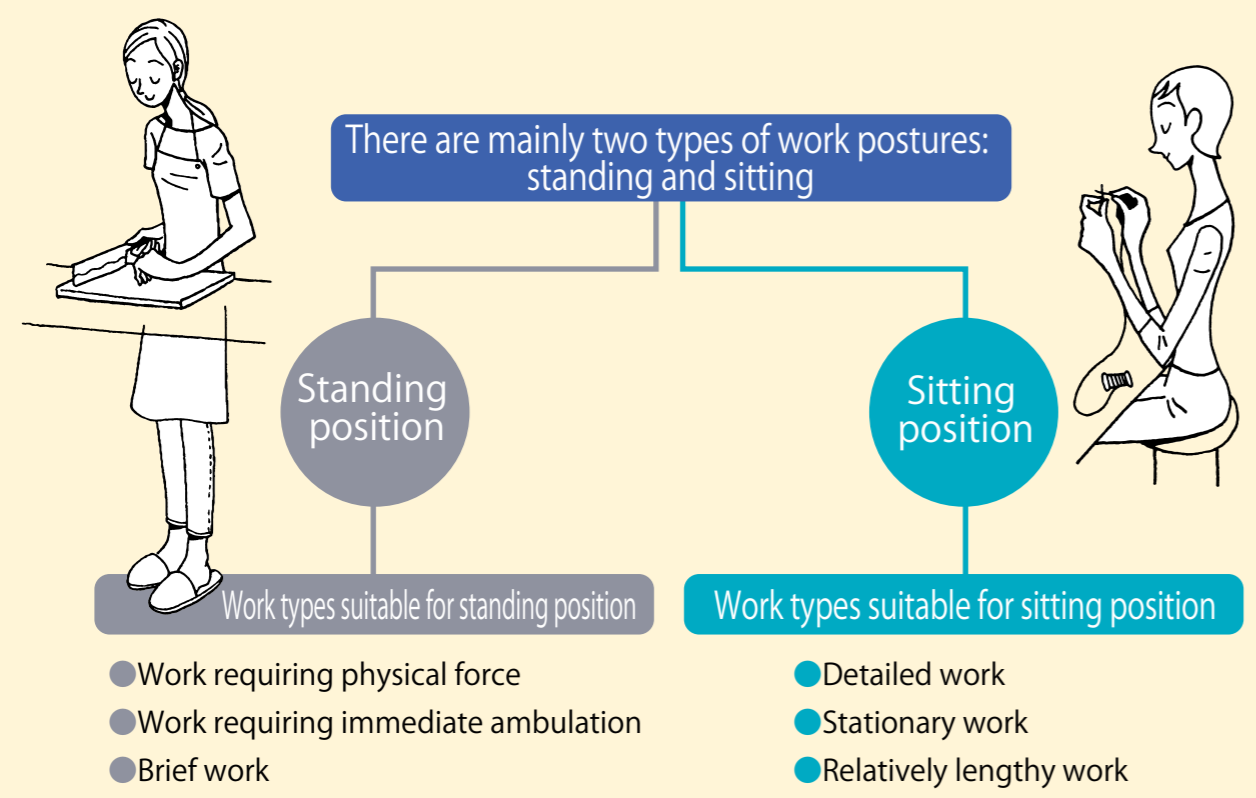
This brochure reviews a dental treatment system that has been designed based on senses common to all people (proprioception) and natural motions of the human body.

.....

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References: Takashi Iijima. CGWORLD Editorial Office, ed. Structure of the Human Body.

Chapter 1 | Work Posture



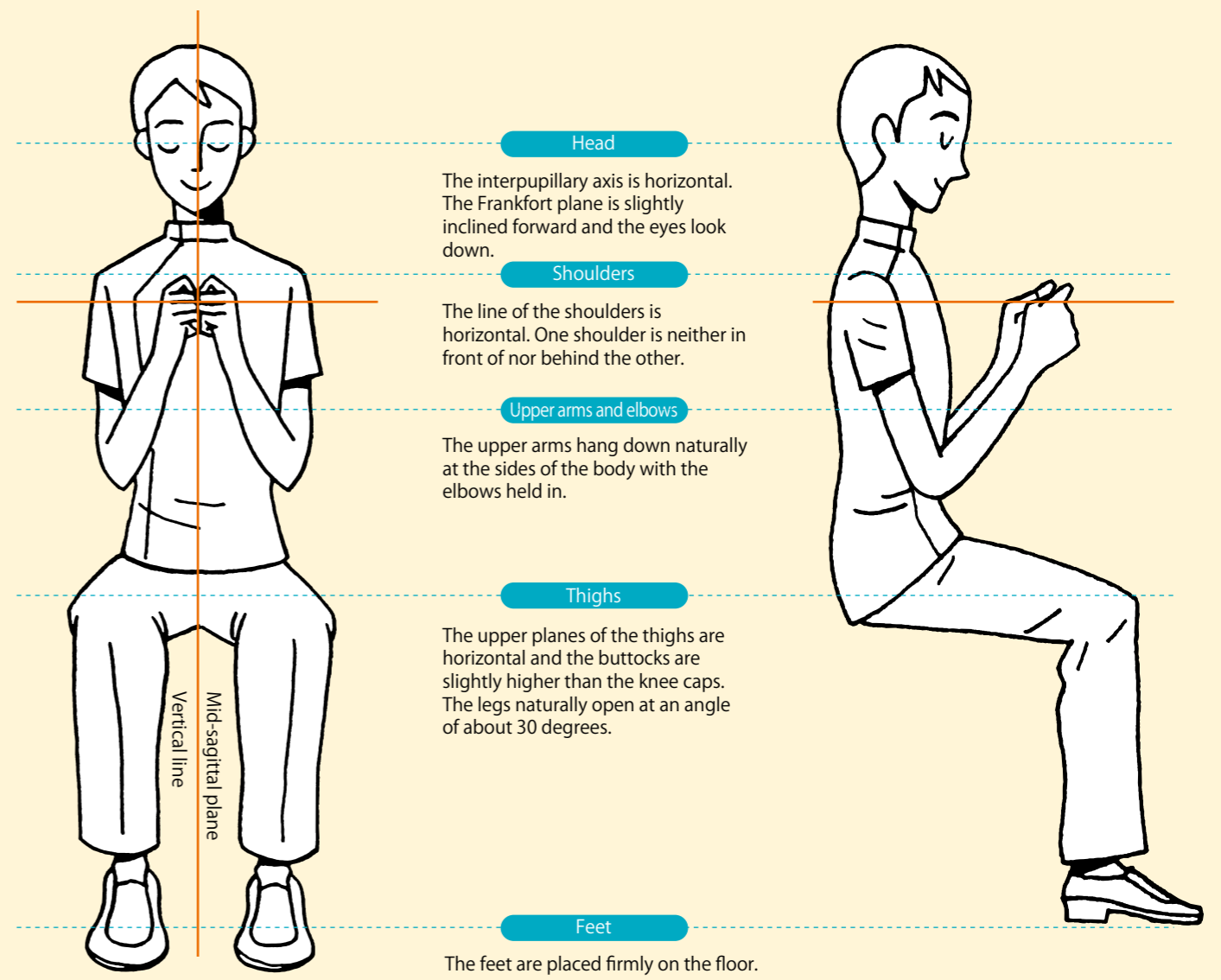
For dental procedures, the operator's manual work in the patient's mouth requires

- accuracy
- stability
- constancy
- little physical force
- a relatively long period of time in a fixed work area

Sitting position is thus appropriate for dental procedures

What body position is best for performing dental procedures?

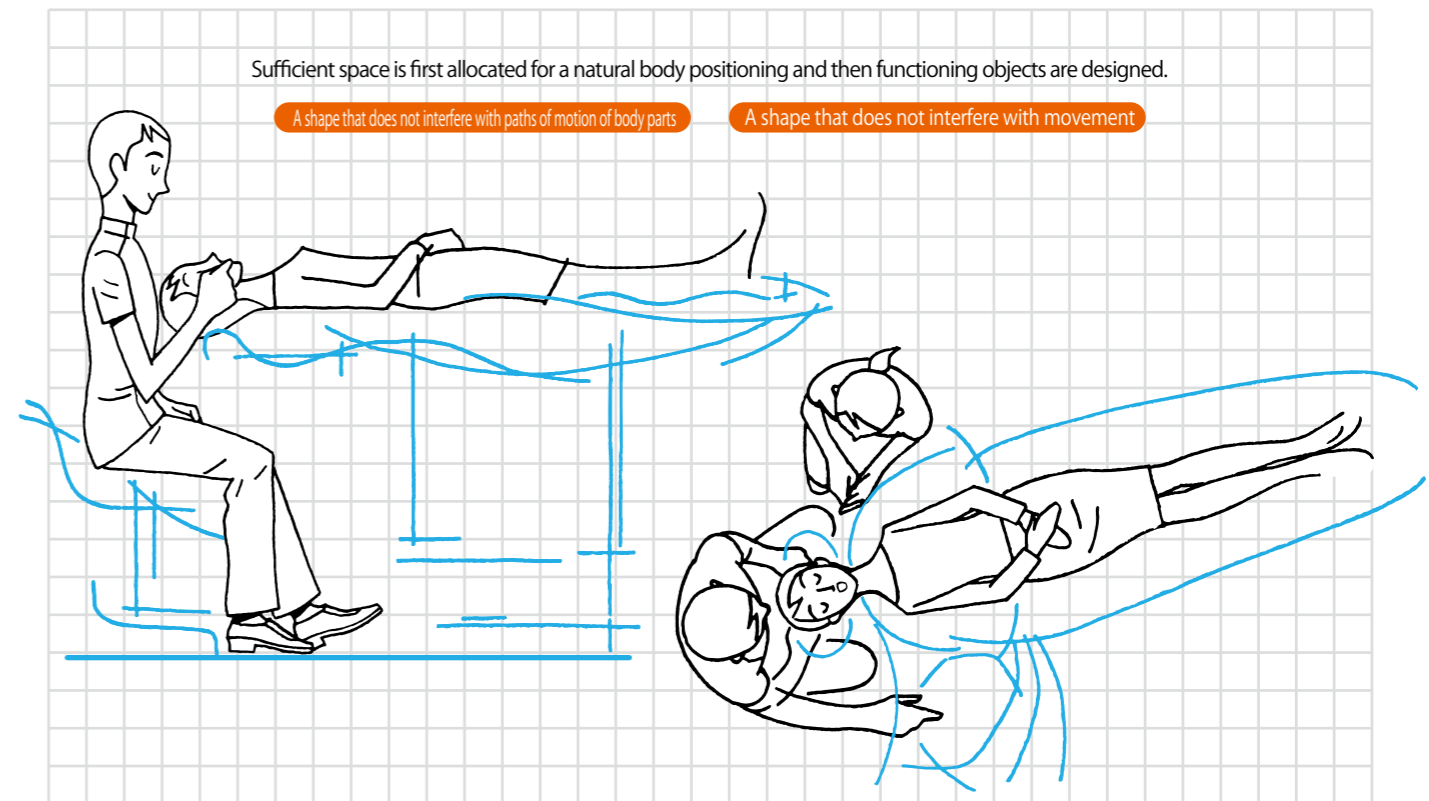
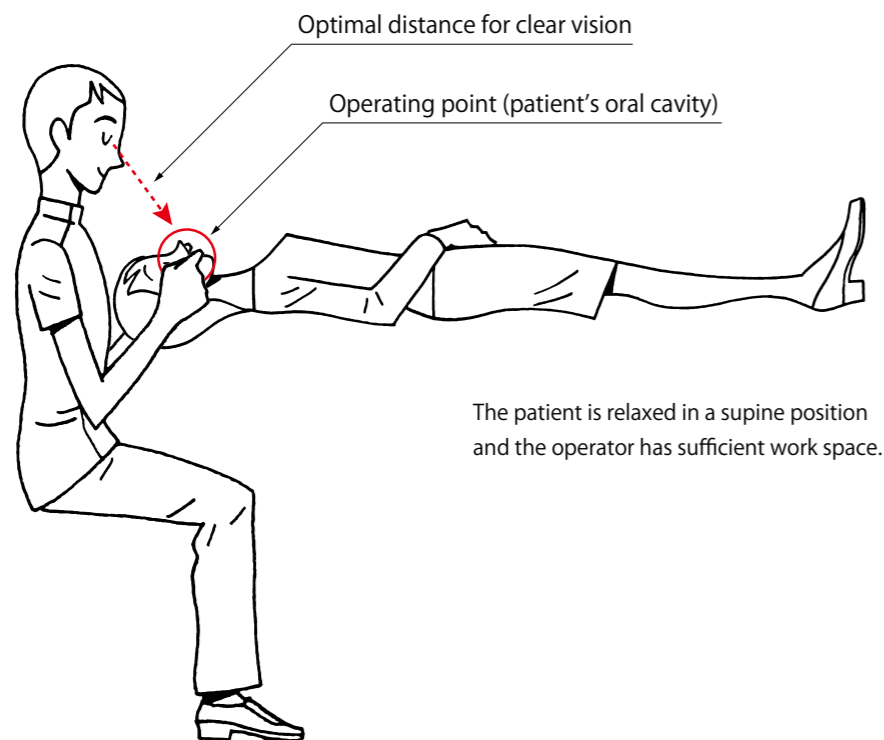
©Common features shared by natural postures



Human-centered design

Optimal performance of a dental care provider is a prerequisite for delivering the best possible dental care to a patient. This idea encourages the establishment of a better work environment including sufficient space for the operator's natural body positioning and effortless motion as well as the design and layout of instruments. This is a path to precise, less tiring, and speedy dental care delivery.

©The operating point (patient's oral cavity) should be within the range of clear vision



What senses are important in dental care?

The following senses are mainly used while an operator performs precise dental procedures.

Balance

This is the most basic human sense for attaining a stable position that withstands the force of gravity. The sense of balance also influences all senses presented below. If our body is not stable, we cannot effectively use other senses.

Kinesthetic Sense

This sense works with the contraction and extension of muscles in response to commands from the brain based on information transmitted from body parts. This sense plays an important role in performing precisely controlled finger work. For instance, this sense controls both direction and distance of bur movement.

Touch

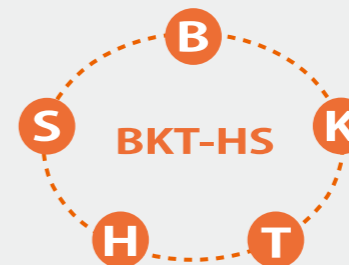
This sense is essential for complete and accurate perception of an object and its form (structure), surface texture, elasticity, pressure and temperature. Tactile sense is used to perceive tooth surface irregularity with the tip of an explorer, to remove tooth structure with a bur, and remove soft dentin in the floor of a cavity with an excavator, to give only a few examples.

Hearing

For instance, this sense is used to operate a high-speed handpiece at the required speed.

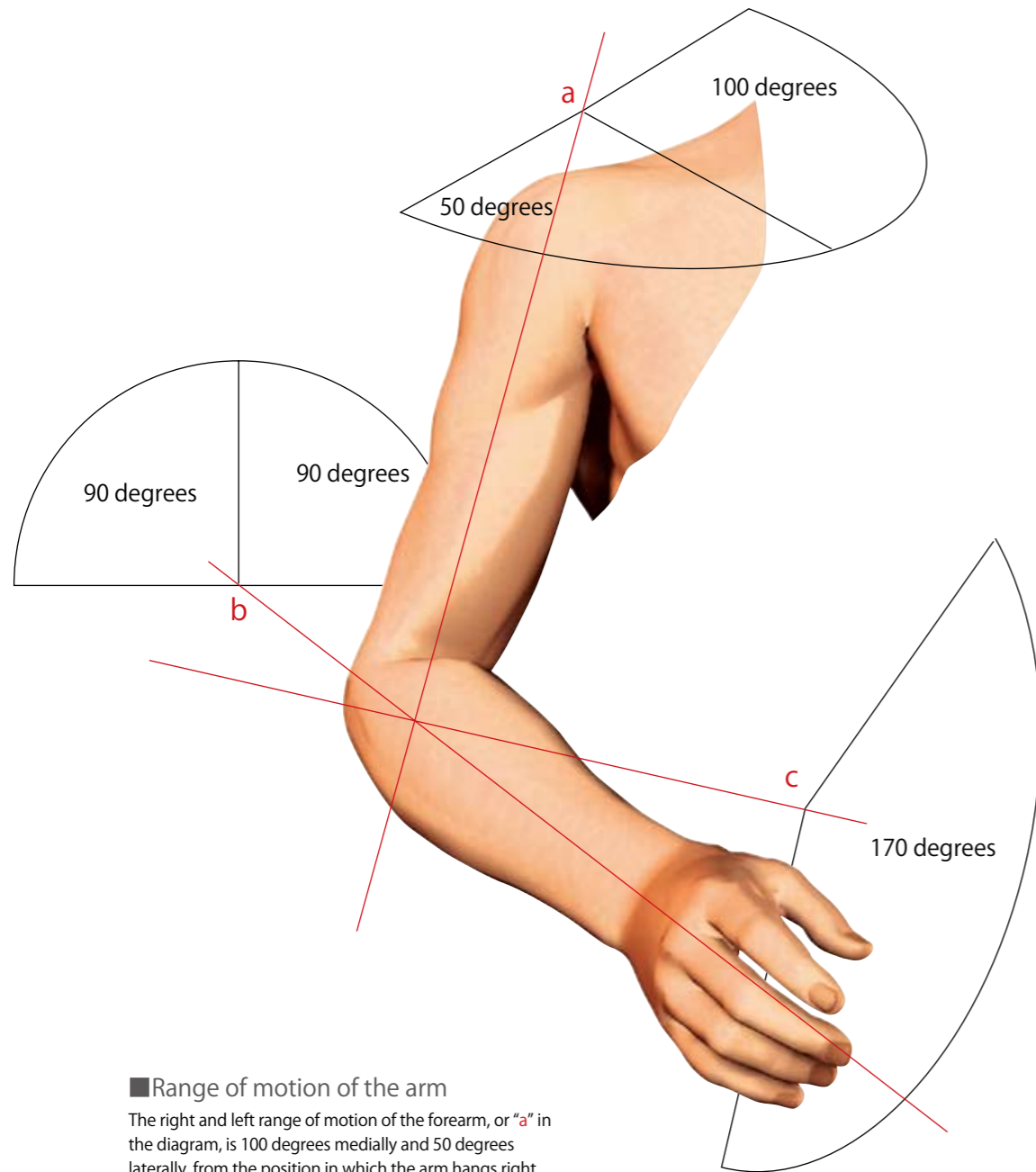
Sight

This sense is the primary one for perceiving an object. However, too much dependence on vision may lead to poor control of fingers. When an operator performs cutting work, kinesthetic and tactile senses play a major role in handpiece manipulation, while vision is mainly for checking the outcome. Relying solely on vision during dental procedures may result in clumsy finger work.



All of these five senses, BKT-HS, are essential for dental work. The first three senses, B, K and T, are for output and basically different from receptive senses of H and S. An appropriate spatial arrangement should be planned by eliminating those factors that may prevent the operator from using these senses during dental procedures, considering the five senses in the order of B, K, T, H and S.

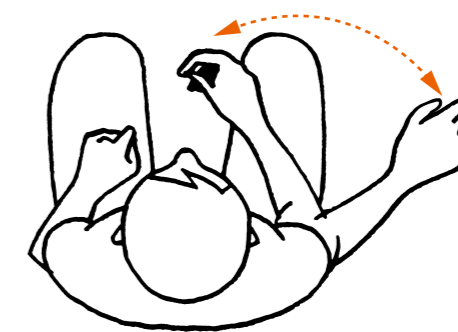
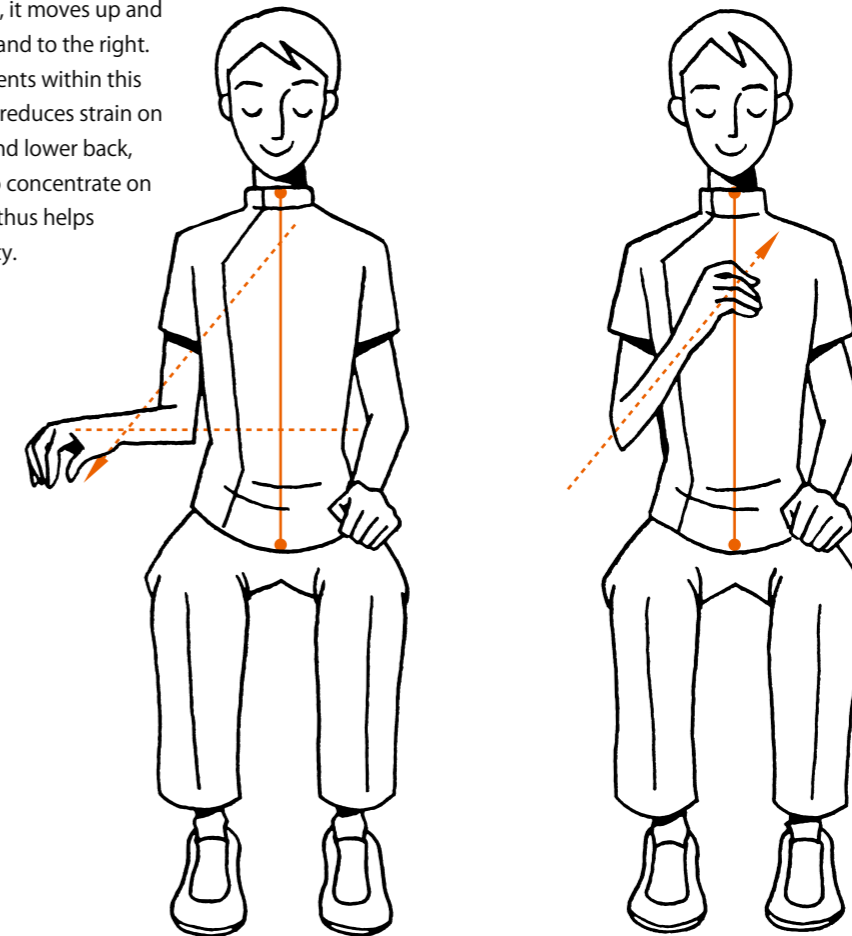
Natural motions and their ranges



Range of motion of the arm
 The right and left range of motion of the forearm, or "a" in the diagram, is 100 degrees medially and 50 degrees laterally, from the position in which the arm hangs right down (rotation angle of 150 degrees). The range of rotation of the wrist, or "b," is 45 degrees toward each side, from the position in which the thumb points forward (rotation angle of 90 degrees). The up and down range of motion of the forearm, or "c," is 170 degrees medially alone, from the position in which the upper arm hangs right down (rotation angle of 170 degrees).

©Natural motion of the right forearm

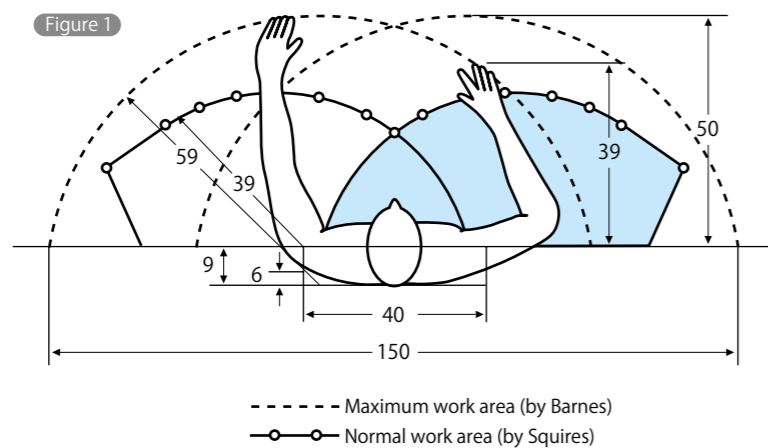
When you naturally move the right forearm up and down, it moves up and to the left, and down and to the right. Placement of instruments within this natural motion range reduces strain on the arms, shoulders and lower back, allows the operator to concentrate on what he is doing and thus helps improve work accuracy.



Instrument arrangement

◎The operator's right arm dictates where to place instruments

The motion of the operator's right forearm naturally dictates where to place instruments. As shown in Figure 1, human arms have their own natural range of motion. If an instrument is within the normal work area, the operator can pick it up and put it back with little physical effort, but if an instrument is outside the normal range, the operator has to fully extend his arm or twist/bend his body to reach it. Whether handpieces are positioned within the normal work area is thus one of the critical criteria for selecting a dental treatment system.



The blue area represents the normal work area for the right hand. The patient's mouth and handpieces should preferably be positioned within this range.

◎How to place instruments (angle and direction)

In addition to placing instruments within the normal work area, how to place them (angle and direction) is also important for work efficiency. Natural motions of the operator's hands and fingers should be considered because, like the arms, hands and fingers also have their own natural range of motion. There are roughly four ways of picking up an instrument as shown below:

- ① Scoop up an instrument with the lateral side of the index finger
- ② Pick up an instrument with the fingertips
- ③ Grasp an instrument with the palm
- ④ Receive an instrument that is delivered into your hand by another person

Of the above, motion ① is the most appropriate for picking up a handpiece connected with a tube, like an air turbine, which is frequently used during dental procedures. If the operator can place such a handpiece on the operating point without adjusting its position in his hand, he can then scoop it up with the same motion and maintain an undisturbed gaze at the operating point while picking the handpiece up and putting it down (Photo A).



(Photo A)

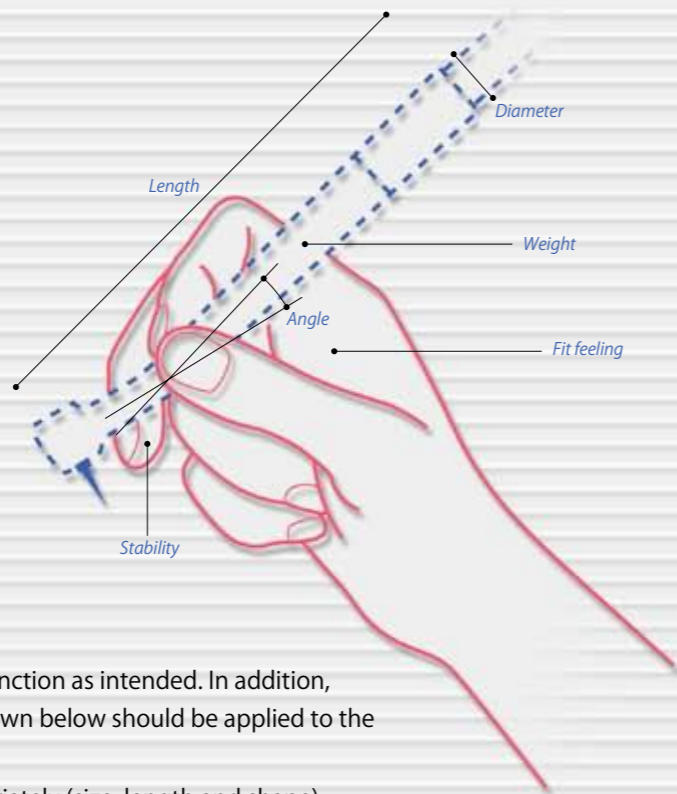


Shifting the operator's sight line puts him in an unstable body position.



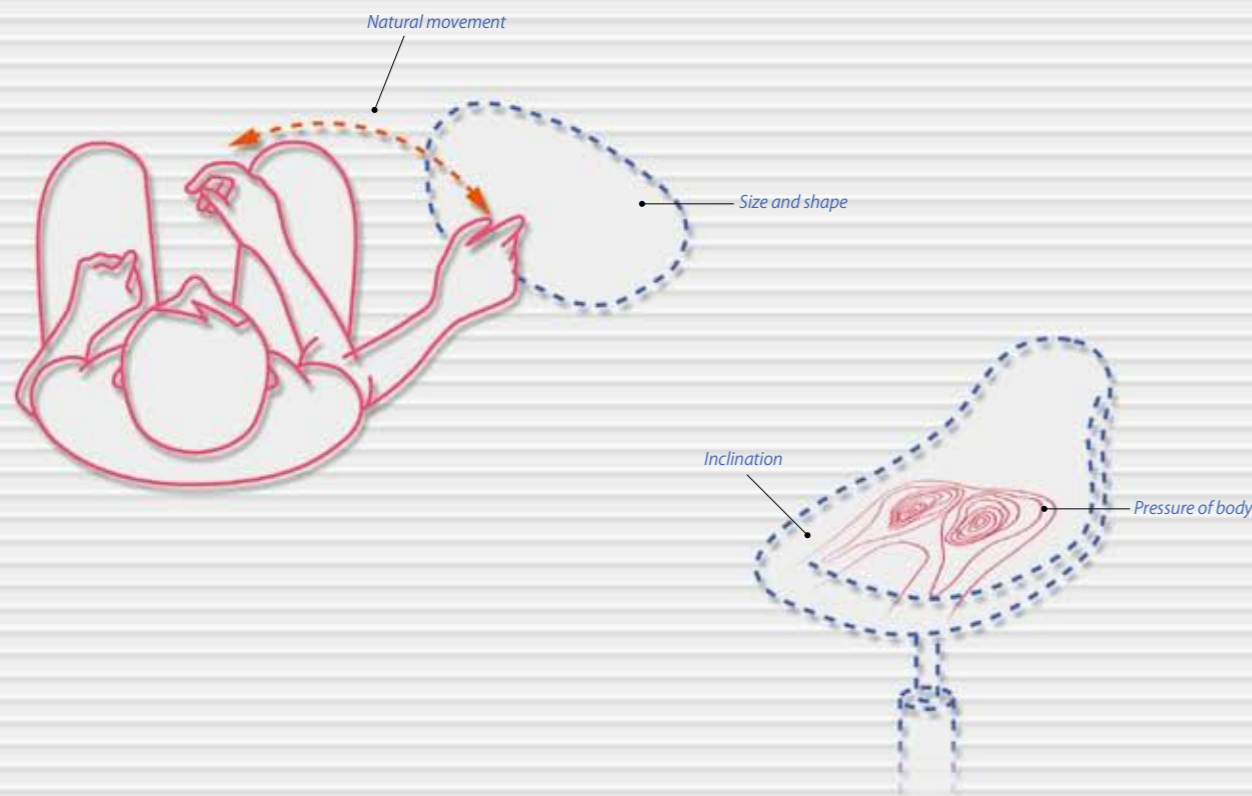
The operator twists his body, and his right forearm and hand are in an unnatural position.

Chapter 4 Instrument Design



Tools should be designed to function as intended. In addition, human-centered criteria as shown below should be applied to the design of tools.

- The tool is shaped appropriately (size, length and shape)
- The location of the tool does not interfere with the operator's natural body and limb motions
- The direction or angle of the tool ensures that the operator's movements are natural and comfortable
- The tool is designed with due consideration given to the kind of body motion needed to use the tool



Air-turbine handpiece

An air-turbine handpiece cuts a tooth at a high-speed rotation of 400,000/minute. Requiring extremely delicate control, it should be manipulated with a pen grip using the first, second and third fingers.

○Diameter and length of the handpiece

For a stable hand hold and fine control, an appropriate diameter and length should be selected for the handpiece. A diameter that is too small requires the operator to apply greater force to his fingertips and compromises handpiece handling, while one that is too large compromises delicate control. The handpiece should therefore ideally be as thick as a ball-point pen or pencil.

The handpiece should also be long enough to be held stably in the operator's hand. However, an excessively lengthy handpiece cannot be balanced easily and is difficult to handle.

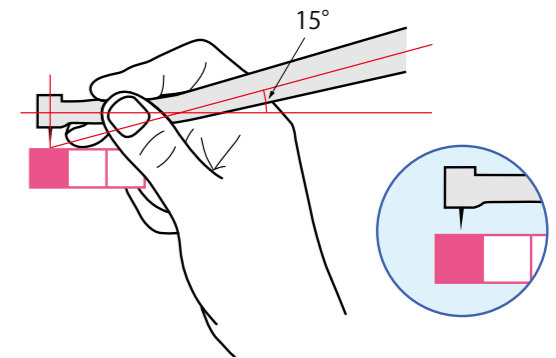


○The angle of the handpiece

The air-turbine handpiece is angled to allow space for the fingers to hold it. The wrong angle (insufficient space) makes it difficult to maintain the correct angle of a tooth surface being treated with the tip of the bur.

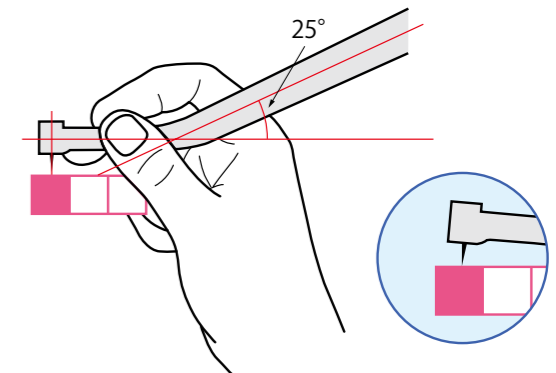
15 degrees

A handpiece rested on the third finger allows natural positioning of the hand and elbow.



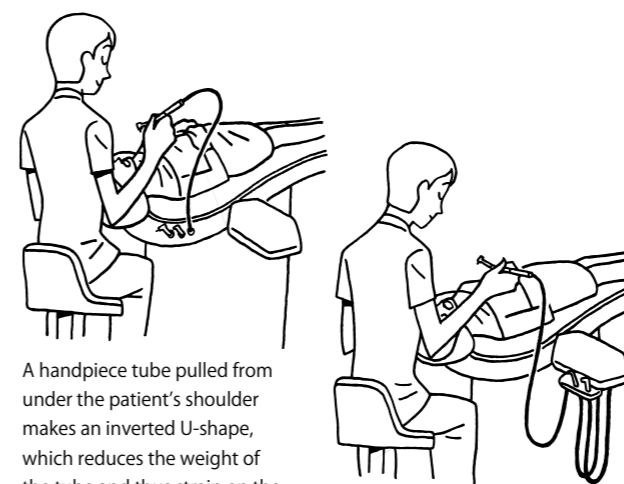
25 degrees

A handpiece angled at larger than 15 degrees may place a greater strain on the hand and fingers or necessitate elbow raising, thus leading to poor manipulation.



○Handpiece weight

The weight of the handpiece is important to its handling. The balance between the handpiece and the connecting tube is also important and the connecting part substantially affects the ease of handling.



A handpiece tube pulled from under the patient's shoulder makes an inverted U-shape, which reduces the weight of the tube and thus strain on the fingertips.

The tube weighs on the fingertips and places stress on the operator.

Three-way syringe

A three-way syringe is designed to irrigate, blow air and spray at a controlled amount or intensity. Since it is used in various parts of the oral cavity, a palm grip is suitable.

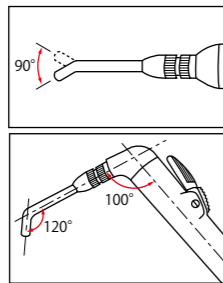
◎The handle is formed to fit the hand

An instrument to be held with a palm grip is designed to fit the natural shape of the hand. The handle is thickest where it makes contact with the index finger and tapers towards the fifth-finger contact area.



◎The nozzle shape

The nozzle is angled at the tip to match the direction of the operator's sight line so that he can easily direct water or air to clean the mirror or dry tooth surfaces. The nozzle can be rotated to achieve the desired angle but rotating the wrist usually results in a quicker response.



◎Location of levers

The thumb is appropriate for operating the irrigation, air and spray levers because it can move in all directions and more easily control the force being applied. If the irrigation and air levers are just under the thumb when the three-way syringe is held, the operator can activate irrigation or air just by sliding the thumb to the right or left and activate spray by pressing both levers. The operator can also control the amount of spray by maintaining pressure on the irrigation lever and sliding the thumb onto the air lever to adjust the amount of air.



Suction cannula

A suction cannula aspirates water, saliva and debris from the treatment site to lessen the patient's discomfort, secure a clear view of the treatment site, and prevent air contamination with flying debris. A suction cannula should be placed so as to protect the patient's cheek walls, lips and tongue and designed to allow sufficient space for the operator's vision and finger control.

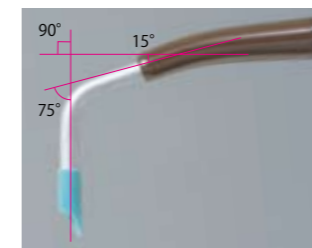
◎Length of the syringe

Since a suction cannula is stabilized during use at any site in the mouth for a relatively long time, it is most natural to hold it with the right hand. The suction cannula should ideally be long enough for the tip of the syringe to reach the patient's right retromolar pad when the assistant extends her right forearm in the reference posture with the right elbow hanging loosely next to her body.



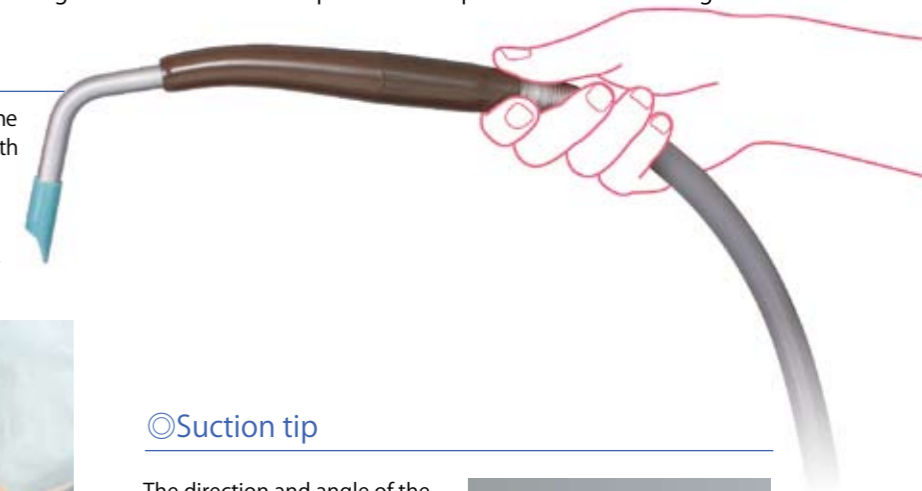
◎Angle between the handle and tip

The vacuum tip is best angled at 90 degrees to the handle of the syringe to enable the assistant to maintain a natural posture while using the vacuum. An additional angle between the tip and handle ensures easier manipulation with smaller motions.



◎Location of the suction cannula

A point below the patient's left shoulder is where the operator can easily pick up a suction cannula and the assistant can also pick it up without twisting her body.



◎Suction tip

The direction and angle of the vacuum tip should be easily alterable to fit the patient's upper or lower jaw and anterior or posterior teeth so that the assistant can assist while adopting a natural posture. The rubber tip can be detached for sterilization.



◎Shape of the rubber tip

The opening of the rubber tip is gently curved to maximize the aspiration area and not block the operator's sight line. The direction of the opening can be freely changed with ease. The rubber tip should remain in place during the use of the suction cannula to protect the patient from pain or discomfort.



■ Suction power

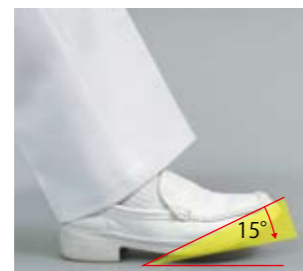
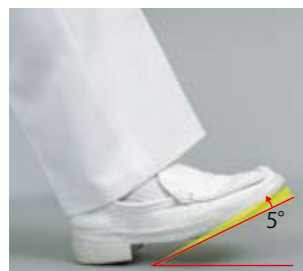
Excessively strong suction may alter air currents in the oral cavity, thus changing the flow of cooling water for cutting, clouding the mirror with cutting debris, or sometimes triggering sucking of the patient's cheek wall or tongue. Furthermore, the patient may lose moisture in the mouth, feel uncomfortable and even swallow saliva or have a coughing fit. An appropriately tuned suction cannula sucks up a glass of water in a second.

Foot controller

In a seated position, the natural motion of the toes is upward or downward. A controller equipped with push-down pedal(s) is therefore most appropriate.

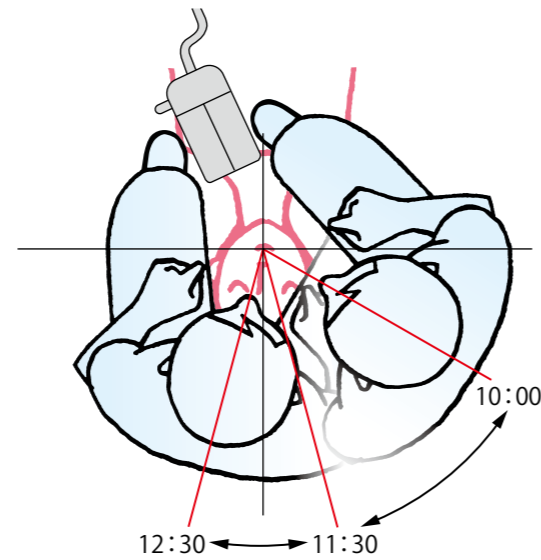
◎The angle of the pedal

When the lower leg is put forward, the toes are naturally raised at an angle of approximately 26 degrees. The foot pedal should ideally be angled to match this. With this as a reference angle, the toes can further move about 5 degrees upward and 15 degrees downward. Therefore, matching the range of movement of the foot pedal to these angles allows natural and comfortable speed control of handpieces. When the lever attached to the side of the foot control is pushed upward with the toes, the patient support goes up and when the lever is pushed downward, it goes down. This intuitive system ensures smooth control.



◎Location of the foot controller

The foot controller should ideally be placed at 11:30, the position that the operator adopts most frequently during dental procedures. Placing the controller at this position almost eliminates the need to change its direction when the operator shifts his position to 10:00 or 12:30.

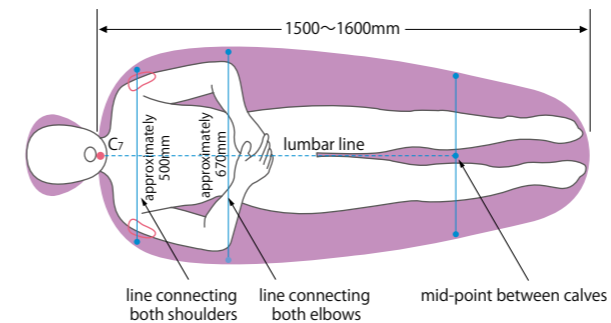


Patient support

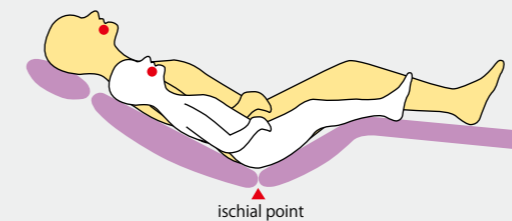
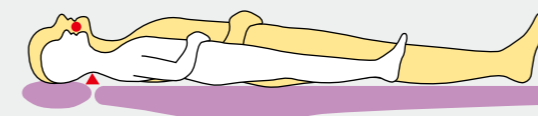
The human body is most relaxed in a sleeping posture. In this supine posture, the body lies horizontally against gravity and the body weight is supported by the largest area of the body. Any body part can move freely without restraints. For dental patients, bucket seats or bending seats are not favored because they prevent free movement of the body. In addition, since some parts of the human body are best not subject to pressure, the patient's body needs to be supported without pressure on such body parts, and with body pressure distribution taken into account.

◎Length and width of the patient support

Generally, a patient support the length of which matches the maximum of standard deviation for the height of Japanese male adults can accommodate almost all Japanese patients. The width and contour of a patient support is determined based on the distance between the right and left elbows (approximately 670 mm), the largest width of a human body in a supine position, and the distance between the right and left shoulders (approximately 500 mm).

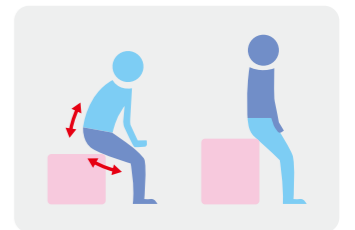


If the buttocks are used as an anchoring point in positioning a patient on a patient support, the location of the patient's mouth varies depending on his/her height and the operator needs to adopt an unnatural posture to treat the patient.



◎Height of the patient support

What counts most about the height of a patient support is the ability to provide the most appropriate vertical position of the operating point for accurate dental work. When a patient sits on a patient support, a seat that is too low places strain on his/her back and may even cause pain in elderly patients or those with back problems. A series of sitting motions from sitting on the seat to adjusting the sitting position by raising the legs also puts strain on patients. Setting the horizontal position of the patient support at a relatively high level and letting the patient rest his/her head on the headrest allow the patient to appropriately position him/herself on the support in one motion and with less strain on the legs and back.



Appropriate height of the patient support for the operator's natural work posture



The seat is so low that the operator has to lean forward

Instrument tray

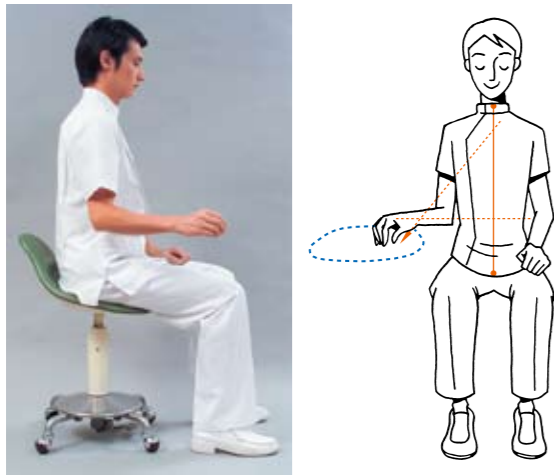
One of the criteria used to specify the location of dental instruments and materials is “predicting use” Some instruments and materials are used by the operator as occasion may demand (therefore the assistant cannot predict exactly when to use them), while others are supposed to be used at a time that the assistant can predict beforehand. Based on this categorization, instruments/materials used at unpredictable times for the assistant are preferably placed on the operator’s right side and those used at predictable times are better placed near the assistant. A basic set of instruments and a bur stand are usually placed on an instrument tray.

Location of the instrument tray

Placing an instrument tray within the “normal work area” allows the operator to pick up instruments, as described in Chapter 3 on page 9.

Height of the instrument tray

When the right forearm is naturally moved outward, it slopes a little downward from the elbow. An instrument tray should therefore be placed slightly lower than the elbow (Chapter 3 on page 8).



1 The left side of a tray located outside the patient support



2 The front side of a tray located in the end of the path on the right



3 Starting point of the path of the right hand as it moves back



4 The path of motion of the right hand as it moves back, and the end of the path on the right



5 Size of a tray, defined by four sides



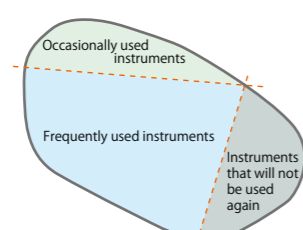
6 Ergonomically shaped instrument tray

Size of the instrument tray

The optimal size of an instrument tray is determined as follows: The left side of a tray does not touch the patient support (Photo 1). The front edge is along the path of lateral motion of the right hand with the elbow naturally hanging at the side of the body and the right end-limit of its motion defines the right end of the front side (Photo 2). The back edge is along the path of lateral motion of the right hand with the elbow slightly extended (Photo 3). The right end-limit of motion of the right hand defines the right end of the back and a line connecting the two points defines the right side of the tray (Photo 4). The range defined by these four sides represents the optimum size of an instrument tray (Photo 5) and the tray is ergonomically shaped (Photo 6). A hanger for a high-speed turbine attached to the front of the tray allows the operator to pick up and put down the handpiece naturally and smoothly.



Pick-up of a high-speed turbine

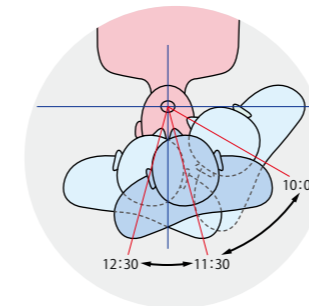
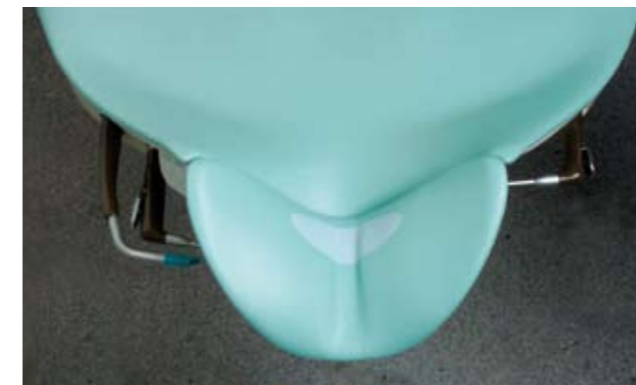


Headrest

Since a headrest is required to support a patient’s head naturally and comfortably, a round shape like a human head (as viewed from above) should be ideal.

Shape of the headrest

If a headrest is too large or too long, the patient’s mouth is positioned too far away and the operator needs to lean forward and cannot maintain the reference posture. The headrest shown in the photo below allows the operator to keep a constant distance to the patient’s mouth even when the operator shifts his position around the patient’s head.



Cross-sectional shape of the headrest

A headrest must be shaped in a way that allows the patient to rest his/her head comfortably. To meet this criterion, a headrest should preferably be semicircular as viewed laterally, to match the contour of the human head. In this way, the patient can comfortably rest his/her head, which is naturally guided into the stable position at the center of the headrest. A headrest should also have some extra room on the sides to avoid applying uncomfortable pressure on the patient’s ear when he/she turns his/her head to the right or left.

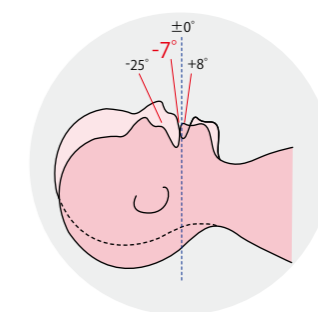


Thickness of the headrest

A headrest should be as thin as possible and have no protrusions, such as a handle, even on the underside because such protrusions may cause the operator to instinctively avoid contact with them during dental procedures, thus making it difficult to maintain the natural work posture.

Movement of the headrest

The required angle of the patient’s head defines the range of upward and downward movements of a headrest. Step-wise inclinations, such as for a resting position and a maxillary or mandibular treatment position, make it easier to achieve the right angle for individual dental tasks. Infinitely variable inclinations may look convenient but in reality, require more time and effort to adjust the headrest angle.



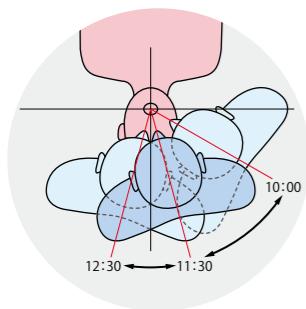
Adjustment of the headrest’s angle Ability to set the patient’s maxillary occlusal plane at -7 degrees, a reference angle, is important for the operator to maintain a natural formation of hand and fingers.

Operator's stool

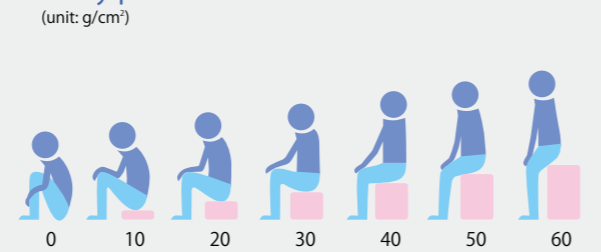
A stool should support the operator's stable posture without placing an excessive strain on the back and legs and also should be shaped in a way that does not interfere with the paths of motion of the operator's legs and arms during delivery of dental care. Since the operator usually shifts his position by rotating around the operating point, casters do not need to be omnidirectional.

Shape of the stool

A seat that fits human buttocks and is slightly sloped downward from posterior to anterior reduces pressure on the thighs and smoothes leg motion. The backrest is not used during dental procedures. An armrest may interfere with the operator's arm motions as well as smooth motion when sitting down and getting up.



Body pressure distribution



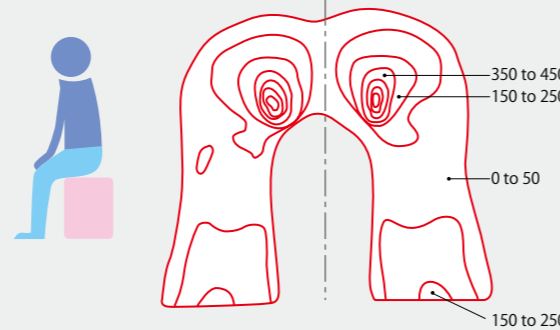
■ The seat is lower than the knee cap by 5 cm:



■ The seat is as high as the knee cap:



■ The seat is higher than the knee cap by 5 cm:



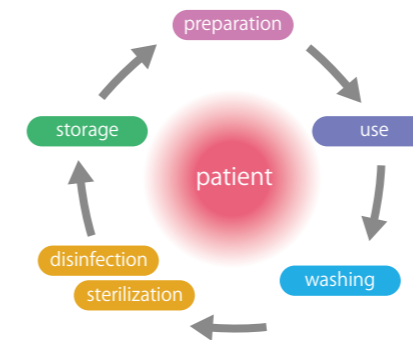
Dental treatment cabinet

Dental instruments and materials are used in a repeated cycle of "pre-treatment preparation" → "use during treatment" → "post-treatment washing and sterilization" → "storage." This work cycle demands arrangement of the storage area, work area and sink in the smallest possible range around the patient's mouth for efficient dental work free from unnecessary physical motion.

Location of the cabinet

A dental treatment cabinet for storing instruments and materials should ideally be installed near the patient and at a place where the operator and the assistant can pick up instruments or materials with equal ease.

The assistant performs assisting work such as vacuuming and handing instruments not only in (or quite close to) the patient's mouth, but also away from the patient's mouth, for example preparing instruments or materials and mixing cement. Ability to perform both types of tasks without shifting the work position reduces time loss due to position shift or fetching an instrument and improves the efficiency of assisting work.



Intraoral work



Extraoral work



Height of the sink

The optimum height of a sink allows the assistant to work in a natural posture without leaning forward. If the sink is too high, the assistant has to raise her forearms and easily gets tired. In addition, water may trickle down along the forearms, which is unsanitary. If the sink is too low, the assistant has to bend down.



Height of the sink



Depth of the sink



The sink is too low

Work surface of the cabinet

The work surface of a cabinet should be slightly convex in the section where the assistant performs tasks such as mixing, to prevent her body twisting during work. The underside of the work surface is cut obliquely so that the assistant can freely take out instruments from drawers.



A human-centered environment for delivery of dental care.

This brochure has reviewed the shapes and arrangement of individual dental equipment and handpieces from the standpoint of natural body positioning and motion. In order to create an optimum environment for efficient delivery of dental care without unnecessary body motion and time loss, the same perspective should be employed.

The work space should first be allocated and then the space for movement of people should be allocated. Next, functioning equipment including cabinets and partitions needs to be arranged to create individual areas.

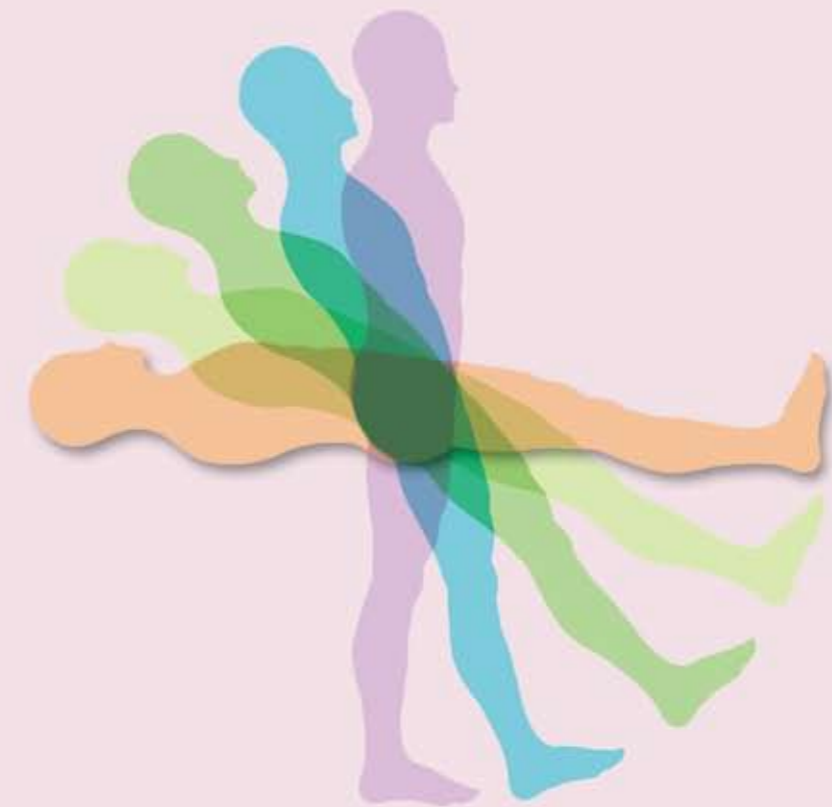
Finally, individual areas should be systematically arranged around the treatment area according to the workflow, to establish a comfortable dental treatment environment.

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Unless the shape and natural motion of the human body undergoes significant changes, this concept of proprioceptive derivation will remain as an immutable logic for many years to come, quite immune to social trends or changes in values.

SPACELINE

Questions & Hints



Spaceline creates the ultimate in comfort and spacious relaxation

Ergonomics and leading-edge technology combine
for superlative function and comfort.

Q1 Why is the three-way syringe housed under the shoulder section of the SPACELINE?



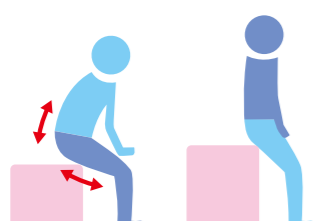
Hint: To balance the handpiece and reduce the patient's anxiety

Q2 Why does the SPACELINE have no armrests?



Hint: What are armrests needed for? Hint: the balance of the operator's body positioning and the patient's protective reaction

Q3 Isn't the seat of the SPACELINE too high at the lowest level?



Hint: No. It is designed to reduce strain on the patient's back and legs, and accommodate the patient's posture during treatment.

Q4 Isn't it better if the back support automatically rises for irrigation?



Hint: Is irrigation necessary during treatment? Assisting work by the assistant

Q5 When a dentist works without the help of an assistant, the suction cannula seems to be located at an inconvenient place for the dentist.



Hint: What type of unit has its suction cannula is the nearest to the patient's mouth? Where is the vacuum is used?

Q6 Isn't the headrest too small?



Hint: What is the range of motions of the patient's head? Five movements to allow home-position treatment

Q7 Do practitioners have to participate in seminars before using SPACELINE?



Hint: From unnatural body positioning to natural body positioning. What is a quicker way to an innovative change in your habit?

Q8 The SPACELINE seems unusable without an assistant.



Hint: Is an assistant needed for the sake of machinery?

Q9 Is the SPACELINE usable only when installed with a cabinet?



Hint: Where are dental instruments and materials used?

Q10 The SPACELINE seems underequipped.



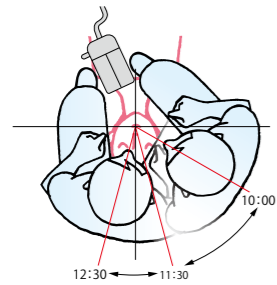
Hint: What instruments are used frequently and when?

Q11 Isn't the basin too small?



💡 Where is the most convenient place for the basin?

Q12 Which foot should be used to operate the foot pedal?



💡 Fine-tuned motion Less-tuned motion

Q13 Why is the head of the turbine angled at 15 degrees?



💡 What is the vector of finger control? Relationships between a tooth, a bur, fingers and the forearm?

Q14 Isn't the instrument tray too small?



💡 What objects are placed on the tray? (instruments/materials that the assistant can anticipate and those that only the operator knows when to use)

Q15 Isn't it better if the operator's stool has armrests?



💡 What is the operator's reference posture? Is the stool used for taking a break?

