SYSTEM AND METHOD FOR RECORDING ODONTOLOGICAL BIOMETRIC DATA

Technical Field

The present invention relates to a system and a method for recording biometric data on the position of the maxilla in the skull for cases of skeletal symmetry and asymmetry.

Background of the invention

For dental examination and treatment/prosthetics, clinical data of a patient's maxilla position with respect to sagittal plane and rotational axis of temporomandibular joints are recorded. For this purpose a face bow (1) commonly used is fixed in ear canals using ear canal holders (1.3', 1.3''), and on a nose, using a nasal shaft (1.1). Such face bow (1) has a pivot joint (1.2) for mounting an occlusal fork (2). A conventional occlusal fork (2) comprises a register holder (2.1) and a holder (2.2) for mounting the register holder in the pivot joint (1.2) of the face bow (1). Such face bow is shown in Figure 1. There are several ways to position such bow, but in in any case the position of the bow is associated with medical statistical planes identified in a human skull. Exemplary planes used are shown in Figures 2a, 2b: Frankfurt horizontal (FH), Camper's plane (KP), and occlusal plane (OP). When recording dental biometric data using a conventional head-mounted face bow (1) and observing the patient, said planes (FH, KP, OP) are clear and informative: it is not difficult to identify position of maxilla with respect to rotational axes of temporomandibular joints (RT). Rotational axes of mandibular joints (RT) are depicted in Figure 2b. Positions of a patient's temporomandibular joints may be asymmetric with respect to the sagittal plane (SP). None of the statistical planes (KP, OP, FH, EP) correspond to x, y, z axes / planes as shown in Figure 3: the *xy* plane is a transversal plane (TP); the *xz* plane is a sagittal plane (SP) and the *yz* plane is a frontal plane (FP). The conventional method of measurement using a face-mounted face bow (1) is not suitable for evaluating / measuring asymmetry of the ear canals and / or rotational axis. As a result, without a patient, spatial position of the odontological maxillary model in an articulator (4) becomes unclear. When transferring data from the head-mounted face bow (1) to the articulator (4), information related to a head asymmetry is not transferred. A conventional articulator (4) is shown in Figure 4. When transferring data from a patient's face and jaw to the articulator (4), they are distorted: mechanical articulators (4) are constructed as geometric mechanical symmetric structures according to X, Y and Z axes but not according to medical statistical planes (KP, OP, FH, EP) that do not generally correspond to the xy, xz, and yz planes (TP, SP, FP). Digital articulators (4') are replicas of

mechanical articulators in digital space. Branches (1.4', 1.4") of the face bow, being at different positions (e.g. at different heights) on the head relative to the sagittal plane (SP), are horizontally and vertically aligned during transfer to the articulator (4). This discrepancy results in distorted biometrics because the genetic reference points are horizon, vertical, and depth, i.e. xy, xz, and yz planes (TP, SP, FP). The discrepancy is illustrated in Figures 5a and 5b. Because of this the resulting position of the maxilla model (VZM) may not correspond to the patient's authentic position: there will be a horizontal inclination and an angle of horizontal error α between the positioning horizontal (PH) of the occlusal fork (2) in the mouth and the tilt plane of the occlusal fork (2). Accordingly, the mandibular model may also be positioned in space inaccurately, which will distort the biomechanics of the patient's occlusion.

Inaccurate models, dental arches, inclination angles of individual dental occlusal surfaces, incorrect angles of occlusal load (β_2, β_3, β_4) result in inaccurate vertical load in the occlusal planes (OP_2, OP_3, OP_4, OP_5) during the maximum intercuspation: individual teeth are subjected to breaking force instead of being loaded with vertical axial loads as shown in Figure 6. While restoring lost occlusal surfaces of molars due to their wear, it is also a big chance to create improperly sloped, too shallow or too steep slopes of the tooth humps, and the mandible can forcefully dislocate to the pathological position by forcibly slipping over the surfaces of incorrect / inauthentic anatomy.

Similarly in the articulator (4), when simulating and restoring mandibular dynamics by restoring anatomical surfaces of the anterior teeth, and moving the mandible into protrusion, laterotrusion or other directions with incorrect position of models, the patient's temporomandibular joints are highly likely to be injured (by restoring too steep or too shallow slopes of the anterior teeth, we create movement disruptions and disrupt authentic trajectories of mandible movement, thereby overloading the joints).

Recording of facial biometric data is performed in case of skeletal asymmetry of a skull as shown in Figures 15 b-d. In the case of asymmetry, the positions of the temporomandibular joints and their rotational axis (RT) with respect to the sagittal plane (SP) are asymmetrical vertically and/or horizontally (vertical, horizontal or vertical and horizontal asymmetries). In this situation in a conventional laboratory articulator (4), positioning of the maxilla model becomes complicated for several reasons. Firstly, the laboratory articulator (4) is a symmetrical instrument, without the possibility of individually changing the position of the pivot joints (4.1', 4.1") in space according to the asymmetric readings obtained with a

conventional clinical ruler. Secondly, although it is possible to rotate / tilt the conventional laboratory ruler according to the readings of conventional clinical ruler so that the measuring points of the conventional clinical ruler coincide with the rotational axis (RA) of the conventional articulator (4) as shown in Figure 16, the maxillary position (VZ) with respect to the horizon plane (HP) and sagittal plane (SP) (aesthetic parameters) cannot be displayed. This results in loss of part of the information needed for high-quality dental prosthesis.

A specialist working with jaw models so positioned may be misled because the geometry of a conventional articulator implies a different illusion of the position of the models in space than it is actually the case.

A method for measuring odontological biometric data, a face bow, an occlusal fork, and an articulator are disclosed in U.S. Patent No. 5090901. The face bow, the articulator, the occlusal fork, and the method for measuring include the above shortcomings of the conventional face-mounted face bow, occlusal fork, articulator, and the method for measuring.

This above mentioned problem of data inaccuracy can be solved by "tying" the measurements of planes required for mandible registration and diagnostics to the X, Y and Z axes, which are clearly identified and understood.

Modern digital data transfer systems operate on the principle of direct information transfer: the position and relationship of the jaw models in a conventional laboratory articulator is scanned and transferred to a virtual space. Alternatively, scanned models are manually (by using a computer mouse and a computer screen) positioned in a virtual articulator according to conventional planes (e.g. occlusal, Bonwill or Balkwill triangle planes). However, virtual tools and their working principal remain the same as in manual systems. Virtual articulators are merely simulations of a real articulator on a computer screen, without the ability to change the position of the pivot joints with respect to the sagittal plane and to each other individually. Therefore, in modern systems, creating an individual asymmetry of the ends of the rotational axis is not possible.

The invention simplifies the recording and transfer of patient’s biometric data, such as the position of the mandible with respect to the rotational axis of the temporomandibular joints, to the articulator ensuring proper data quality for diagnostics and restoration of the patient's chewing apparatus in cases of skeletal symmetry and asymmetry.

Short Description of the Invention

The invention discloses a method for recording the maxilla position with respect to the vertical rotational axes of heads of temporomandibular joints, a system for recording and tools for recording and transferring biometric data to a laboratory articulator and / or digital chewing simulator with customizable positions of ends of rotational axis with respect to the sagittal plane. The system comprises a dedicated clinical occlusal fork for measuring facial biometric parameters, such as maxilla position in the head. The clinical occlusal fork includes a register holder, face center ruler and face sides' rulers. The system also comprises a laboratory occlusal fork for transferring facial biometric data, such as maxilla position to the laboratory articulator, both in normal and virtual environments. The laboratory occlusal fork comprises a register holder and side rulers in holders, the interposition of which substantially corresponds to those of the clinical occlusal fork register holder and the side rulers' holders. Depending on whether the system is used in case of skeletal symmetry or asymmetry, a conventional or modified articulator is used. The modified articulator that is used in the case of skeletal asymmetry comprises an interchangeable individual connection between the lower part of the articulator and one of the articulator branches with a pivot joint. The method for recording involves the use of said occlusal forks in cases of skeletal symmetry and skeletal asymmetry.

Short Description of Drawings

Other features and advantages of the invention are described in the detailed description of the invention with reference to the following drawings:

Figure 1 depicts a head-mounted, ear canal-mounted and face-mounted face bow and an occlusal fork for recording odontological biometry data known from prior art.

Figure 2a depicts planes in a human head model.

Figure 2b depicts the planes in a human skull.

Figure 3 depicts the xy, yz, xz planes.

Figure 4 depicts a known system for recording facial biometric data corresponding state of the art.

Figure 5a depicts a system for recording facial biometric data and an occlusal fork attached horizontally to the patient's maxillary teeth (front view) known from prior art: due to skeletal asymmetry, the transfer of face-mounted face bow with occlusal fork to the articulator causes the transverse tilt of the latter and results in horizontal deviation.

Figure 5b depicts the transverse and horizontal tilt of the jaw model resulting from skeletal asymmetry after transferring the face bow with the occlusal fork to the articulator.

Figure 6 depicts normal individual positions of patient's maxilla model with respect to the rotational axis: if the position is incorrect, the angle of occlusal load is incorrect. The Special Line (OP_3) is the most popular reference for positioning the maxilla model when working without any face bow and positioning the model in a normal way. The optimum angle of the trajectory of motion of the mandible to the occlusal surface of the maxilla is 90 degrees.

Figure 7 depicts an example of a clinical occlusion fork for recording facial biometric data according to the invention, which is mounted to the maxilla and positioned horizontally.

Figure 8 depicts an example of a laboratory occlusal fork for positioning in the articulator according to the invention.

Figure 9 depicts a comparison of a clinical occlusion fork for recording facial biometric data and a laboratory occlusal fork for positioning in the articulator.

Figure 10 depicts an example of an articulator table for positioning a laboratory occlusal fork for positioning in an articulator, according to the invention: a) side view; b) front view; c) top view.

Figure 11 depicts an example of a system for recording facial biometric data according to the invention with an articulator table and a laboratory occlusal fork with a silicone register.

Figure 12 depicts the possible position of the maxilla with respect to the rotational axis of temporomandibular joints and the positioning points of the occlusal fork.

Figures 13a and 13b illustrate an example of a system for recording facial biometric data according to the invention and reference points for positioning a laboratory occlusal fork for positioning on the articulator with a maxilla model.

Figure 14 depicts directions for changing position of virtual pivot joints with respect to the sagittal plane (XZ plane).

Figure 15 depicts position of rotational axis of a mandible with respect to the parasagittal (PSP', PSP'') and sagittal (SP) planes at: (a) skeletal symmetry; (b) vertical skeletal asymmetry in which the joints of the mandible and the ends of their rotational axis (RA), respectively, are at different heights (with respect to the sagittal plane (SP)); (c) horizontal skeletal asymmetry in which the joints of the mandible and the ends of their rotational axis (RA), respectively, are at different depths (distally or medially with respect to the sagittal plane (SP)); (d) horizontal and vertical skeletal asymmetry in which the joints of the

mandible and the ends of their rotational axis (RA), respectively, are at different depths and in height (with respect to the sagittal plane (SP)).

Figure 16 depicts lower part of a standard articulator with symmetrical branches.

Figure 17 depicts lower part of the articulator according to one embodiment of the invention with a pivot part: a) rear view; b) side view.

Figure 18 depicts the lower part of the articulator according to one embodiment of the invention with asymmetrical branches and interchangeable individual connection: a) rear view; (b) side view; c) lateral cross-section of the connection.

Figures 19a to 19c illustrate a replaceable individual connection according to an exemplary embodiment of the invention: assembled and cross-sectional view.

Figure 20 depicts a three-dimensional matrix of a virtual articulator: a) with the location of position of the register holder; (b) mandible and maxilla models.

Before submitting a detailed description of the invention with reference to drawings of embodiments we note that identical elements are indicated by the same numerals in all the drawings.

Detailed description of the invention

It should be understood that numerous specific details are set out in order to provide a complete and comprehensive description of the embodiments of the invention. However, the skilled person will understand that the level of details of embodiments does not limit the embodiments of the invention, which can be embodied without such specific instructions. Well-known methods, procedures and components have not been described in detail to make sure that embodiments are not misleading. Furthermore, this description should not be considered as limiting exemplary embodiments provided, but merely as an implementation thereof.

Although exemplary embodiments of the invention or aspects thereof, as illustrated and described, comprise many components that are depicted in a particular common space or location, some components may also be remote. It should also be understood that the examples given are not limited to the components described but also include other elements required for their functioning and interaction with other components, the existence of which is self-explanatory and therefore not detailed.

Explanation of some of the terms used in the description:

Tragus (T) – an anatomical structure in an outer ear used as one of the reference points for identifying the plane of a head and the rotational point (RT) of the mandible.

Sagital Plane (SP) – divides a body into a symmetrical left and right side through a center: used as a reference plane for positioning a clinical occlusal fork (7) and identifying skeletal asymmetries in the skull and chewing apparatus.

Frankfurt Horizontal (FH) – passes through the center of the tragus (T) and the orbital point (OT).

Camper's Plane (KP) – passes through the center of the tragus (T) and the sub-nasal point (PT).

Occlusal plane (OP) – passes through the occlusal surface of the dental arch.

Conventional Laboratory Articulator (4) – laboratory simulator of chewing apparatus: can be digitally embedded in odontological image editing programs (such as 3shape, exocad), usually comprising at least the upper part that imitates the maxilla with joint sockets and the lower part that imitates the mandible, symmetrical pivot connections with the head of the mandible joint and the surfaces that imitate the slope of the joint socket, vertical shaft (4.3) adjusting the ratio by height of the upper part and the lower part.

Clinical occlusal fork (7) is a tool for measuring facial biometric parameters, such as maxilla in a head, a measuring tool with register holder (7.4), face center ruler (7.9), and face sides rulers (7.1', 7.1").

Laboratory occlusal fork (8) – tool for transferring facial biometric data, such as maxillary position, into laboratory articulator (4) by placing onto articulator table (10), wherein the interposition of its register holder (8.7) and side ruler holders (8.6', 8.6") substantially matches the interposition of the register holder (7.4) and the side ruler holders (7.2', 7.2") of the clinical occlusal fork (7).

Silicone register (3) is an individual register made from odontological basic silicone or other material used to register the occlusion.

In one embodiment of the invention, the odontological biometric data recording system for recording biometric data when the mandibular joints are symmetrical with respect to the sagittal plane (SP) and the ends of their rotational axis (RA) are symmetrical with respect to the sagittal plane (SP). The system comprises a clinical occlusal fork (7) with a face center ruler (7.9) and two face sides rulers (7.1', 7.1"); a conventional laboratory articulator (4)

comprising a frame (12.3), a rotational axis (RA), an articulator shaft (4.3), a maxilla model holder (11.1), a laboratory occlusal fork (8) for mounting in the articulator (4), and a height-adjustable table (10) for positioning the laboratory occlusal fork (8) in the articulator with two face sides rulers (8.1', 8.1").

Figure 7 depicts an example of an embodiment of a clinical occlusal fork (7) according to the invention for measuring facial biometric parameters. The clinical occlusal fork (7) comprises a frame (7.5) that includes a register holder (7.4) whose position, when measured, coincides with the occlusal plane (OP) of the maxilla, on one side of which the recording material (3) is placed; a face center ruler (7.9) extending along and within the sagittal plane (SP), which is intended to prevent deviation from the sagittal plane (SP) when applying a clinical occlusal fork (7) in the mouth; a facial left side ruler (7.1') and a facial right side ruler (7.1") for recording biometric parameters of left side of the face and the right side of the face respectively. The clinical occlusal fork (7) may further comprise a level (5) for ensuring horizontal positioning of the register holder (7.4) and the occlusal plane (OP) in the patient's mouth. The facial left side ruler (7.1') is inserted into the lateral ruler locking member (7.2'), which is located on the left branch (7.5') of the frame (7.5) of clinical occlusal fork (7). The facial right side ruler (7.1") is inserted into the lateral ruler locking member (7.2"), which is located on the right branch (7.5") of the frame (7.5) of clinical occlusal fork (7). Said locking elements (7.2', 7.2") of the left and right rulers (7.1', 7.1") prevent spontaneous movements of the left and right rulers (7.1', 7.1") during the measurement of facial biometric parameters. Said left and right branches (7.5', 7.5") are formed so that they are substantially in the same plane as the register holder (7.4), and the ruler locking elements (7.2', 7.2") therein are offset from the face center ruler (7.9) and its locking element (7.2"') to the left and right, respectively, so that the left and right rulers (7.1', 7.1") after locking thereof are at the left and right side tragus points (T), respectively. The side rulers can be of any shape that ensures that the rulers can be brought to the tragus points (T) on the left and right side of the face. Such a shape may include a first part (7.6', 7.6") that engages in a locking member (7.2', 7.2") and slides along its axis (7.7', 7.7"), and a second part (7.8', 7.8''), which, when sliding the first part along its said axis (7.7', 7.7"), could be brought to tragus points (T). Such a shape may include a first part (7.6', 7.6") that engages in a locking member (7.2', 7.2"), slides along its axis (7.7', 7.7") and would be perpendicular to the register holder (7,4), and a second part (7.8', 7.8") that, when sliding the first part along its said axis (7.7', 7.7"), could be brought to the tragus point (T) and is perpendicular to the first part (7.6', 7.6"). The clinical

occlusal fork frame (7.5) also includes a locking member (7.2''') of the face center ruler (7.9) that functions in the same way as the locking members (7.2', 7.2'') of the side rulers (7.1', 7.1'') and is in the sagittal plane during the measurement of the facial biometric parameters. The locking member (7.2''') of the center ruler (7.9) is preferably in line (7.10) with the locking members of side rulers and / or in the same plane with the said locking members of side rulers.

Figure 8 depicts a laboratory occlusal fork (8) for transferring biometric data to the register. The laboratory occlusal fork (8) comprises a frame (8.14) comprising a register holder (8.7) that, at the time of data transfer, is in the same plane as the occlusal plane; and sagittal edges (8.3', 8.3''), which are intended to position the laboratory occlusal fork (8) on the adjustable table (10) of the articulator (4) so that said edges are in parallel with the corresponding edges (10.1', 10.1'') on the adjustable table for guiding the movement of the laboratory occlusal fork and parallel to them. The laboratory occlusal fork (8) also comprises a left branch (8.4') and a right branch (8.4'') for fixing the left ruler (8.1') and the right ruler (8.1''), respectively, using the locking members (8.6', 8.6'') which operate on the same or a similar principle as the ruler locking members (7.2', 7.2'') of the clinical occlusal fork (7). Said branches (8.4', 8.4'') extend from the register holder (8.7) so that there is a gap (8.5) between the first parts (8.8', 8.8'') of said branches. Said first parts (8.8', 8.8'') extend from the register holder (8.7) to the second parts (8.9', 8.9'') that extend in opposite directions. Said left and right branches (8.4', 8.4'') are formed so that they are substantially in the same plane as the occlusal plane (8.2), and the ruler locking elements (8.6', 8.6'') therein are offset from the center line (8.10) of the register holder to the left and right, respectively, so that after locking the left and right rulers (8.1', 8.1'') they are, during the measurement, at the left and right side ends (RA) of rotational axis (RA) of the articulator (4). The side rulers can be of any shape that ensures that the rulers can be brought to the left and right ends of rotational axis (RA) of the articulator. Such a shape may include a first part (8.11', 8.11'') that engages in a locking member (8.6', 8.6'') and slides along its axis (8.13', 8.13''), and a second part (8.12', 8.12''), which, when sliding the first part along its said axis (8.13', 8.13''), could be brought to rotational axis (RA). Such a shape may comprise a first part (8.11', 8.11'') that engages in a locking member (8.6', 8.6'') and is slideable along its axis (8.13', 8.13'') and would be perpendicular to the occlusal plane (8.2), and a second part (8.12', 8.12'') which, when sliding the first part along its axis, could be brought to the rotational axis (RA) and is perpendicular to the first part (8.11', 8.11'').

Figure 9 illustrates how in one embodiment of the invention in case of the laboratory occlusal fork (8), as described above, and the clinical occlusal fork (7), as described above, the positions of the register holders (8.7, 7.4) and the locking means (7.2', 7.2''; 8.6', 8.6'') of the side rulers, located on the frames of laboratory and clinical occlusal forks, match each other in the structure of the laboratory and the clinical occlusal forks, with the laboratory and clinical occlusal forks positioned in parallel and symmetrically above each other.

In one embodiment of the invention, width between the rulers (8.1', 8.1'') of laboratory occlusal fork (8) is 185 mm, which should coincide with the width of the clinical occlusal fork (7) between the rulers (7.1', 7.1''), the latter should have sufficient space between the rulers (7.1', 7.1'') to accommodate the patient's head between them. The space of movement of the laboratory occlusal fork (8) should be at least 40 mm deep / long. This is the maximum amplitude space of movement of the laboratory fork (8) on the laboratory table (10) without interference with front corners of the table. The width of the central space should be 20 mm so as not to interfere with the central shaft of the articulator. As an example, the table width can be 70 mm. This is the optimum width needed to accommodate a laboratory occlusal fork (8) with a silicone register. The table should be approximately 80 mm in length or such as to allow sliding of the laboratory occlusal fork (8) in a buccal-distal direction without loss of stability.

Figures 10a, 10b and 10c illustrate an adjustable table (10) for positioning the laboratory occlusal fork (8) of the articulator (4) in the articulator (4). The adjustable table comprises a base (10.2) for connection to the holder (4.2') of the articulator (4); a table top (10.3) for positioning the laboratory occlusal fork on and between its sagittal edges (10.1', 10.1''); a lifting mechanism (KM) for the table top (10.3), which comprises pantographs (P', P'') symmetrically arranged on the left (KR) and right (DS) sides of the table (10), each comprising associated supports (10.4', 10.4'', 10.4''', 10.4''''), wherein two upper supports (10.4', 10.4'''') are pivotally attached at the first end to the base of the table top (10.6) and pivotally attached at the second end to the ends of the other two supports (10.4'', 10.4'''), wherein the second ends of the other two supports are pivotally attached to the base (10.5) of the lifting mechanism (KM), the first ends (10.10') of said associated supports (10.4''', 10.4'''') at which said supports are connected*,* are pivotally attached to the side of the cylindrical member (10.6) having an internal thread, and the second ends (10.10'') of the other associated supports (10.4', 10.4'') at which said supports are connected, are pivotally attached to the side of cylindrical member (10.8) having a central cavity without a thread. A

longitudinal cylindrical member (10.7) is passed through both of said cylindrical members (10.6, 10.8), one end of which has an outer thread that interacts with the inner thread of the cylindrical member (10.6) and the other end is passed through the cylindrical member (10.8) having no thread in which the longitudinal movement of the longitudinal cylindrical member (10.7) is restricted and it can only rotate around its central axis (10.9). By rotating the longitudinal cylindrical member around its longitudinal axis (10.9), the cylindrical member (10.6) having an internal thread interacts with the outer thread of the longitudinal cylindrical member (10.7) and, depending on the direction of rotation of the cylindrical longitudinal member (10.7) the interconnected ends (10.10') of associated supports (10.4‘‘‘, 10.4‘‘‘‘) relatively approach or move away with respect to the interconnected ends (10.10'') of other associated supports (10.4', 10.4''). As the said ends move away from the other ends, the table top (10.3) descends and, as they approach, it rises.

Figure 11 depicts the position of the laboratory occlusal fork (8) on the adjustable table (10) of the articulator. The space (8.5) between the left branch (8.4') and the right branch (8.4'') of the laboratory occlusal fork (8) is configured so that the laboratory occlusal fork (8) can be relatively moved with respect to the articulator shaft (4.3) with the help of articulator table (10) in all directions of table adjustment. In parallel to said space (8.5) designed for articulator shaft, the laboratory fork additionally includes one blank area (8.5') on the other side of the first part (8.8') of the left branch (8.4'), relative to the space (8.5) designed for the articulator shaft, and one blank area (8.5'') on the other side of the first part (8.8'') of the right branch (8.4''), relative to the space (8.5) designed**)** for the articulator shaft.

The articulator table can be secured to the lower part of the articulator by means of a magnetic coupling: with the help of a magnet present in the table base (10.2) that secures the table to the lower part of the articulator holder (4.2'), which is made of a material that interacts with a magnet, such as iron.

The following is a description of data transfer from the clinical occlusal fork (7) to the articulator (4), when the laboratory occlusal fork (8) is used according to the embodiment of the invention.

The holder (7.4) of the register (3) of the clinical occlusal fork (7) is applied horizontally in the patient's mouth, where it is attached to the upper jaw (VZ), for example, by using basic silicone, horizontally with respect to X, Y, Z axes. The position of the face center ruler (7.9) coincides with the patient's sagittal plane (SP). The lateral rulers (7.1', 7.1'') are then inserted so as to coincide with the tragus (T) or externally measured statistical locations (RT) of

rotational axes, which are about 12 mm medially away and about 4 mm vertically down from the center of the tragus. The data from the scales of the rulers (7.1', 7.1") are then recorded: the distance between the first point (13.1', 13.1") and the second point (13.2', 13.2") of the side rulers (7.1', 7.1") is measured according to horizontal scales of the side rulers (7.1', 7.1"). The first point (13.1', 13.1") is recorded on both side rulers (7.1', 7.1") at tragus (T) point on both sides of the face where the said side rulers are positioned, or externally measured statistical locations (RT) of rotational axes that are about 12 mm medially away and about 4 mm vertically down from the center of the tragus. The second point (13.2', 13.2"), with respect to both side rulers, lies at connection of the first part (7.6', 7.6") and the second part (7.8', 7.8") of each side ruler (7.1', 7.1"). Then, the distance from the second point (13.2', 13.2") to the third point (13.3', 13.3") is measured according to the scale of the side rulers (7.1', 7.1") in horizontal position of the ruler according to the readings of the level (5). The third point (13.3', 13.3") coincides with the upper surface of the side ruler holders (7.2', 7.2") of the clinical occlusal fork (7), i.e. the surface through which the side rulers are inserted in the holders. For both side rulers, the measurements are made individually.

The silicone register (3) obtained from the patient's mouth is attached to the register holder (8.7) of the laboratory occlusal fork (8) as shown in Figures 13a and 13b. The laboratory occlusal fork (8) is placed on the articulator table (10) so that the articulator shaft (4.3) is located between the first parts (8.8‘, 8.8") of the side branches (8.4', 8.4") of the laboratory occlusal fork (8). The laboratory occlusal fork (8) is positioned in the articulator (4) by setting on both lateral rulers (8.1', 8.1") of the laboratory occlusal fork (8) the position of the first (13.1"', 13.1""), the second (13.2"', 13.2"") and the third (13.3"', 13.3"") points with respect to corresponding branches (8.4', 8.4") and each other according to the measured values from the first point (13.1', 13.1") to the second point (13.2', 13.2") horizontally and from the second point (13.2', 13.2") to the third point (13.3', 13.3") vertically by using the clinical occlusal fork (7). The side rulers of the laboratory occlusal fork (8) and the clinical occlusal fork (7) are of the same shape and dimension to accurately reproduce the measurements of the clinical occlusal fork (7) on the laboratory occlusal fork (8). A maxilla model (VZM) is placed on the silicone register (3) of laboratory occlusal fork (8). The scales of the side rulers (8.1', 8.1") must reproduce the measured height of the clinical occlusal fork (7). The side rulers (8.1', 8.1") are positioned at the height of the rotational axis (RA) of articulator by raising or lowering the articulation table (10) if the recording according to the individual rotational axis (RT) took place at the clinic. If recording according to tragus (T) took place at

the clinic, then the ruler should be 4 mm higher. When moving the laboratory occlusal fork (8) with the maxillary (VZM) model horizontally on the articulator table, through the sagittal plane (SP), its scale must coincide with the clinically recorded dimension at the individual rotational axis (RT). If recording according to tragus (T) took place at the clinic, then the scale of the side ruler (8.1'; 8.1") should be 12 mm distally to the rotational axis (RA). The vertical shaft (4.3) of the articulator (4) is adjusted at a height of 0 mm. The maxilla model (VZM) is fixed, by means of articulating plaster, to the magnetic pad (12.4) of the articulator. The mandibular model is attached to the maxilla model.

In the case of a virtual articulator, all of the above operations involving positioning of the laboratory occlusal fork (8) in the laboratory articulator (4') with respect to the measurement data of the clinical occlusal fork (7) are performed in the same manner as using the real articulator (4).

The construction of the virtual articulator (4') is substantially consistent with that of the physical articulator (4) as described above.

In the virtual matrix of the articulator (4') that is constructed relative to the sagittal plane, the digital patient's model with the virtual ruler is a reference point for spatially positioning the rotational axis of the temporomandibular joints. By entering readings of the clinical ruler in the input fields, even in case of skeletal asymmetry, the articulator can be set individually (by changing the positions of the virtual pivot joints relative to the x, y, z axes) as shown in Figure 14: the vertical and horizontal asymmetries of the temporomandibular joints are customized by changing the positions of the pivot joints (4.1', 4.1") of the virtual articulator (4') a) vertically (z) /vertically (z) asymmetrically, b) horizontally (x) /horizontally (x) asymmetrically, c) vertically (z) and horizontally (x) /vertically (z) and horizontally (x) asymmetrically. Modern systems operate on the principle of direct information transfer, when the position and relationship of jaw models in the laboratory articulator is scanned and transferred to a virtual space. Likewise, in a more primitive way, scanned jaw models are manually (by using a computer mouse and computer screen) positioned in the virtual articulator along conventional planes (e.g., occlusal, Bonwill, or Balkwill triangular planes). However, virtual tools and their working principal remains the same as in manual systems (as described above). Virtual articulators are merely simulations of a real articulator on a computer screen, without the ability to change the position of the pivot joints with respect to the sagittal plane and to each other individually. Therefore, in modern systems, creating an individual asymmetry of the ends of the rotational axis is not possible. This requires a new

articulator matrix with facial ruler data entry and ability to change automatic adjustment of pivot joints position in space.

Each patient's maxillary model has an individual position with respect to his mandibular rotational axis (RT): if the position of the jaw model in the articulator (4, 4') is incorrect, the angles (β_2, β_3, β_4) of the occlusal load are incorrect, as shown in Figure 6. Using the laboratory occlusal fork (8) and the method of transferring biometric data to the articulator as described above, the scale of the side ruler (8.1', 8.1") defines where the maxilla model should be attached in the articulator (4, 4') with respect to the individual rotational axis of patient's mandible.

With the patented method, these planes (FH, KP, OP) become irrelevant in recording the patient's maxilla position in space.

In another embodiment of the invention, the biometric recording is performed in case of skull skeletal asymmetry. In the case of skull skeletal asymmetry, the positions of the temporomandibular joints and their rotational axis (RT) with respect to the sagittal plane are asymmetrical vertically and / or horizontally (vertical, horizontal or vertical and horizontal asymmetries).

Like in the embodiment of the invention described above, the clinical occlusive fork (7), as shown in Figure 7, is used for the measurements. Measurements are made as described in the previous example. In case of vertical asymmetry, during the measurement of patient's biometric data it appears that the corresponding side rulers (7.1', 7.1") of the clinical occlusal fork (7) make different distances, i.e. the distance from the second point (13.2') to the third point (13.3') measured by one side ruler (7.1') is not equal to the distance from the second point (13.2") to the third point (13.3") measured by the other side ruler (7.1"), as shown in Figure 15b. In case of horizontal asymmetry, the corresponding side rulers (7.1', 7.1") of the clinical occlusal fork (7) make different distances, i.e. the distance from the first point (13.1') to the second point (13.2') measured by one side ruler (7.1') is not equal to the distance from the first point (13.1") to the second point (13.2") measured by the other side ruler (7.1"), as shown in Figure 15c. In case of both horizontal and vertical asymmetry, the corresponding side rulers (7.1', 7.1") of the clinical occlusal fork (7) make different distances in both directions, i.e. both the distance from second point (13.2') to the third point (13.3') measured by one side ruler (7.1') is not equal to the distance from the second point (13.2") to the third point (13.3") measured by the other side ruler (7.1") and the distance from first point (13.1')

to the second point (13.2') measured by one side ruler is not equal to the distance from the first point (13.1") to the second point (13.2") measured by the other side ruler, as shown in Figure 15d.

In this embodiment of the invention, and as depicted in Figures 17a and 17b, one branch (16") of the laboratory articulator (17) is disconnected from the lower part (17.3) of the articulator while the other branch (16') remains connected. The disconnected part (16") is the pivot part (17.1) and it is disconnected from the lower portion (17.3) as shown in Figure 17a. The pivot part (17.1) and the lower part (17.3) are connected by a replaceable individual connection (18), as shown in Figures 18 and 19. Figure 19 shows an example of a replaceable individual connection (18).

Along with manufactured patient jaw models, by means of software and 3D printer, a unique hard plastic replaceable individual connection (18) is printed for each patient. The replaceable individual connection (18) comprises a connection filling (18.3) for interaction with the locks (17.2) of the pivot joint (17.1) and the lower part (17.3) of the articulator (17) for their fixed connection, and a frame (18.1) for holding the filling part (18.3) and preventing movement with respect to the pivot part (17.1) and the lower portion (17.3) and also restricting movement of the pivot part (17.1) and the lower part (17.3) relative to each other. By joining in this way the said pivot part (17.1), the lower part (17.3) and the asymmetrical part of the articulator, which imitates the mandible, are rigidly fixed to each other. Then, the part that imitates the maxilla with the upper jaw with joint sockets and a height adjusting shaft are attached to the latter. Other operations are performed as described above, such as transferring data to the articulator by using a laboratory occlusal fork (8). The highly precise connection is made of sturdy plastic by using a high-resolution 3D printer. The pieces must be precisely and firmly fixed so that they do not have free movement, detach or break while making plaster jaw models in the articulator (17) and while simulating the movements of the mandible.

The method of manufacturing the replaceable individual connection (18) of the articulator (17) comprises scanning the silicone register (3) attached to the scanning table that is part of a laboratory scanner to which a subject has to be rigidly attached. The register scanning also includes scanning of gypsum models of the upper and the lower jaws, or making upload of an intraoral camera scanning data of the jaws and their relationship (occlusion) to the digital matrix. The biometric data obtained with the clinical occlusion fork (7) are entered into the computer program input fields: face sides' rulers (7.1', 7.1 ") data, such as distances

from the first points (13.1', 13.1") to the second points (13.2', 13.2 ") and to the third points (13.3', 13.3") of the face sides rulers (7.1', 7.1 ").

If the replaceable individual connection (18) is created in a virtual space, the matrix of the articulator (4') has the same engineering parameters and construction as the physical articulator (17), i.e. the construction of the virtual articulator (4') is substantially consistent with that of the physical articulator (17) as described above. As in the above-mentioned physical articulator (17), like in Figures 17a-17b and 18a-18c, with pivot part (17.1) detached from the lower part (17.3), the part (17.3) imitating the mandible is detached from the branch (16") having pivot joint. The ends of the latter have locks (17.2), by means of which the individual connection (18) is firmly fixed to the ends of the pivot part (17.1) and the lower part (17.3) that includes locks (17.2). The vertical gap between the ends with the locks (17.2) must be at least 25 mm with respect to the lower part (17.3) of the articulator so that the branch (16") with the pivot joint (17.1) can descend down with respect to the sagittal plane and the opposite branch (16'). The spatial position of the virtual articulator is fixed. Its center corresponds to the sagittal plane (divides it in half lengthwise) and divides the articulator to the left and right sides, where the ends of the rotational axis are equidistant from the center at 60 mm and are located in parallel parasagittal planes. The end of the rotary axis of one side (e.g., left) is fixed, the position of the other is variable in the parasagittal plane in all directions. It varies in case of asymmetric biometric measurement data.

The virtual matrix of the articulator, as shown in Figure 20, operates on basis of three vertical planes, one perpendicular to the latter and divided in half. The horizontal plane corresponds to the plane of the register holder. In the virtual space, the biometric data of the clinical occlusal fork (7) are transmitted to the parasagittal planes on both sides of the articulator, binding to a fixed end / point of the rotational axis corresponding to the first point (13.1') of the clinical occlusal fork and the point of rotational axis (4'.1) of the articulator (17).

After input of measurement data of the clinical occlusal fork (7) into the virtual matrix of the articulator, the algorithm automatically calculates the asymmetry of pivot axis horizontally and / or vertically with respect to the sagittal plane and changes the position of the pivot part (17.1) with respect to the lower part of the articulator (17.3) accordingly. In the resulting gap between the pieces, a drawing of the individual connection (18) is automatically generated for printing with 3D printer. In this way, by joining the lower part of the articulator (17.3) with the individual connection (18) to the pivot part (17.1), the standard articulator becomes

individual, since the change in length of the branches (16', 16'') of its lower part (17.3) results in corresponding change of the position of rotational axis (RA).

In the virtual version of the articulator, the position of the rotational axis calculated by the algorithm is fixed in a three-dimensional matrix and a digital maxilla model is bound to it in an individual / unique position relative to the sagittal plane and the ends of rotational axis as described above. The mandibular model is then attached to the maxilla model, according to the occlusion register data. The matrix data can be displayed on the operator's monitor as an articulator with maxilla and mandibular models, or simply as a jaw models with a coordinate system.

Although the present description includes numerous characteristics and advantages of the invention together with structural details and features, the description is given as an example of the invention embodiment. There may be changes in details, especially in the form, size and layout of materials without departing from the principles of the invention, in accordance with the widely understood definition of terms used in claims.

Claims

1. A system for recording biometric data of the maxilla position in the skull comprising means for measuring the maxilla position with respect to the sagittal plane and the rotational axis of the temporomandibular joints (RA) comprising a clinical occlusal fork, means for transferring measurement data to the laboratory articulator (4, 4', 17) comprising a laboratory occlusal fork, and a laboratory articulator (4, 4', 17) comprising a lower part (17.3) with an articulator table and side branches (16', 16") with pivot joints (4.1', 4.1"), characterized in that

the clinical occlusal fork (7) for measuring biometric facial parameters comprises

a frame (7.5), which comprises

a register (3) holder (7.4),

a face center ruler (7.9) extending along and within the sagittal plane (SP);

a left-side face ruler (7.1') and a right-side face ruler (7.1") for biometric measurements of the left side of the face and the right side of the face;

a left branch (7.5') of the frame (7.5) and a right branch (7.5") of the frame (7.5);

wherein said left and right branches (7.5', 7.5") are formed so that they are substantially in the same plane as the register holder (7.4), and the ruler locking elements (7.2', 7.2") therein are offset from the face center ruler (7.9) to the left and right, respectively, so that the left and right rulers (7.1', 7.1") after locking thereof are at the left and right side tragus points (T), respectively, or rotational axes of temporomandibular joints (RT) when making the measurements;

a laboratory occlusal fork (8) for mounting in an articulator (4, 4', 17), comprising:

a frame (8.14), which comprises

a register holder (8.7),

sagittal edges (8.3', 8.3"), which are intended to position the laboratory occlusal fork (8) on the adjustable table (10) of the articulator (4, 4', 17) so that said edges are in parallel with corresponding edges (10.1', 10.1") for guiding the movement of the laboratory occlusal fork and parallel thereto;

a left branch (8.4') and a right branch (8.4") for mounting the left ruler (8.1') and the right ruler (8.1") respectively, wherein said branches (8.4', 8.4") extend from the register holder (8.7) so that there is a gap (8.5) between the first parts (8.8', 8.8") of said branches;

wherein said first parts (8.8', 8.8'') extend from the register holder (8.7) to the second parts (8.9', 8.9'') that extend in opposite directions,

wherein said left and right branches (8.4', 8.4'') are formed so that they are substantially in the same plane as the occlusal plane (8.2), and the ruler locking elements (8.6', 8.6'') therein are offset from the center line (8.10) of the register holder to the left and right, respectively, so that after locking, the left and the right rulers are at the left and the right side ends of the rotational axis (RA) of the articulator (4, 4', 17), respectively;

adjustable table (10) for positioning articulator's (4, 4', 17) laboratory occlusal fork (8) in the articulator (4, 4', 17) comprises

a base (10.2) for connection to the holder (4.2') of the articulator (4, 4', 17);

a table top (10.3) for positioning the laboratory occlusal fork on and between its sagittal edges (10.1', 10.1'');

a lifting mechanism (KM) for the table top (10.3), which comprises pantographs (P', P'') symmetrically arranged on the left (KR) and right (DS) sides of the table (10);

wherein the gap (8.5) between the left branch (8.4') and the right branch (8.4'') of the laboratory occlusal fork (8) is configured so that the laboratory occlusal fork (8) can be relatively moved with respect to the articulator shaft (4.3) with the help of the articulator table (10) in all directions of table adjustment;

wherein parallel to said gap (8.5) dedicated for shaft (4.3) of the articulator (4, 4', 17), the laboratory fork additionally comprises one empty space (8.5') on the other side of the first part (8.8') of the left branch (8.4'), relative to the space (8.5) dedicated for the articulator shaft (4.3), and one empty space (8.5'') on the other side of the first part (8.8'') of the right branch (8.4''), relative to the space (8.5) dedicated for the articulator shaft (4.3).

2. A system according to claim 1, wherein one branch (16'') of the articulator (4', 17) is a pivot part (17.1) and is connected in a releasable way to the lower part (17.3) of the articulator via a replaceable individual connection (18), and the other branch (16') is permanently connected, wherein the individual connection (18) comprises

connection filling(18.3) for interaction with the locks (17.2) of the pivot part (17.1) and the lower part (17.3) of the articulator (4',17) for their fixed connection, and

a frame (18.1) for holding the filling part (18.3) and preventing movement with respect to the pivot part (17.1) and the lower portion (17.3) and also restricting movement of the pivot part (17.1) and the lower part (17.3) relative to each other.

3. A method for recording biometric data of the maxilla position in the skull, comprising measurements of the position of the maxilla with respect to the sagittal plane and rotational axis (RA) of the temporomandibular joints by using means with a register (3) holder, transferring measurement data to a laboratory articulator (4, 4‘, 17), comprising a lower part (12.3, 17.3), an articulator table (10) and a side branches (16', 16") with pivot joints (4.1', 4.1”), by using data transfer means with a register (3) holder, characterized in that

it comprises:

usage of the clinical occlusal fork (7) comprising face sides’ rulers (7.1', 7.1") for obtaining biometric data, wherein the obtaining of biometric data comprises:

horizontal application of the clinical occlusal fork (7) register (3) holder (7.4) in patient's mouth and attaching it to the maxilla (VZ);

aligning the face center ruler (7.9) with patient's sagittal plane (SP).

inserting the sides’ rulers (7.1', 7.1") into the locking means (7.2', 7.2") of the sides branches (7.5', 7.5") of clinical occlusive fork (7) so that the rulers (7.1', 7.1") coincide with tragus (T) or externally measured statistical locations of rotational axes (RT);

measuring the distance from the first point (13.1', 13.1") of the sides’ rulers (7.1', 7.1") to the second point (13.2', 13.2") according to horizontal scales of the sides’ rulers (7.1', 7.1"), wherein

the first point (13.1', 13.1") is recorded on both sides rulers (7.1', 7.1") at tragus (T) point on both sides of the face where the said side rulers are positioned, or externally measured statistical locations (RT) of rotational axes,

the second point (13.2', 13.2"), with respect to both sides rulers, lies at the connection of the first part (7.6', 7.6") and the second part (7.8', 7.8") of each side ruler (7.1', 7.1");

measuring the distance from the second point (13.2', 13.2") to the third point (13.3', 13.3") according to the scale of the side rulers in vertical position of the ruler, wherein

the third point (13.3', 13.3") coincides with the upper surface of the sides’ rulers holders (7.2', 7.2") of the clinical occlusal fork (7), i.e. the surface through which the side rulers are inserted in the holders;

removing the silicone register (3) from the register holder (7.4) of clinical occlusal fork (7) and attaching it to the register holder (8.7) of the laboratory occlusal fork (8);

and

usage of the laboratory occlusal fork (8) comprising side rulers (8.1', 8.1") for transferring biometric data to the articulator (4, 4‘, 17), wherein transfer of biometric data comprises:

positioning of the laboratory occlusal fork (8) on the articulator (4, 4‘, 17) table (10) so that the articulator shaft (4.3) is located between the first parts (8.8', 8.8'') of the side branches (8.4', 8.4'') of the laboratory occlusal fork (8), comprising

setting on both lateral rulers (8.1', 8.1'') of the laboratory occlusal fork (8) the position of the first (13.1''', 13.1''''), the second (13.2'''), 13.2'''') and the third (13.3''', 13.3'''') points with respect to the corresponding branches (8.4', 8.4'') and each other according to the measured with the use of the clinical occlusal fork (7) values from the first point (13.1', 13.1'') to the second point (13.2', 13.2'') horizontally and from the second point (13.2', 13.2'') to the third point (13.3', 13.3'') vertically.

placing the maxilla model (VZM) on the silicone register (3) of the laboratory occlusal fork (8);

replication of the measured distance from the clinical occlusal fork (7) on the scales of the side rulers (8.1', 8.1'') of the laboratory occlusal fork (8).

4. A method according to claim 3, further comprising the modifying of the position of one branch (16'') of the articulator (4', 17) relative to the other branch (16') of the articulator.

5. A method according to claim 3 or 4, comprising usage of the system to any one of the claims 1 to 2, wherein the method for recording biometric data of the maxilla position in the skull is performed in a virtual environment.

Abstract

A method and apparatus for recording the maxilla position with respect to the vertical rotational axes of temporomandibular joint heads for recording and transferring biometric data to a laboratory articulator and / or digital chewing simulator are presented. The system comprises a special clinical occlusal fork that comprises a register holder, face center ruler and face sides' rulers. The system further comprises a laboratory occlusal fork that comprises a register holder and side rulers in holders, the interposition of which substantially corresponds to those of the clinical occlusal fork register holder and the sides' rulers' holders. Depending on whether the system is applied in case of skeletal symmetry or asymmetry, a conventional or modified articulator is used. The modified articulator used in the case of skeletal asymmetry includes a changeable individual connection between the lower part of the articulator and one of the articulator branches with a pivot joint. The method for recording involves usage of said occlusal forks in cases of skeletal symmetry and skeletal asymmetry.

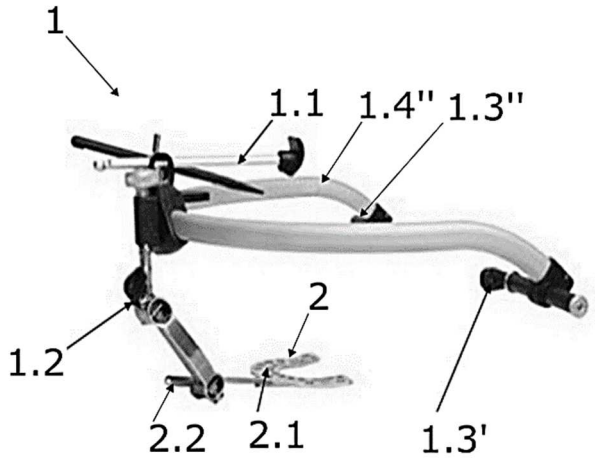

Fig. 1

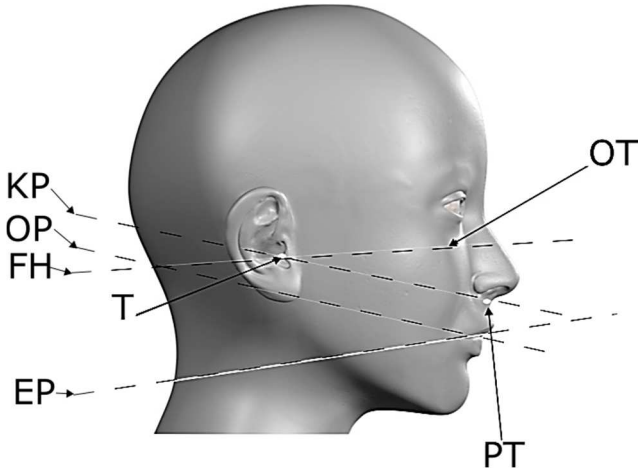

Fig. 2a

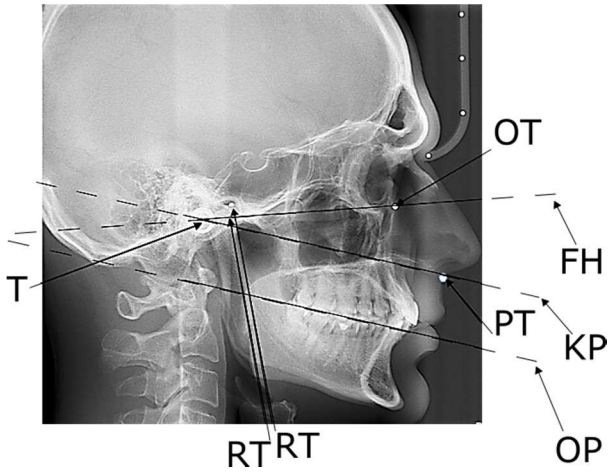

Fig. 2b

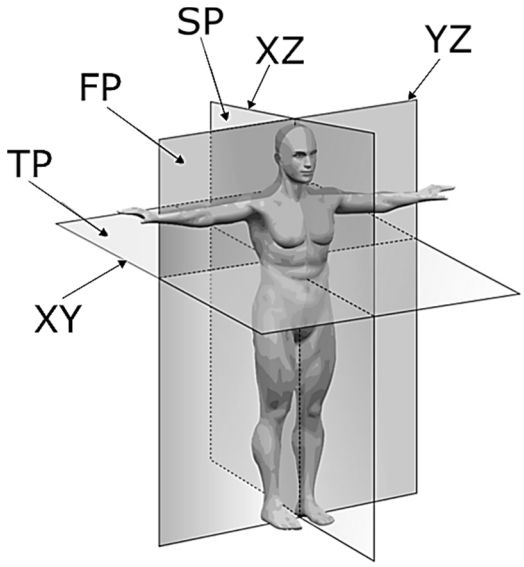

Fig. 3

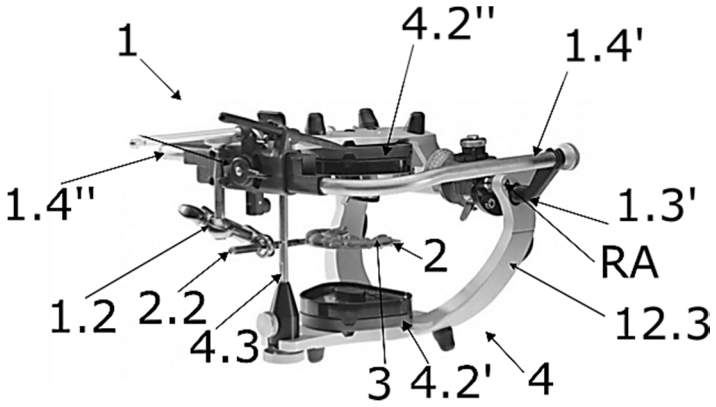

Fig. 4

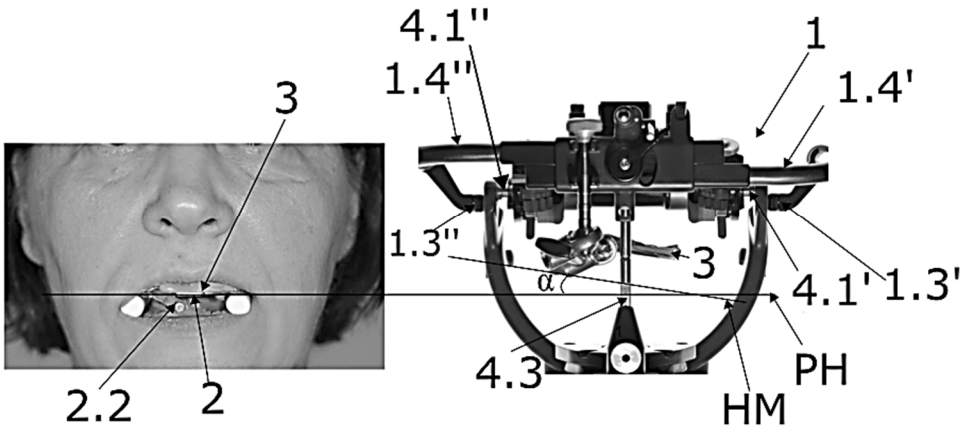
4.1''
1
1.4''
1.4'
3
1.3''
3
α
4.1'
1.3'
4.3
PH
HM
2.2
2

Fig. 5a

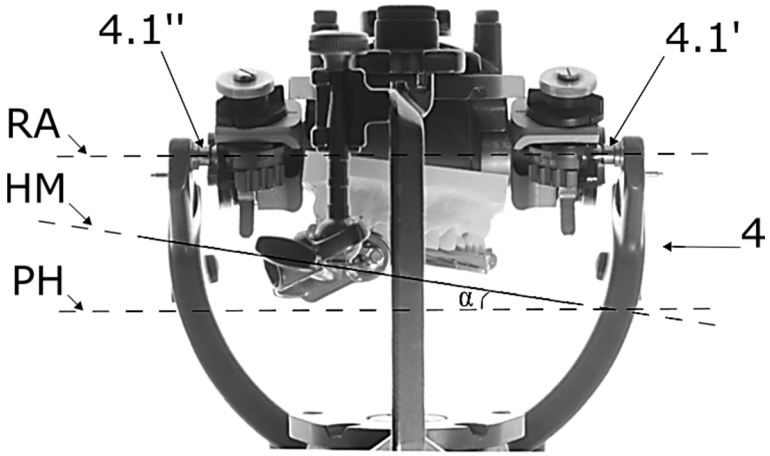
4.1''
4.1'
RA
HM
4
PH
α

Fig. 5b

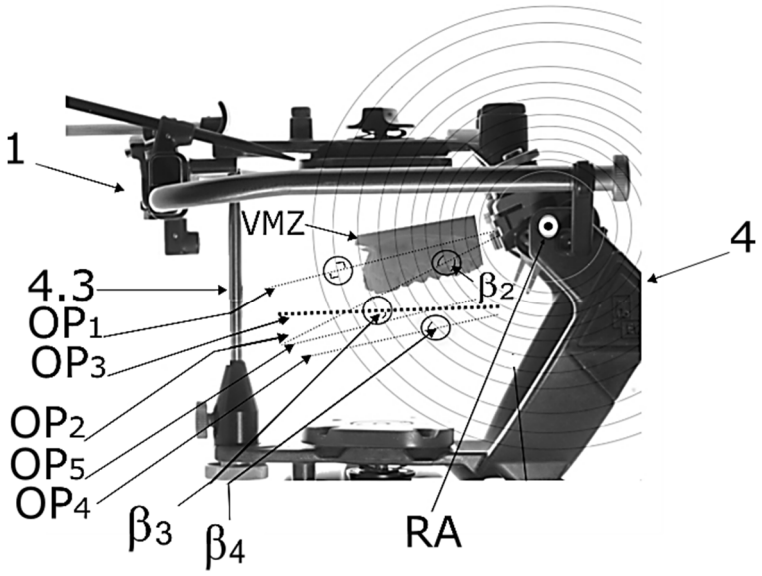
1
VMZ
4
4.3
β2
OP1
OP3
OP2
OP5
OP4
β3
β4
RA

Fig. 6

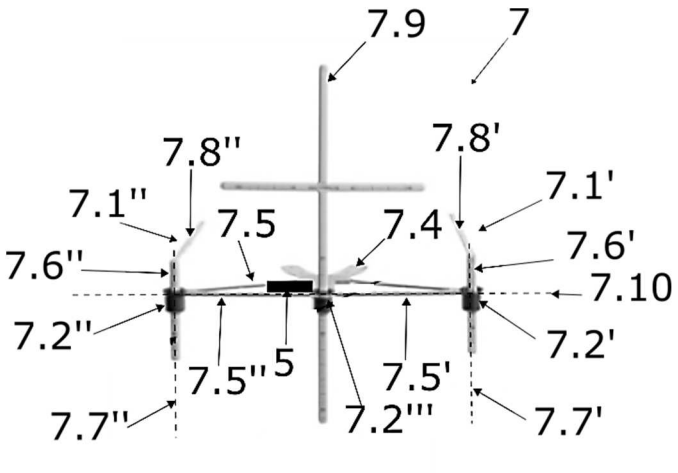

Fig. 7

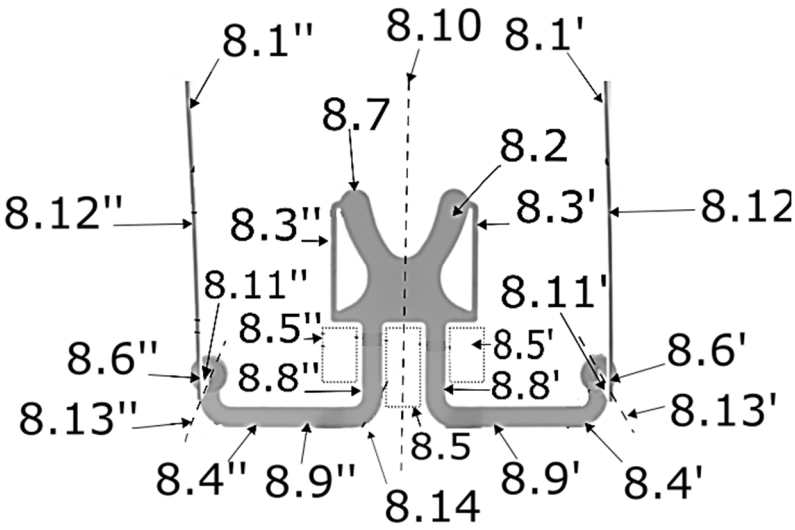

Fig. 8

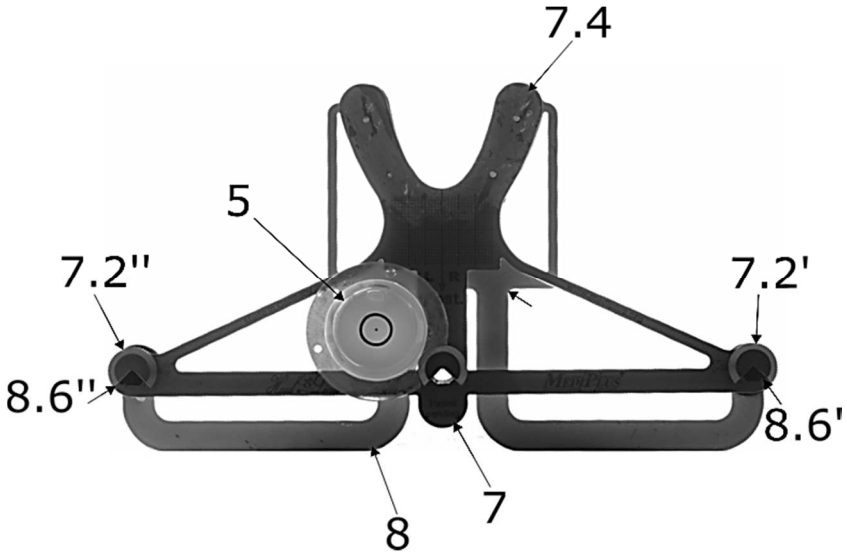

Fig. 9

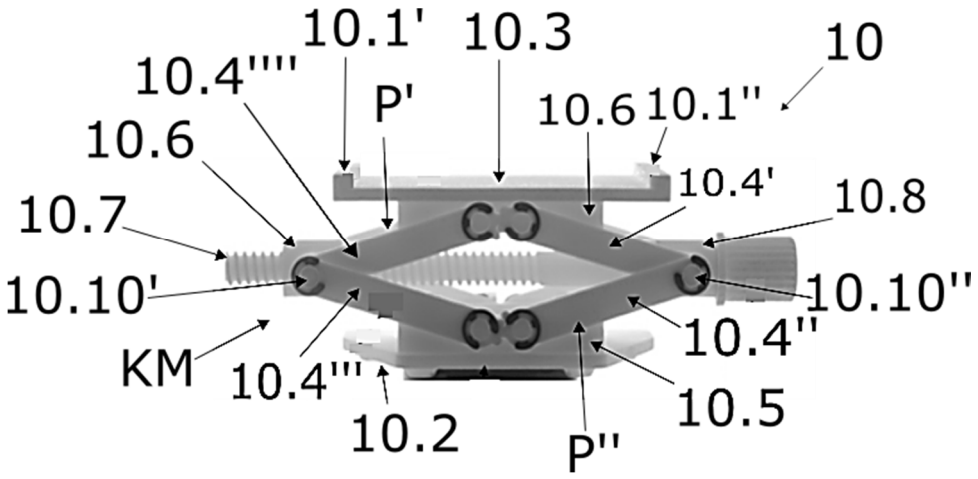

Fig. 10a

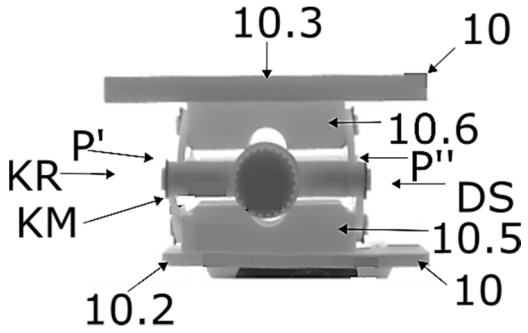

Fig. 10b

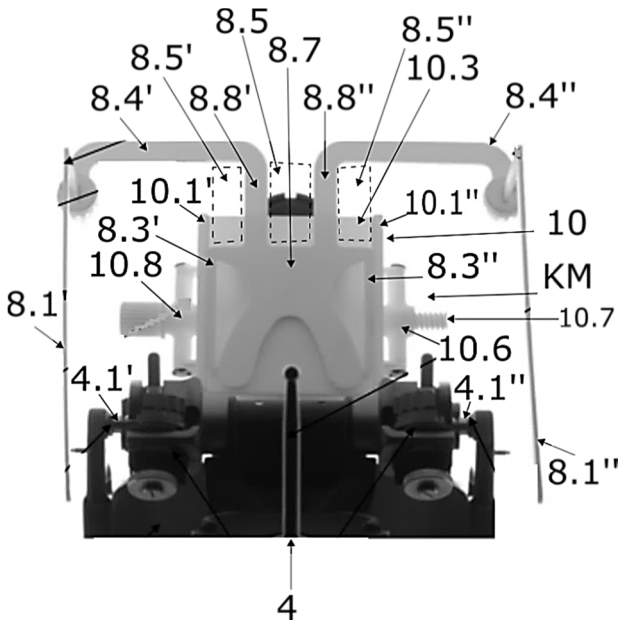

Fig. 10c

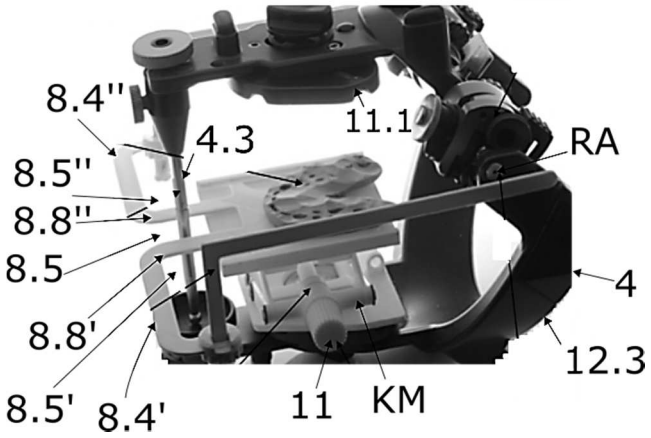

Fig. 11

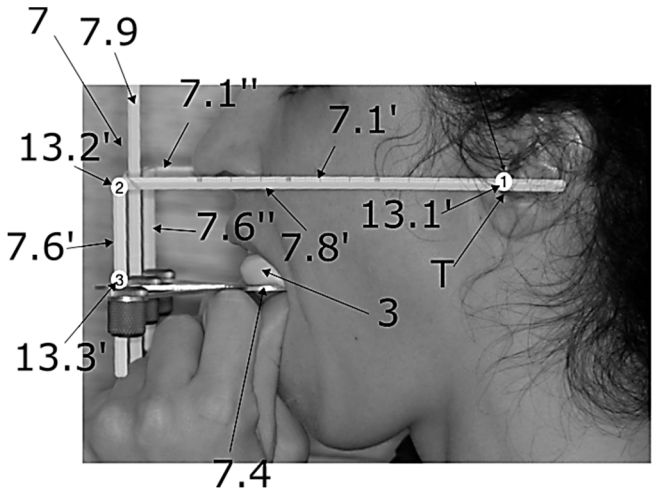

Fig. 12

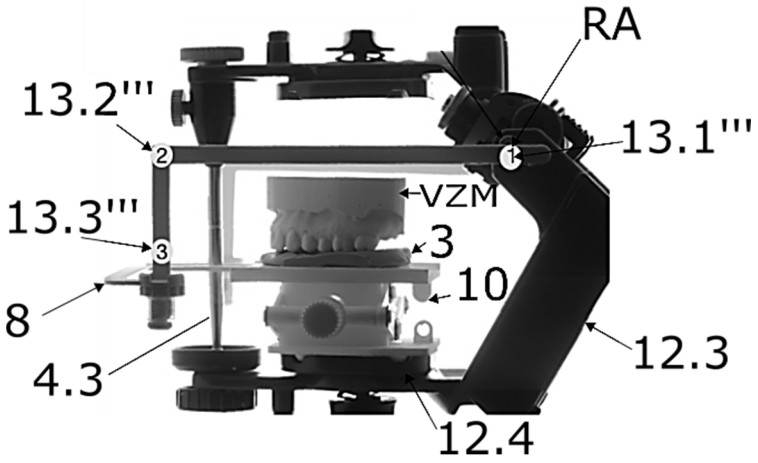

Fig. 13a

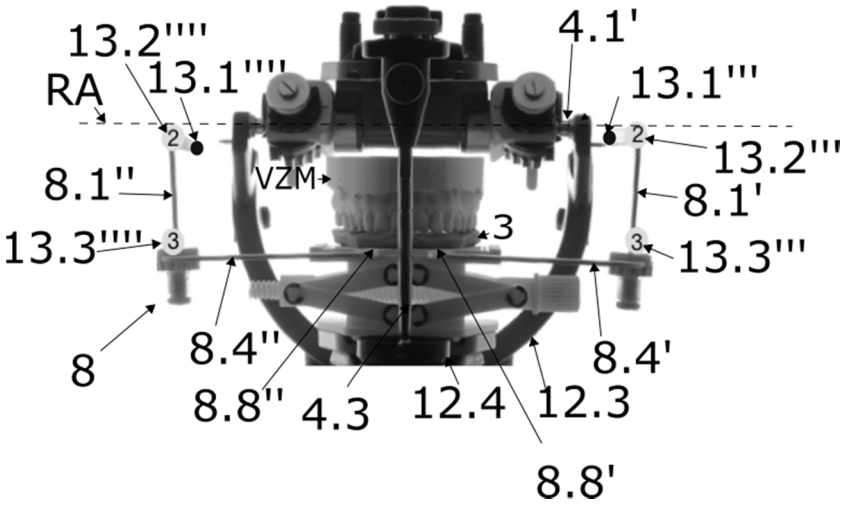

Fig. 13b

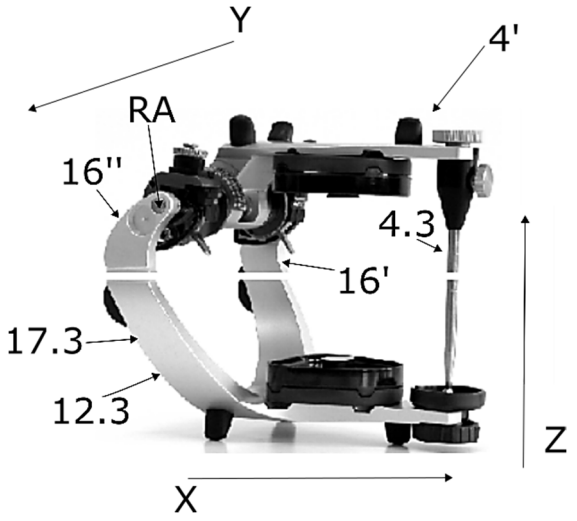

Fig. 14a

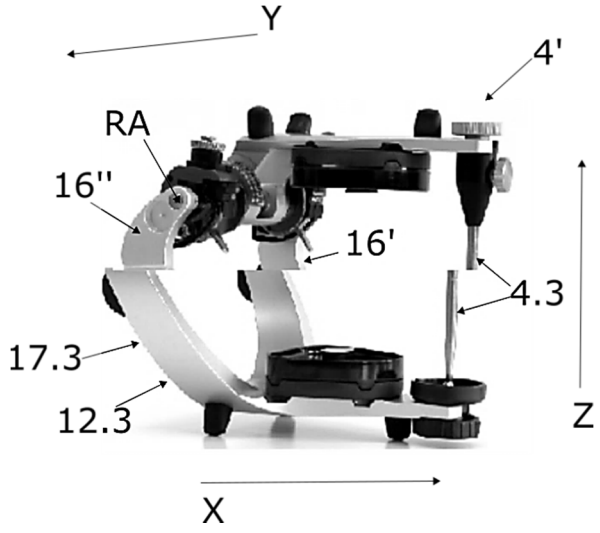

Fig. 14b

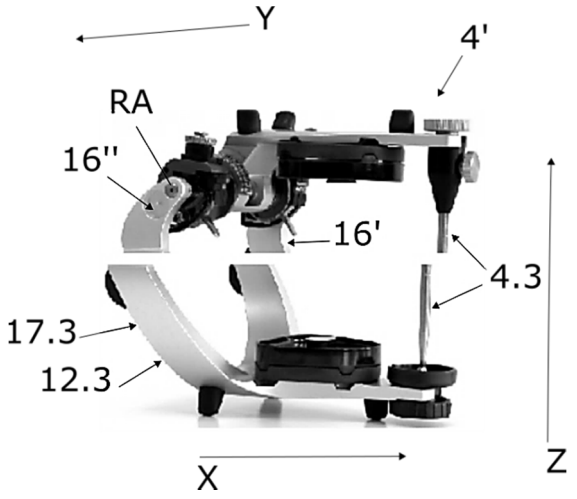

Fig. 14c

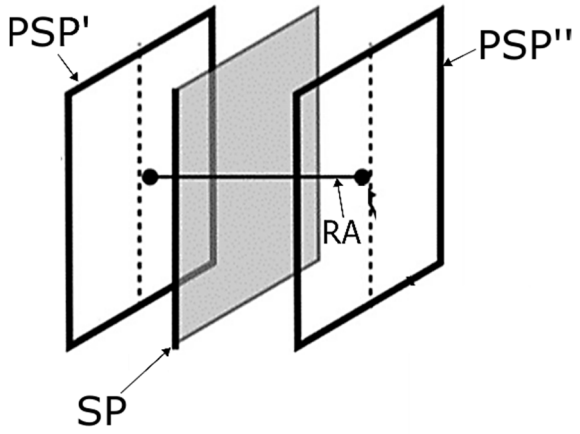

Fig. 15a

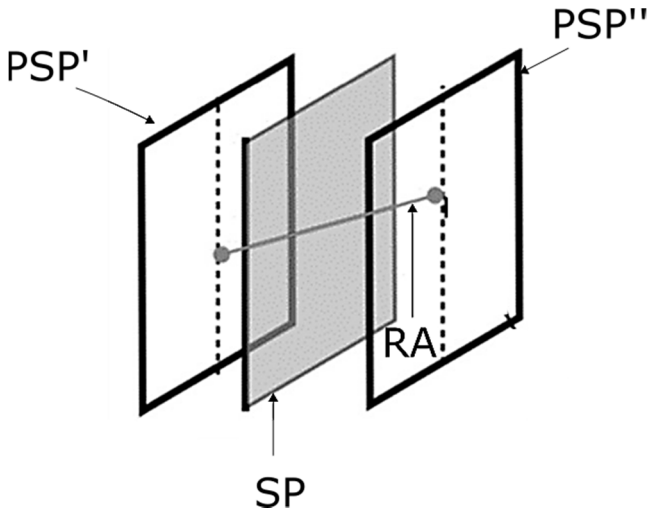

Fig. 15b

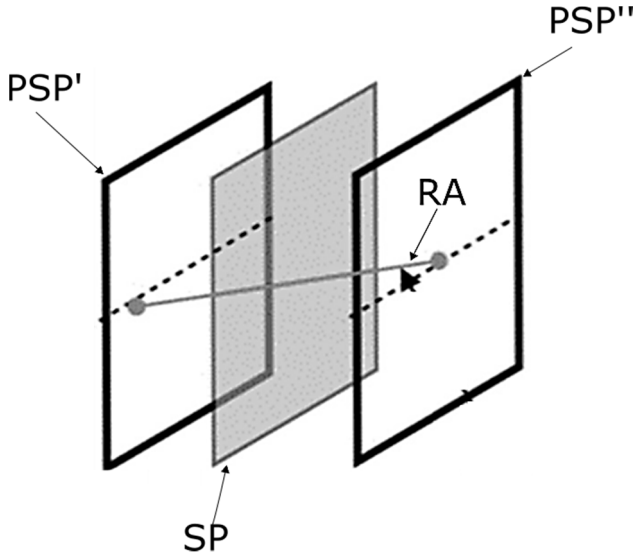

Fig. 15c

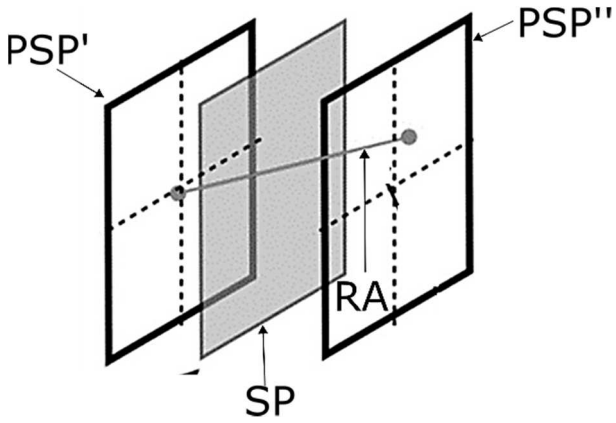

Fig. 15d

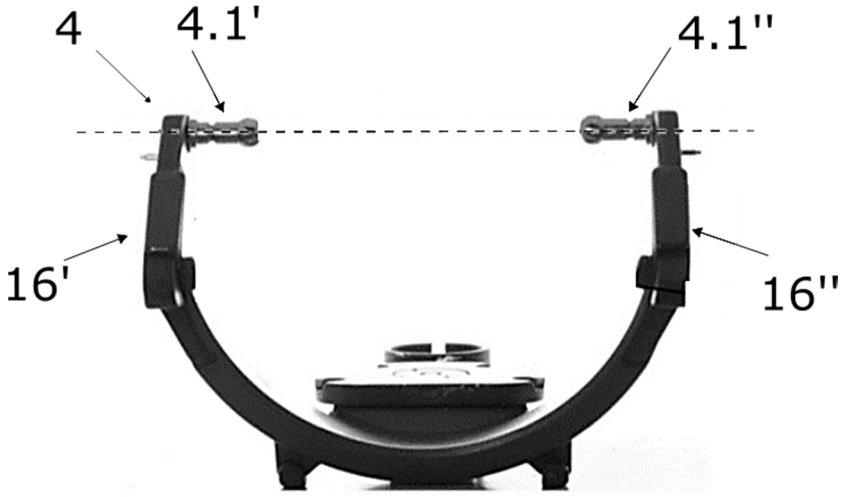

Fig. 16

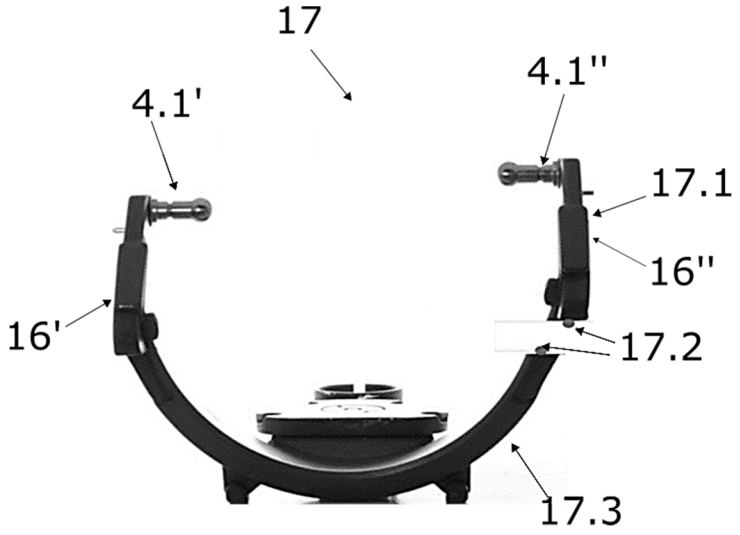

Fig. 17a

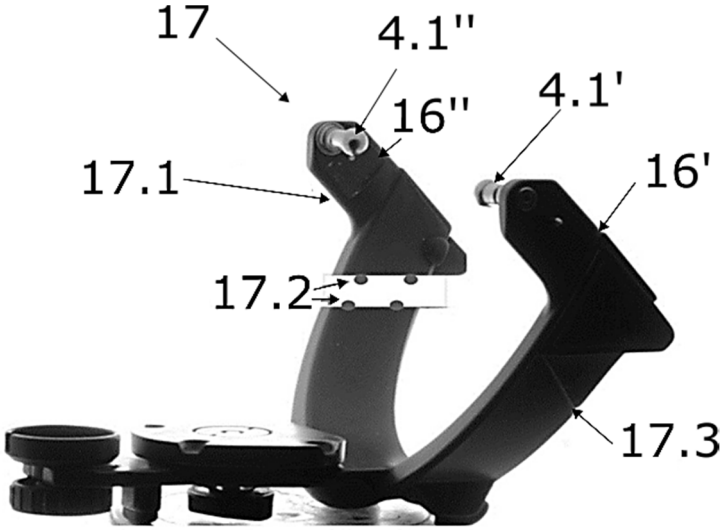

Fig. 17b

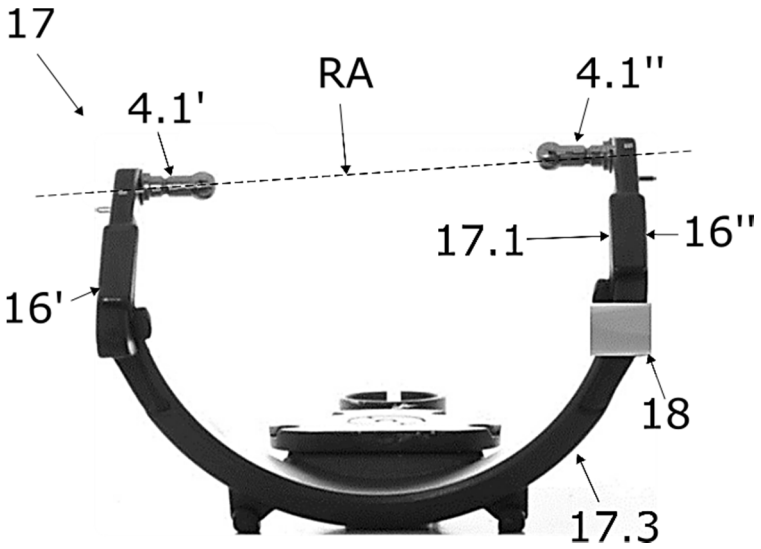

Fig. 18a

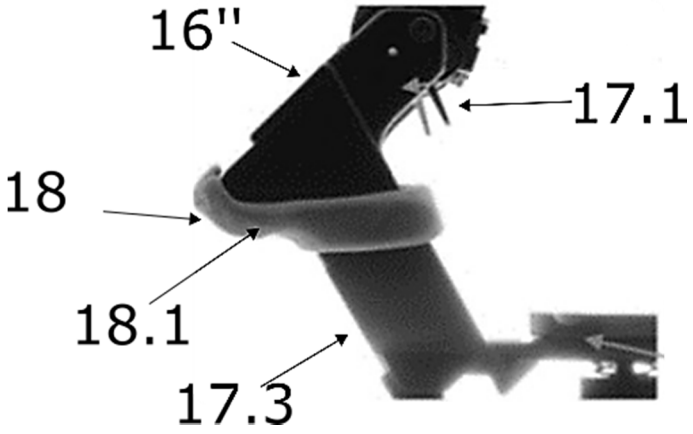

Fig. 18b

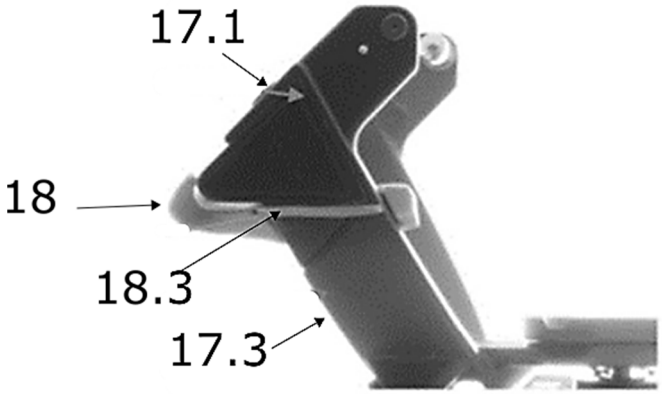

Fig. 18c

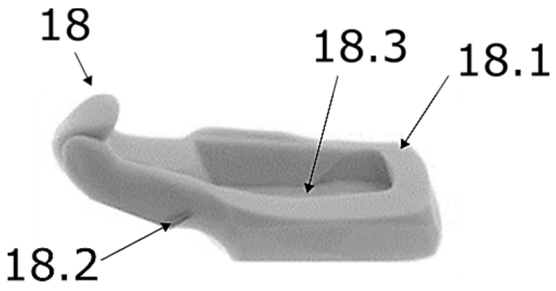

Fig. 19a

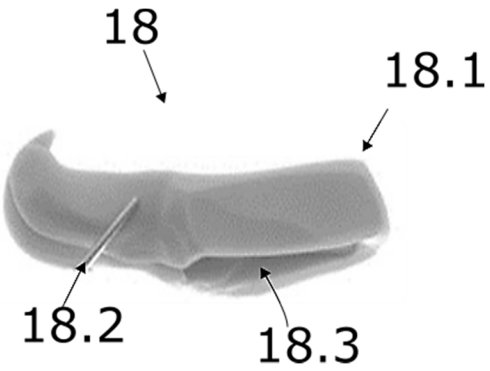

Fig. 19b

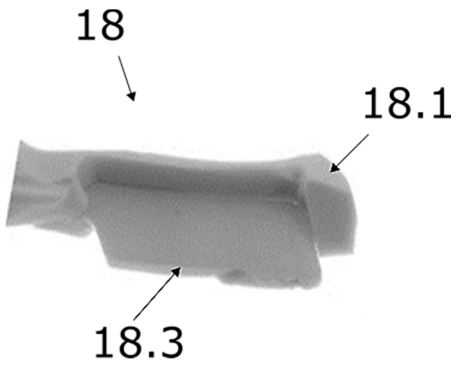

Fig. 19c

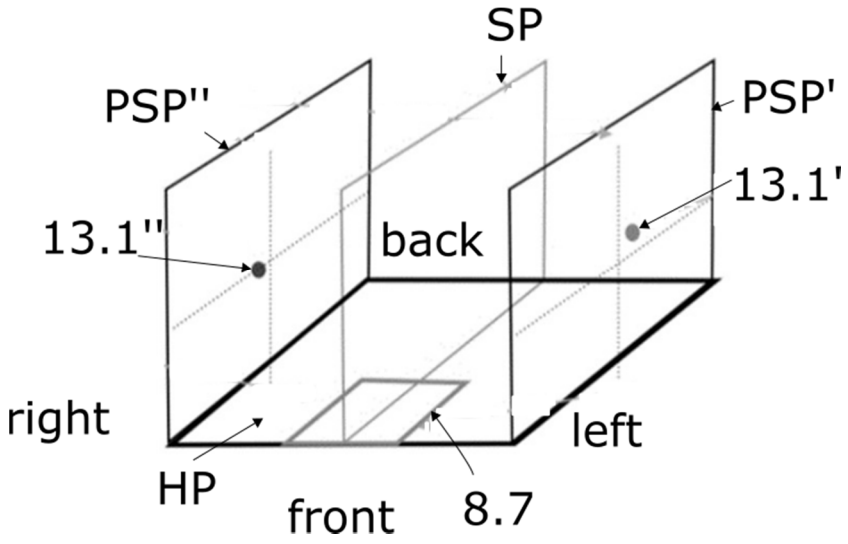

Fig. 20a

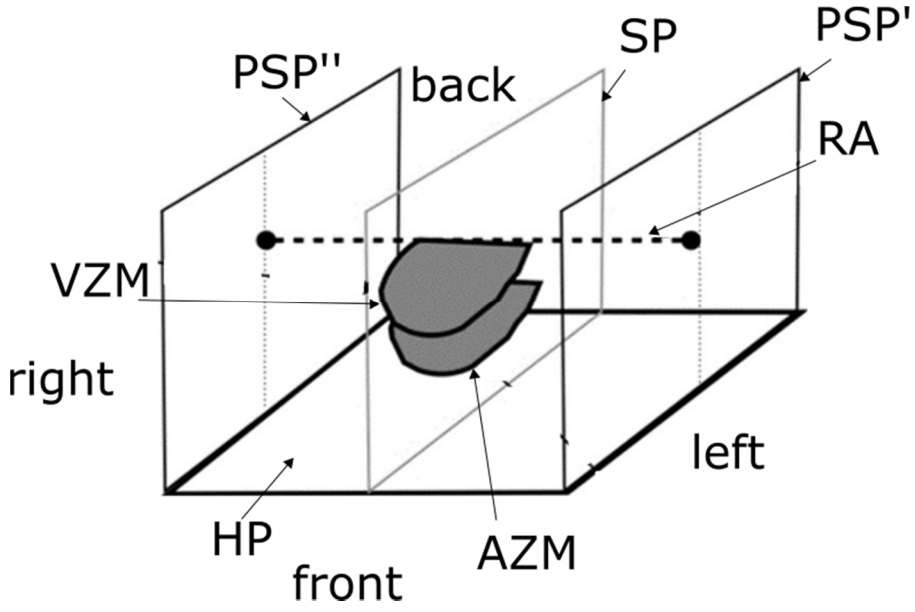

Fig. 20b