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(71) Applicant *(for all designated States except US)*: **ORATIO B.V.** [NL/NL]; Cole Porterhof 168, NL-1628 TN Hoorn (NL).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **VAN DER ZEL, Joseph, Maria** [NL/NL]; Cole Porterhof 168, NL-628 TN Hoorn (NL).

(74) Agent: **VAN WESTENBRUGGE, Andries**; Postbus 29720, NL-2502 LS Den Haag (NL).

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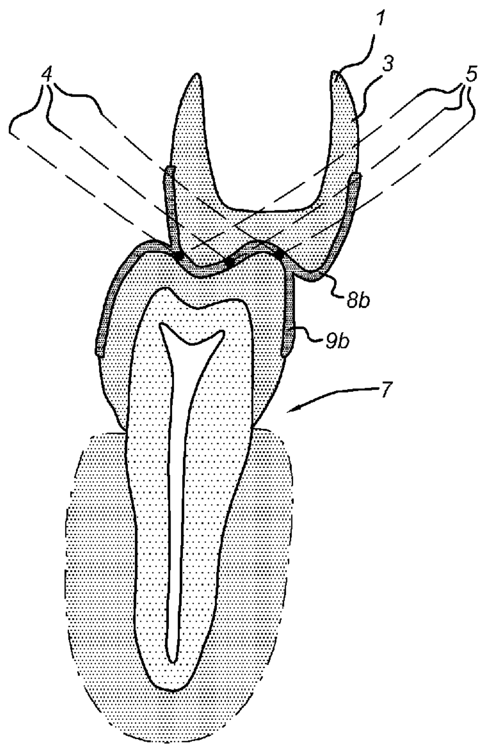
(54) Title: METHOD OF MANUFACTURING A MULTI-LAYERED DENTAL RESTORATION USING A SACRIFICED OCCLUSAL BUILD-UP LAYER INTERMEDIATE

Fig 3



(57) Abstract: A method of manufacturing a dental restoration element (1) that includes an occlusal build-up layer (40) on a support structure (12), comprises the application of an occlusal build-up intermediate (13) of a sacrificial material on the support structure. The occlusal build-up intermediate is fixed by a retention element (11) on the support structure and has a shape and dimensions substantially identical to the occlusal build-up layer.

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Method of manufacturing a multi-layered dental restoration using a sacrificed occlusal build-up layer intermediate

FIELD OF THE INVENTION

The present invention relates to a method of manufacturing a dental restoration element. Also, the present invention relates to a computer program for designing and manufacturing a dental restoration element.

Further, the present invention relates to an intermediate product for manufacturing a dental restoration element and to a dental restoration element.

BACKGROUND OF THE INVENTION

Dental restorative systems seek to provide cosmetic and functional replacements for missing teeth. A dental restorative system that replaces a single tooth or multiple elements comprises a supporting base structure of metal or aluminium- or zirconium-oxide covered by a porcelain for tooth-like aesthetics. The restorations replicate the contour and appearance of the visible portion of the restorative system to match that of the natural dentition. Finally, the dental restoration must have appropriate contact relation with its opposing teeth in static occlusion and dynamic articulation during chewing and approximal contacts with its neighboring teeth to keep a stability in the teeth row in the jaw.

In the presently used method of manually layering of porcelain powder on the base structure the provision of appropriate occlusal and approximal contacts are difficult to achieve because of the unpredictable shrinkage of the porcelain powder, and can only be achieved by tedious corrective grinding afterwards.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of manufacturing of a multi-layered dental restoration.

Moreover, it is an object of the present invention to provide a method of manufacturing aesthetic restorations having static and dynamic contact with the adjacent and opposing teeth.

It is yet another object of the present invention to provide a manufacturing method which provide better accuracy and faster results than conventional methods.

According to a first aspect of the invention, there is provided a method of manufacturing a dental restoration element that comprises an occlusal build-up layer on a support structure in accordance with claim 1.

Advantageously, the present invention provides that a dental restoration element for a patient can be produced by CAD/CAM technology. CAD/CAM is used to create and produce an occlusal surface for the dental restoration element on an intermediate layer which by its snap-fitted position on the support structure can have an already relatively precise shape.

According to a second aspect, the method provides that a shape of a first occlusal surface of the occlusal build-up intermediate is created in relation to a predetermined shape of a second occlusal surface of an antagonist tooth that jointly share one or more contact points of the first occlusal surface and the second occlusal surface, wherein the first occlusal surface is being shaped in such a way that each contact point remains connected and keeps a pre-determined disclusion path; the disclusion path describing an interference free chewing movement of the first occlusal surface relative to the second occlusal surface at the respective contact point.

Advantageously, a functional occlusal and approximal surface design can exactly be reproduced without any corrective grinding and mutilation by corrective actions necessary for an interference free articulation (chewing).

The described method is especially suitable for molars and pre-molars but can also be used to produce restorative restorations in the cuspid and incisor region of the mouth.

Modeling of the occlusal surface of teeth is an important step in computer-aided design (CAD) of dental restorations. Without CAD-software an occlusal surface with satisfactory contacts can also be copied from a digital scan of the original tooth or a modeled wax reproduction of the restoration. The designed shape must fit the existing jaw articulation and increase the stability of the elements. Also, the design process must be fast to be practical in clinical applications. The present invention makes use of the virtual occlusal surface of the new restoration that is in occlusal and approximal contact with a group of virtual teeth and has disclusion paths together with the surface of the antagonist teeth that was merged with the actually scanned surface of the registration bite of the treated patient.

According to a further aspect, the method provides that the contact points at the first occlusal surface and approximal contact points at the first occlusal surface are obtained by:

determining a surface contour of a group of teeth in a same jaw, a model of the dental restoration element being one of the group of teeth, by merging with a surface contour of still existing teeth surfaces in the same jaw, the first and second occlusal surfaces remaining connected at the contact points that maintain their disclusion paths;

and positioning the model of the dental restoration element in the group of teeth with disclusion paths that are suitable for a patient for which the restoration is meant.

Here a method is presented for automatic adjustment of the occlusal surface of restorations based on a model of articulation simulation in group function. During the mathematical operation the shape of restorations is changed to avoid interpenetrations with the opponent teeth during functional jaw movements, without losing occlusal contacts. The modification of the shape must guarantee the surface smoothness and preservation of the main topological features of the occlusal and approximal surfaces.

The CAD-software described herein enables the modification of the tooth shape without loosing the contact points with the anatomy of virtual antagonistic teeth that are mathematically merged to coincide with the physical surface of the scanned opposing and adjacent teeth.

Instead of designing individual teeth a group of virtual teeth, an assembly or connected group of teeth are placed in the scan of the existing teeth by merging with existing antagonistic surfaces.

In the present invention an occlusion and articulation model is proposed whereby not a single crown is brought into contact and articulated, but a group of virtual molars of the upper and lower jaw, already in perfect occlusal and approximal contact and with individualized disclusion paths is merged with the scanned surface of the antagonist and adjacent teeth, whereby the newly designed teeth are automatically in perfect contact relations with the neighboring teeth and with chewing movements without interferences.

Occlusion, as a functional outcome of the interaction of the stomatognatic structures, should be individualized to meet the needs of the patient. Careful recording and analysis of jaw-motion should be included in the design process in view of the events at the condyle-fossa-surface.

The ideal form of the occlusal surface of the dental restoration is automatically designed using generic library models of the occlusal surfaces of the newly designed restoration and the antagonists, whereby both surfaces have pre-determined contacts and disclusion paths.

The method according to the present invention comprises optical scanning of a study cast, previously made of the patient's mouth. This study cast serves as a model of the patient's mouth and shows the site of desired tooth replacement as well as the relation of such a replacement tooth to the surrounding teeth. Also an bite impression (a registration bite), made for example in a heavy body silicone material, is scanned to gain surface data of the antagonistic teeth.

In a further aspect of the invention, the present invention provides a computer program for designing and manufacturing a dental restoration element that comprises an occlusal build-up layer on a support structure; the manufacturing comprising:
applying an occlusal build-up layer intermediate o a sacrificial material on the support structure, the occlusal build-up intermediate being fixed by a retention element on the support structure and having a shape and dimensions substantially identical to the occlusal build-up layer, the computer program after being loaded by a computer allowing the computer to execute: creating a first occlusal surface of the occlusal build-up intermediate in relation to a second occlusal surface of an antagonist tooth that jointly share one or more contact points of the first occlusal surface and the second occlusal surface, the first occlusal surface being shaped in such a way that each contact point remains connected and keeps a pre-determined a disclusion path; the disclusion path describing an interference free chewing movement of the first occlusal surface relative to the second occlusal surface at the respective contact point.

The computer program is used for planning the dental restoration (e.g. a crown or a bridge) and for designing a model of the customized crown or bridge based on the optical scanning data. The computer is arranged for carrying out a program capable of generating a mathematical model of the surface of the customized dental restoration as part of the assembly or connected group of teeth and the merging of the contact surface of the antagonists with the scanned registration bite based on the optical scan data. The computer has access to a database containing a mathematical model of standard tooth shapes for each type of tooth, connected as it where like a pearl necklace and with an occlusal surface with pre-determined contact points that are in contact with a virtual antagonistic surface and with pre-determined patient-dependent discursion path directions for each contact point. The standard mathematical surfaces for the particular group of teeth, from first pre-molar till second molar, being replaced is then computationally modified and customized by a parametric deformation algorithm. To obtain an real-world object according to this customized model, the computer program is capable of generating a series of instructions for milling paths to be used in a milling machine for the automatic production of an occlusal build-up intermediary.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of teaching of the invention, preferred embodiments of the method and devices of the invention are described below. It will be appreciated by the person skilled in the art that other alternative and equivalent embodiments of the invention can be conceived and reduced to practice without departing form the true spirit of the invention, the scope of the invention being limited only by the appended claims.

Figure 1 shows a sectional view of the inner and outer contour of a newly designed tooth in contact with an existing natural tooth and three contact points;
Figure 2 shows a sectional view with an occlusal surface of the new tooth with predetermined disclusion paths, that are designed to give an interference-free disclusion for that particular patient;
Figure 3 shows a cross section of the surface of the new tooth, the disclusion paths and the merged surface of the existing tooth superimposed of the newly designed tooth in contact with the antagonist;
Figure 4 shows a dental restoration according to the present invention;
Figures 5a-5c show the processing sequence of hot-pressing a veneer build-up over the support structure of the dental restoration;
Figure 6 illustrates how teeth in a jaw act like pearls on a string make contact at their approximal contact points;
Figure 7 shows the occlusal contacts in the lower (mandible, right) jaw and contact fields in the upper jaw (maxilla, left) of the teeth groups from the first pre-molar till the second molar, grouped in pairs, and
Figure 8 shows schematically a computer arrangement as used in the system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In an article in Quintessence International Volume 24, Number 11/1993 by Jef M. van der Zel “Ceramic-fused to-metal restorations with a new CAD/CAM system” a mathematical articulation model is described with the aim to design a mandibular first molar in occlusion and with cusps that escape and return to their fossae without interferences. The aim of single tooth design is that cusps should escape and return to their fossae without interferences. Mandibular movements in three dimensions have been simulated by dental articulators whose condylar and incisal guides define the condilary movement patterns. A three-dimensional locus of points scribed by a cusp tip of one dental arch transversing an opposing occlusal surface may be described as an arc or pathway of movement. These can be obtained by registering the functionally generated path (FGP) obtained by chewing movements by registration of the movements of the mandible joints. In the last case it is possible to calculate the working, balancing and protrusive pathways and run a simulation of these chewing movement paths of the antagonists against the new dental restoration by the computer, whereby any interferences are removed by withdrawal of the interfering surface under control by a parametric warping algorithm. The optimum type of occlusion which can resist differences in abrasion rate between enamel and porcelain surfaces must conform to one that provides minimal tooth contact outside centric relationship.

The three-dimensional pathways which the supporting maxillary or mandibular cusps follow during mandibular movements are computed mathematically.

A model of the craniomandibular system was developed in a way that it simulates the action of the human stomatognathic system. All elements of the biomechanical model are incorporated into the mathematical model and can be varied. Initial standard or default settings other than zero are selected for certain parameters. The default setting for the intercondylar distance is 110 mm, or 55 mm on either side of the midline. The standard medial wall configuration, or Bennett angle, is 10 degrees, and the standard anteroposterior condylar inclination is 35 degrees.

Other variables are related to the location of the dental arches within the model system. The standard location of the incisal edges of the mandibular incisors is 85 mm anterior and 33 mm inferior to the horizontal (transverse) axis. The initial inclination of the occlusal plane is parallel to the horizontal.

The condylar and incisal controls of the mathematical model have limits of the natural model imposed on their ranges. The location of the simulated arches is also limited to keep the arches within the confines of normal anatomy. Registrations such as electronic axiography can be used to change the default settings in the computer. Initial default settings other than zero were selected for certain parameters.

Vertical contacts are made with the antagonist at the mesiolingual cusp, distobucal cusp, distal marginal ridge, distolingual triangular ridge, mesial marginal ridge and mesiolingualtriangular ridge of the upper first molar. Some contacts will also be found on the upper second premolar.

The design of the crown or bridge outer contour follows the following procedural steps: selection of proper element from the library, modeling the support structure (substructure) or substructure crown on the screen to fit in with the remaining dentition and final adjustment of approximal contacts by the computer. A maxillary second pre-molar to be replaced by an implanted crown was designed on a scanned implant with an substructure with a margin line that was adapted to the mucosa surrounding the implant location. The appropriate tooth is chosen by the operator from an extensive collection of generic forms of theoretical teeth in the program's library. When an intact mirror-element can be found in the arch, it can be scanned and used as a standard tooth. The distal and mesial contacts indicated by the operator in the occlusal and buccolingual views of the scan form the first step in the fitting of the generic tooth. The margin line of the new crown is adjusted to the mucosa line that was isolated automatically from the scan of the implant location.

The lingual and buccal boundaries are clicked in and dragged with the mouse, to shape the tooth so that it fits in a natural appearing row with the adjacent teeth. A warping algorithm generates a deformation field and deformation vectors within the field to generate the new form as directed by the drag vector indicated with the mouse. This way the external contours of the new crown can be adjusted interactively with the mouse, in much the same way of the building-up of porcelain by brush or spatula. After the crown has been fitted into the row, the computer adjusts the mesial and distal contacts to within +/- 0.02 mm of the adjacent teeth. The centric tooth-to-tooth contacts are obtained in relation to the quality of the opposing occlusal surface. Resulting contacts vary from a complex tri-podic occlusal situation in case of an ideal antagonist surface to a simple central contact on a less-defined occlusal surface.

The new crown is then superimposed on the opposing teeth which are displayed on the screen as a relief map. The CAD program deforms the generic tooth parametrically (with conservation of shape) according to gnathologic principles. On the library tooth preferred points of contact are used as anchor points to direct the search for contacts with the antagonist. The different fields of contacts of the crown are deformed to give maximal tooth-to-tooth contact with the opposing teeth. Because the theoretical tooth is brought into contact with antagonist as scanned, it can be assumed that contacts are also in the same range as the scanning accuracy, that is 0.01 mm.

The occlusal surface should allow cusps to escape and return to their fossae without interferences. Proper prosthetic fabrication should ensure that functional contact relationships are restored for both dynamic and static conditions. Maxillary and mandibular teeth should contact in a harmonious manner that allows optimum function, minimum trauma to the supporting structures, and an even distribution of load throughout the dentition. Positional stability of the occlusion is critical if implant integrity and proper function are to be maintained over time.

The problem with this single crown concept is three-fold:

a. the exact locations of the contacts are not clearly defined;

b. the approximal contacts are not easily found in proper place;

c. the articulation movement will mutilate the crown is such a way that some functionalities like balance and chewing efficiency will suffer.

In present CAD systems, the surface of the antagonists obtained by the scan of the registration bite is used to bring the contour of the translucent porcelain layer of the aesthetic crown or bridge in occlusal contact with the antagonist. After the computer calculates a simulated chewing movement eventual clenching intrusion can be corrected in the occlusal plane of the crown. The deformation caused by this correction gives the crown a mutilated unnatural contour which effects the functionality for chewing and stability. For multi-element bridges this operation is performed for each element, by which the total group function is lost.

The present invention relates to methods and materials for use in dental restorative systems. A dental restorative system replaces a tooth in a patient's mouth. A dental restorative system is shown in Figure 1 as described below and comprises a dental restoration shown here in occlusal contact with the opposing dentition and with disclusion paths that guarantee a free movement of the opposing teeth during chewing.

The dental restoration is fabricated based on a reconstruction of data derived from optical scanning of impressions. For scanning an optical scanner can be used, for instance CyrtinaScanner (Oratio B.V., Zwaag, The Netherlands). After a study cast and impression are completed, the method according to the invention provides the scanning of the cast and an impression of the antagonist teeth obtained by a registration bite in the patient’s mouth.

Design data for the dental restoration include the generation of a generic model of the restoration customized by not only entering measurements into an algorithm but also by taken into account the occlusal and disclusion relations between restoration and antagonists from pre-molar till molar, based on a mathematical model of the opposing occlusal surfaces and approximal contacts a generic library model that can be deformed parametrically to give a functional and aesthetic restoration of the lost elements.

The computer is programmed to fit the generic model of the customized restoration (either a crown or a bridge) to the adjacent element(s) and the antagonistic teeth. The computer is pre-programmed to contain a series of connected library teeth from first pre-molar till second molar of the upper and lower jaw, and to modify the standard group of connected generic library teeth by merging the surfaces of the virtual teeth with the surfaces of the real antagonistic teeth surfaces by an mathematical merging algorithm.

Such surface merging algorithms can be found in dental CAD/CAM software packages such as CyrtinaCAD (Oratio B.V., Zwaag, The Netherlands). Once the surface data of the antagonists are merged to the virtual antagonist surface, while leaving the contact points and the disclusion directions that where pre-determined for that particular patient intact, the resulting newly designed restoration is viewed and modified if necessary in a correct position on the computer screen. The restoration is interactively manipulated to include the mesial-distal contacts and natural contours in a patient's mouth. Other scanned data may be used to guide the manufacture of a customized dental restorations, such as the occlusal surface obtained by a micro-CT scan of the impression of the preparation or the registration bite impression.

Mesial and distal contacts if present are determined to design the “equator”-feature of the restoration.

Figure 1 shows a sectional view of the inner and outer contour of a newly designed tooth 1 (dental element) as a dental restoration in contact with an existing natural tooth (i.e., the antagonist) 7. The contact is established by three contact points 6, which are joint between the newly designed restoration and the antagonist, and have each a disclusion path 4, 5 that guarantees an interference free chewing movement without causing clenching of the teeth. The sectional view shows the new tooth 1 with an inside 2 and an outside surface 3. The disclusion trajectories 4, 5 are indicated for each of the three contact points 6 of the new tooth 1 with the existing antagonist tooth 7.

Figure 2 shows a sectional view with an occlusal surface 8 of the new tooth 1 in contact with an occlusal surface 9 of the existing tooth 7.

The occlusal surface 8 of the new tooth 1 comprises predetermined disclusion paths 4, 5, that are designed to give an interference-free disclusion for that particular patient. The surface 8 of the new tooth is described by a mathematical model of the two occlusal surfaces 8, 9 attached at their joint contact points 6 and the disclusion paths 4, 5. The contacts 6 between the new tooth 1 and the existing tooth 7 remain in contact, during the merging of the virtual antagonist surface with the existing antagonist surface.

Figure 3 shows a cross section of the surface 8b of the new tooth 1, the disclusion paths 4, 5 and the merged surface 9b of the existing tooth 7 superimposed on the newly designed tooth in contact with the antagonist, showing how the virtual occlusal surface 9 according to the mathematical model is merged with (a model of) the real surface of the antagonist 7, which real surface (model) is obtained by an optical scan of a registration bite. For the design of the support structure (substructure) a dental CAD/CAM software package can be used, for instance CyrtinaCAD (Oratio B.V., Zwaag, The Netherlands).

The dental restoration made from the design as described above consists of a support or base structure, made of zirconia or metal, and a veneer layer of overpressed material.

The shape of the veneer layer is made by a separate process such as milling or stereolithography or 3D printing, and fits with a snap-fit on the structure on a retention rim, preferably located at the cervical part of the structure.

Figure 4 shows a cross-section of the dental restoration 1. The dental restoration 1 comprises a coping support structure 12, a retention rim 11, and a occlusal build-up layer intermediate 13.

The retention rim 11 is arranged to hold the occlusal build-up layer intermediate 13 at its position. The occlusal build-up layer intermediate 13 is in a position covering the support structure, snapped over the retention rim.

The material of the occlusal build-up layer intermediate 13 has mechanical characteristics such as a suitable elastic behavior to allow a placement of the intermediate 13 on the support structure 12 by a snap-fit arrangement.

The occlusal build-up layer intermediate 13 is made using CAD/CAM by milling or by stereolithography or by 3D printing and comprises a plastic material suitable for CAD/CAM technique such as a plastic for example, polyurethane.

As will be described in more detail below, the occlusal build-up layer intermediate 13 is a sacrificial layer that is to be replaced by the veneer layer at a later stage. This is described with reference to Figure 5.

Figure 5 shows the processing sequence of the formation of the veneer layer over the support structure.

As shown in Figure 4, the occlusal build-up intermediate 13 is snapped in place on the support structure. The support structure 12, typically consists of cold isostatically pressed Y-TZP zirconia, that may be shaded by ion exchange of Zirconium-II by Manganese-II and Yttrium-III by Iron-III, such as BioZyram (Oratio B.V., Zwaag, The Netherlands). Alternatively, the support structure 12 consists of a metal with a thin opaque ceramic layer.

At a first stage as shown in Figure 5a, the occlusal build-up intermediate 13 comprises a sprue with a cylindrical form attached to the occlusal build-up. The sprue may consist of for example, wax or the same material as the occlusal build-up intermediate 13 is made of.

The assembly 30 of the support structure 12 and the occlusal build-up intermediate 13 provided with the sprueform and the sprue 32 is embedded in a block of refractory material 34.

The block of refractory material may comprise a phosphate-bonded silica sand containing magnesium oxide and ammonium-hydrogen-phosphate as binders, mixed with a water-based colloidal silica mixing liquid, for instance Carrara Universal Dustless Investment (Elephant Dental B.V., Hoorn, The Netherlands).

At a next stage, the block of refractory material 34 is heated in a furnace. Of the invested assembly 30, the sprue 32 and the occlusal build-up intermediate 13 are removed by melting, burning or evaporation. Thus by removal of the sprue 32 and the occlusal build-up intermediate 13, a mould is created in which the veneer layer can be formed by casting.

The mould, i.e., the refractory block 34 now containing only the support structure 12, is then further heated to an elevated temperature that allows a non-disturbed entry of a hot, molten press ceramic. The mould is held at elevated temperature for some time for example, 1 hour.

Then at a further stage as shown in Figure 5b, a press ceramic material, in the form of pellets is placed in the sprueform space 32. The press ceramic material may be Sakura Volumia (Elephant Dental B.V., Hoorn, The Netherlands).

A plunger 38 is placed on top of the pellets. The filled mould 34 with the plunger 38 in the sprueform is placed in a special furnace with a moving piston and heated to an elevated temperature at which the press ceramic material melts. The moving piston is in contact with the plunger 38 and presses (as indicated by arrow 39) the molten press ceramic material into the hollow sprue and subsequently in the space that was previously formed by the sacrificed occlusal build-up intermediary 13.

The plunger may be consisting of alumina or the same refractory material as the mould.

After completion of the casting and subsequent cooling down, the assembly of mould 34 and plunger 38 is divested and the casting 36 that comprises the support structure 12, the ceramic layer that replaces the occlusal build-up intermediate 13 and the sprue, is removed.

Finally, at a further stage, as shown in Figure 5c, any remaining refractory investment is removed from the casting by gently blasting with glass pearls. For example the glass pearls may have a diameter of about 50 μm, the blast pressure may be about 1 to about 3 bar (100 – 300 kPa). The sprues are removed by grinding. The dental restoration 1 at this stage comprises the support structure 12 and the veneer layer 40. The dental restoration now has the shape as designed by the CAD/CAM system. Due to a suitable choice of the materials of the support structure and the veneer layer it is conceivable to form a dental restoration 1 which substantially does not exhibit any thermal shrinkage so as to realize the designed contacts 6.

The dental restoration 1 is now ready for finishing and glazing. The technician needs only to characterize the final product by staining and glazing as necessary before the dentist will cement the dental restoration into the patient's mouth by a suitable cement, for instance, Panavia F (Kuraray, Japan).

Figure 6 illustrates an occlusion and articulation model for a group of virtual molars of the upper and lower jaw.

The shape of the occlusal layer of the dental restoration is adapted to the antagonist tooth without loosing contacts with the virtual restoration. Also, the shape can be further adapted by taking into account adjacent teeth in the same jaw in which the dental restoration is to be placed and teeth adjacent to the antagonist tooth in the opposite jaw.

The virtual group of molars, already in perfect occlusal and approximal contact and with individualized disclusion paths is merged with the scanned surface of the antagonist and adjacent teeth, whereby the newly designed teeth are automatically in perfect contact relations with the neighboring teeth and with chewing movements without interferences.

In Figure 6 it is illustrated that teeth in a jaw act like “pearls on a string” 15 making contact at their approximal contact points 14. The teeth form a row that resembles a pearl necklace that can move around these approximal contacts.

During modification of the newly to design teeth against the existing teeth, the mathematical model of the two occluding rows of teeth makes sure that these contacts remain intact hold by a dashed line 15 and the occlusal contact points.

The contact groups for first premolar pair 16, second pre-molar pair 17, first molar pair 18 and second molar pair 19 remain connected during the modification process. The occlusal contacts 6 in the upper jaw (maxilla, left) and the contact fields in the lower (mandible, right) jaw of the teeth groups from the first pre-molar till the second molar are grouped in pairs as described below.

Contacts and contact fields are indicated on each tooth by solid dots. The pairing of an occlusal contact and the corresponding contact field is schematically indicated by lines 61 – 72.

Pair 16: The palatinal (lingual) cusp of the first maxilla pre-molar have contact with the edge of the lower first and second pre-molar;

Pair 17: The palatinal (lingual) cusp of the second pre-molar have contact with the approximal edge of the second lower pre-molar and the first molar;

Pair 18: The mesio-palatinal cusp of the first upper molar makes contact with the triangle edge of the central valley of the first lower molar;

Pair 19: The disto-palatinal cusp of the first upper molar has contact with the approximal of the first and the second lower molar;

Pair 20: The mesio-palatinal cusp of the second upper molar has contacts on the triangle edge of the central valley of the second lower molar;

Pair 21: The disto-palatinal cusp of the second upper molar is in contact with the distal edge of the second lower molar.

Figure 7 shows the occlusal contacts 6 in the lower (mandible, right) jaw and contact fields in the upper jaw (maxilla, left) of the teeth groups from the first pre-molar till the second molar, grouped in pairs. Contacts and contact fields are indicated on each tooth by solid dots. The pairing of an occlusal contact and the corresponding contact field is schematically indicated by lines 75 – 87.

Pair 22: The buccal cusp of the lower first pre-molar is in contact with the mesial edge of the first upper pre-molar;

Pair 23: The buccal cusp of the second lower pre-molar has contact with the approximal edge of the upper pre-molar;

Pair 24: The mesio-buccal cusp of the lower first molar makes contact with the approximal edge of the pre- molar and molar in the upper jaw;

Pair 25: The central buccal cusp of the first lower molar has contact with the triangle edge at the central valley in the upper first molar;

Pair 26: The mesio-buccal cusp of the lower second molar has contact in the approximal area between the first and second upper molar;

Pair 27: The disto-buccal cusp of the lower second molar makes contact with the triangle edge at the central valley of the upper molar.

Figure 8 shows schematically a computer arrangement as used in the method according to the present invention to define a dental restoration with an occlusal build-up as illustrated above.

Computer system 1308 comprises host processor 1321 with peripherals. The host processor 1321 is connected to memory units 1318, 1319, 1322, 1323, 1324 which store instructions and data, one or more reading units 1330 (to read a data carrier, e.g., floppy disks 1317, CD ROM's 1320, DVD's, or solid state memory devices), a keyboard 1326 and a mouse 1327 as input devices, and as output devices, a monitor 1328 and a printer 1329. Other input devices, like a trackball or a touch screen as well as other output devices may be provided.

Further, a network I/O device 1332 is provided for a connection to a network 1333.

Also, the host processor is capable of importing data from another computer system by reading data from a data carrier or through the network connection.

Finally, the host processor 1321 may be connected to a scanning device 1334 capable of capturing 3D image data from objects. The 3D image data may comprise surface data of the object being scanned. The surface data may relate to any measurable property of the object such as color, translucency, any visible internal structure and geometry of the outer surface. Alternatively, the scanning device 1334 may be connected to the host processor via the network 1333. As a further alternative scanning data from the scanning device 1334 may be available to the host processor by means of a data carrier.

Moreover, the processor is connected directly or alternatively, via the network, to a manufacturing device (not shown) for manufacturing the support structure 12 and to a further manufacturing device (not shown) for manufacturing the occlusal build-up intermediate 13 for communicating manufacturing instruction data to either of these manufacturing devices. Alternatively, the host processor may store manufacturing instruction data to either of these manufacturing devices on a data carrier that can be read by the respective manufacturing device.

The memory units shown comprise RAM 1322, (E)EPROM 1323, ROM 1324, tape unit 1319, and hard disk 1318. However, it should be understood that there may be provided more and/or other memory units known to persons skilled in the art. Moreover, one or more of them may be physically located remote from the processor 1321, if required.

The processor 1321 is shown as one box, however, it may comprise several processing units functioning in parallel or controlled by one main processor, that may be located remotely from one another, as is known to persons skilled in the art.

The computer system 1308 shown in Figure 13 is arranged for performing computations in accordance with the method of the present invention.

The thickness of the occlusal layer build-up can be varied by the external dimensions of the colored support structure 12. The support structure body forms a background in order to arrive at the right color at the external surface of the restoration.

The task of replacing teeth with a prosthesis which by its shape and colour does not substantially differ from the other teeth, is conventionally made of two separate steps. The first step is to measure the shape and color shade of a tooth to be replaced and the second step is to make a duplicate of that tooth according to the measurements taken in the first step.

To obtain color information of a tooth a line scanning data acquisition method is used, in which a controlled white light illuminates the visible part of the tooth. The reflected light is recorded by means capable of detecting spectral information from the reflected light. In the art, such spectral information is typically defined in accordance with a standard known as the CIE lab color standard.

It is to be noted that the line scanning data acquisition method may provide a high spatial resolution in the direction perpendicular to the scan direction. However, there is a trade-off between the spatial resolution in the scan direction and temporal resolution. Since the dental industry does not use the CIE LAB color to communicate tooth color, but a color shade guide provided by the manufacturers of the ceramic powders used to manufacture dental prosthesis, CIE lab color results must be further processed. Different digital measurement techniques are presently used to quantize the reflected light coming from an illuminated object. These techniques usually consist in a spectral decomposition of the light reflected from a selected area of the object surface. To get a natural appearance of the support structure 12 or support structure crown one or more aesthetic cover layers of translucent tooth colored glass ceramic are necessary on the support structure. The support structure body may be pigmented zirconia or a metal with a masking pigmented opaque layer, to obtain a tooth color.

The method of the present invention comprises five steps:
1) establishing the available outer shape and dimensions of the dental restoration in contact with the opposing teeth and the adjacent teeth using design software;
2) acquiring an image of a natural tooth to be replaced by the artificial tooth or corresponding natural tooth over at least the in use visible outer surface thereof, including variations in appearance in said outer surface;
3) determining variations in the appearance determining properties of the occlusal build-up layer 13; 40 to correspond with the variations in the appearance of the corresponding natural tooth, and determining the thickness of the occlusal layer build-up locally (in a three-dimensional coordinate-system) required for said correspondence;
4) constructing the top part topography of the support structure body to a shape and dimensions, which are based on the shape and dimensions available for the artificial tooth, and prior to construction deducting in the design software from the shape and dimensions, the locally required thickness of the occlusal build-up layer 13; 40, and

fitting the occlusal layer build-up over the structure and replace it by press ceramic using a thermal pressing system.

EXAMPLE 1

An impression is made of the dental arch to be restored with a U-form non-opaque tray, filled with silicone. The silicone negative is poured in gypsum. Then a registration bite impression is made, while the patient bites in central occlusion.

The next step in the fabrication of a crown or bridge is to create an optical impression obtained by laser scanning of the cast and the registration bite (see e.g., Van der Zel et al., The CICERO system for CAD/CAM fabrication of full-ceramic crowns. J Prosthet. Dent 2000;85:261-7). The CAD/CAM system may use of a fast laser-stripe scanning method to measure the 3D geometry of the arch of the opposing teeth. A straight laser stripe, which is projected onto the cast, is deformed by the 3D occlusal geometry of the tissues, and this deformation is used by the computer to determine the actual 3D positions of those points on the surface of the tissues. A charged coupled device (CCD) camera scans the projected line. The model is placed in the scanner clamping device, so that the path of insertion of the restoration coincides approximately with the vertical z-axis of the scanner.

A rough overall-scan, using steps between consecutive scan lines of 0.2 mm, of the total arch which is to be implanted is made and converted to a 3D surface. In this relief, the location of the implant site, the approximal contacts of adjacent teeth and the extent of the scan area and the neighboring elements are entered . The incisal point, and a cusp tip on the last molar bilaterally are marked by clicking on the screen using the mouse. From this information the orientation of the occlusal plane in the masticatory system is defined and the scanner software generates a scanning protocol that prevents shadowed parts.

Then, the antagonist impression, placed on the model, is fine-scanned, using steps between consecutive scan lines of 0,05 mm, with a high definition. After removal from the cast, the cast with the implant site is subsequently scanned. Then the impression tray with the three reference spheres is placed on the model and the three spheres are scanned. The accuracy of the scanning method lies within 0.01 mm.

The registration bite data are merged with the virtual surface of the antagonists and adjacent teeth in the mathematical model of the molars in occlusal and approximal contact with each other.

The design data of the occlusal layer build-up layer intermediate are converted to STL format and used to be milled in polyurethane, by 3D printing in resin or by stereo lithography in poly methyl methacrylate resin (PMMA).

After the exterior tooth surfaces has been designed, several interface surfaces between the ceramic support structure core and between dentine and incisal porcelain are defined. The CAD-CAM software calculates the interior surface of the top topography of the pigmented zirconia support structure core. Taking the digital color map of the corresponding tooth the shade type of glass ceramic and the thickness of the shaded translucent layer, which determines the distance of the top side topographic surface from the designed outer contour of the aesthetic substructure crown, are calculated.

A hexagon block of a isostatically pressed 3Y-TZP zirconia (Tosoh, Tokyo, Japan) was clamped on its two lateral sides in the prismatic clamping device in the milling machine. The support structure 12 was milled. The support structure is sintered at a temperature between about 1300 and about 1600 ^{o}C, and experiences a shrinkage of about 15 – 25%.

The support structure 12, may consist of cold isostatically pressed Y-TZP zirconia (as mentioned above), optionally shaded by ion exchange of Zirconium-II by Manganese-II and Yttrium-III by Iron-III, (e.g., BioZyram, by Oratio B.V., Zwaag, The Netherlands). Alternatively, the support structure 12 may comprise a metal with a thin opaque ceramic layer.

Then the occlusal build-up layer 13 is milled from a polyurethane block. The occlusal build-up 13 is snapped in place on the support structure 12.

A sprue with a cylindrical form, made in wax or in the same material as the occlusal build-up intermediate 13, is attached to the occlusal build-up intermediate 13 . The assembly of the support structure , the occlusal build-up intermediate and the sprueform is embedded in a refractory material.

Such a refractory material is for example a phosphate-bonded silica sand containing magnesium oxide and ammonium-hydrogen-phosphate as binders, mixed with a water-based colloidal silica mixing liquid, (for instance Carrara Universal Dustless Investment by Elephant Dental B.V., Hoorn, The Netherlands) . Of the invested assembly the sprue and the occlusal build-up intermediate are removed by melting, burning or evaporation (or a combination thereof). The refractory block now contains the support structure and a shaped void left by the occlusal build-up intermediate and can function as a mould. The refractory block is further heated to an elevated temperature that allows a non-disturbed entry of hot, molten press ceramic. The investment mould is held at elevated temperature for some time , for example, 1 hour. Then a press ceramic, (for instance Sakura Volumia by Elephant Dental B.V., Hoorn, The Netherlands) in the form of 2 til 3 gram pellets are placed in the sprueform space. A plunger consisting of alumina or the same refractory material as the mould is placed on top of the pellets. The mould with the plunger is placed in a special oven with a moving piston and heated to an elevated temperature at which the press ceramic melts. The piston presses the molten press ceramic into the hollow sprue and subsequently in the void that is previously formed by the sacrificed occlusal build-up intermediary. The press assembly is divested and any remaining refractory investment is removed by a cleaning procedure for example by blasting with glass pearls (with e.g. 50 μm diameter particles) at a working pressure of about 1 - 3 bar (100 – 300 kPa). Finally, the sprue is removed by grinding and the restoration is ready for finishing and glazing. The technician needs only to characterize the final crown by staining and glazing as necessary before the dentist will cement the restoration into the patient's mouth by a suitable cement, for instance, Panavia F (Kuraray, Japan).

Although the present invention has been described hereinabove by way of preferred embodiments thereof, it can be modified, without departing from the spirit and nature of the subject invention as defined in the appended claims.

Claims

1. A method of manufacturing a dental restoration element (1) that comprises an occlusal build-up layer (40) on a support structure (12),
the method comprising:
applying an occlusal build-up intermediate (13) of a sacrificial material on the support structure, the occlusal build-up intermediate being fixed by a retention element (11) on the support structure and having a shape and dimensions substantially identical to the occlusal build-up layer.

2. Method according to claim 1, wherein a shape of a first occlusal surface (8) of the occlusal build-up intermediate (13) is created in relation to a predetermined shape of a second occlusal surface (9) of an antagonist tooth (7) that jointly share one or more contact points (6) of the first occlusal surface (8) and the second occlusal surface (9), wherein the first occlusal surface (8) is being shaped in such a way that each contact point (6) remains connected and keeps a pre-determined disclusion path (4, 5); the disclusion path describing an interference free chewing movement of the first occlusal surface relative to the second occlusal surface at the respective contact point.

3. Method according to claim 2, wherein the first and second occlusal surfaces comprise three contact points (6).

4. Method according to claim 2 or 3, wherein the contact points (6) at the first occlusal surface and approximal contact points at the first occlusal surface are obtained by:
determining a surface contour of a group of teeth in a same jaw, a model of the

dental restoration element being one of the group of teeth, by merging with a surface contour of still existing teeth surfaces in the same jaw, the first and second occlusal surfaces remaining connected at the contact points that maintain their disclusion paths;

and positioning the model of the dental restoration element in the group of teeth with disclusion paths that are suitable for a patient for which the restoration is meant.

5. Method according to any one of claims 1 – 4, wherein the occlusal build-up intermediate (13) comprises a plastic material.

6. Method according to claim 5, wherein the plastic material is one from a group of polyurethane and a poly methyl methacrylate resin.

7. Method according to claim 5 or 6, wherein the occlusal build-up intermediate (13) is manufactured by either milling or stereolithography or 3D printing.

8. Method according to claim 1, further comprising:

creating a sprue on the occlusal build-up intermediate, the sprue being of a further sacrificial material, and

embedding the assembly of the occlusal build-up intermediate and the support structure in a refractory mould;

heating the refractory mould to remove the further sacrificial material of the sprue and the sacrificial material of the occlusal build-up intermediate from the refractory mould so as to form a shaped void in the refractory mould, and

filling the shaped void with a molten press ceramic material to form the occlusal build–up (40).

10. Method according to claim 9, wherein the filling of the shaped void comprises:
filling the sprue with press ceramic pellets,
placing a plunger on top of the pellets,
placing a moveable piston on the plunger,
heating the refractory mould, and
at an elevated temperature, pressing the molten press ceramic into the shaped void.

11. Method according to claim 9 or 10, wherein the press ceramic material is a translucent glassy material.

12. Method according to claim 11, wherein the occlusal build-up (40) comprises at least one aesthetic cover layer;
the method comprising a determination of a thickness of the occlusal build-up (40) in relation with the color of the press ceramic material and the color of the support structure, so as to provide the dental restoration element, after overpressing, with a final shade substantially equal or similar to that of either a corresponding tooth or a tooth to be replaced.

13. Method according to claim 11, wherein the occlusal build-up (40) comprises at least one aesthetic cover layer and has a thickness in relation with the color of the press ceramic material and the color of the support structure, chosen to give the dental restoration element with the occlusal build-up a final shade close to that of a corresponding tooth, after overpressing.

14. Method according to any one of the preceding claims, wherein the support structure is manufactured by milling a block of isostatically pressed zirconia, which has been debinded and presintered, in an size enlarged to compensate a sintering shrinkage and subsequently sintered to substantially full density.

15. Method according to any one of the preceding claims, wherein the support structure is manufactured by milling a block of an isostatically pressed Yttrium stabilized Tetragonal Zirconia Polycrystal material, pigmented by an ion exchange of Yttrium-III by Iron-III and/or Zirconium-II by Manganese-II, in a size enlarged to compensate for a sintering shrinkage and subsequently sintered to substantially full density.

16. Method according to claim 15, further comprising:

a) acquiring an image of either a natural tooth to be replaced by the dental restoration element or a corresponding natural tooth over at least a visible outer surface thereof, including variations in appearance in said outer surface;

b) determining from the image and its variations in the appearance, an appearance of the occlusal build-up layer so as to correspond with the appearance of either the natural tooth to be replaced or the corresponding natural tooth,

and determining a thickness of the occlusal build layer locally required for creating said appearance;

c) constructing the support structure to a shape and dimensions, based on the shape and dimensions available at the location of the natural tooth to be replaced and prior to construction deducting from the dimensions available the locally required thickness of the occlusal build-up layer.

17. Method according to any one of the preceding claims, wherein the shape of the occlusal build-up intermediate is created by computer-aided-design/computer-aided manufacturing.

18. Computer program for designing and manufacturing a dental restoration element (1) that comprises an occlusal build-up layer (40) on a support structure (12), the manufacturing comprising:

applying an occlusal build-up layer intermediate (13) of a sacrificial material on the support structure, the occlusal build-up intermediate being fixed by a retention element (11) on the support structure and having a shape and dimensions substantially identical to the occlusal build-up layer,

wherein the computer program after being loaded on a computer, allowing the computer to execute:

- creating a first occlusal surface (8) of the occlusal build-up intermediate (13) in relation to a second occlusal surface (9) of an antagonist tooth (7) that jointly share one or more contact points (6) of the first occlusal surface (8) and the second occlusal surface (9), the first occlusal surface (8) being shaped in such a way that each contact point (6) remains connected and keeps a pre-determined a disclusion path (4, 5); the disclusion path describing an interference free chewing movement of the first occlusal surface relative to the second occlusal surface at the respective contact point.

19. An intermediate product for manufacturing a dental restoration element (1), the dental restoration element comprising an occlusal build-up layer (40) on a support structure (12), wherein the intermediate product comprises an occlusal build-up layer intermediate (13) of a sacrificial material on the support structure, the occlusal build-up intermediate being fixed by a retention element (11) on the

support structure and having a shape substantially identical to the occlusal build-up layer.

20. A dental restoration element (1) comprising an occlusal build-up layer (40) on a support structure (12), wherein the occlusal build-up layer is positioned on the support structure the support structure having the shape of a retention element (11) at an interface between the support structure and the occlusal build-up layer.

Fig 1

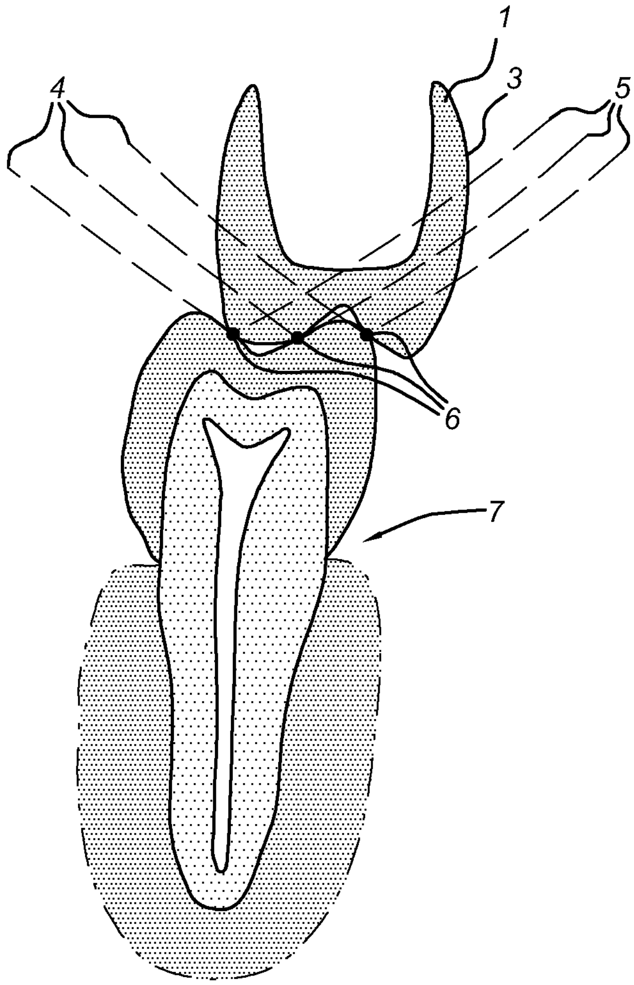

Fig 2

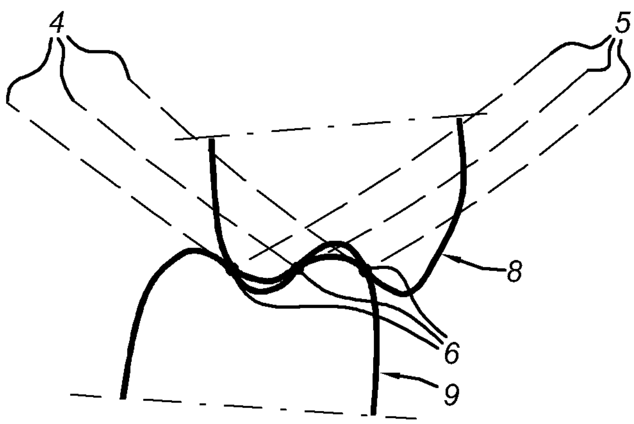

Fig 3

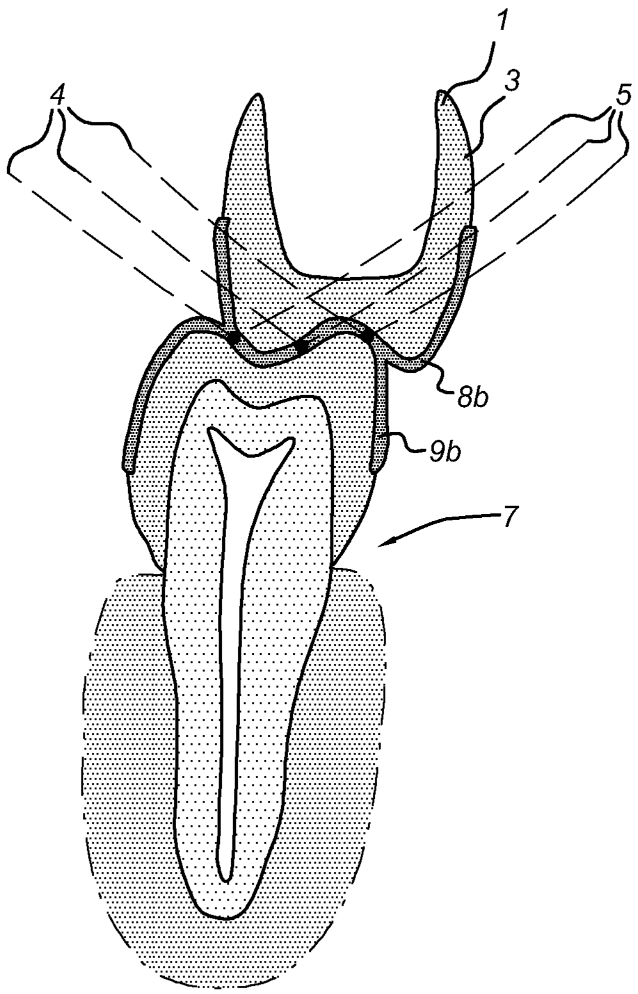

Fig 4

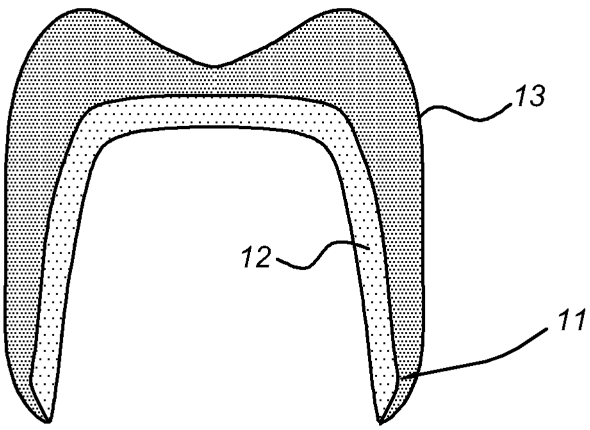

Fig 5a

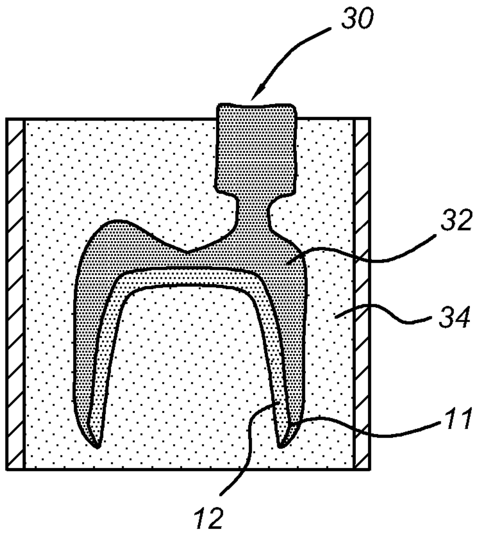

Fig 5b

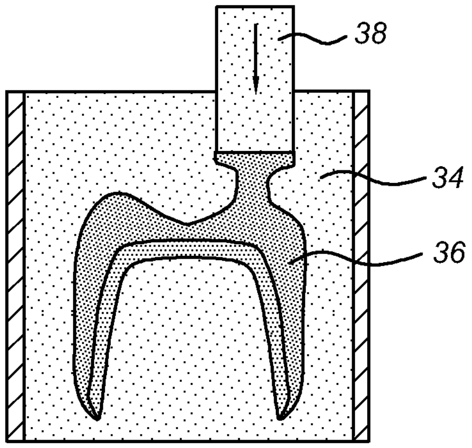

Fig 5c

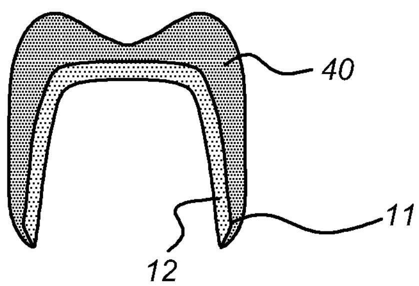

Fig 6

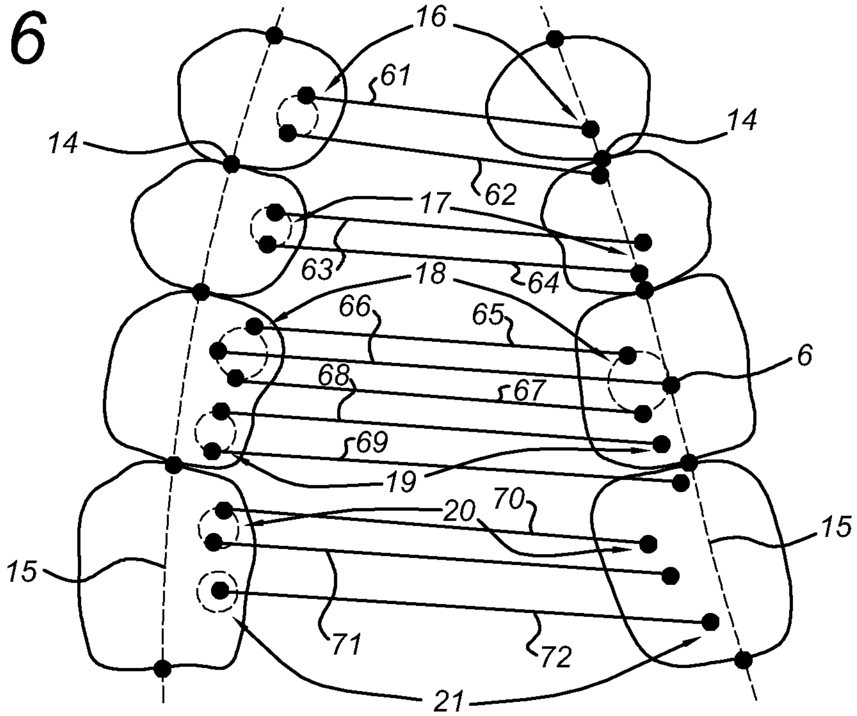
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Fig 7

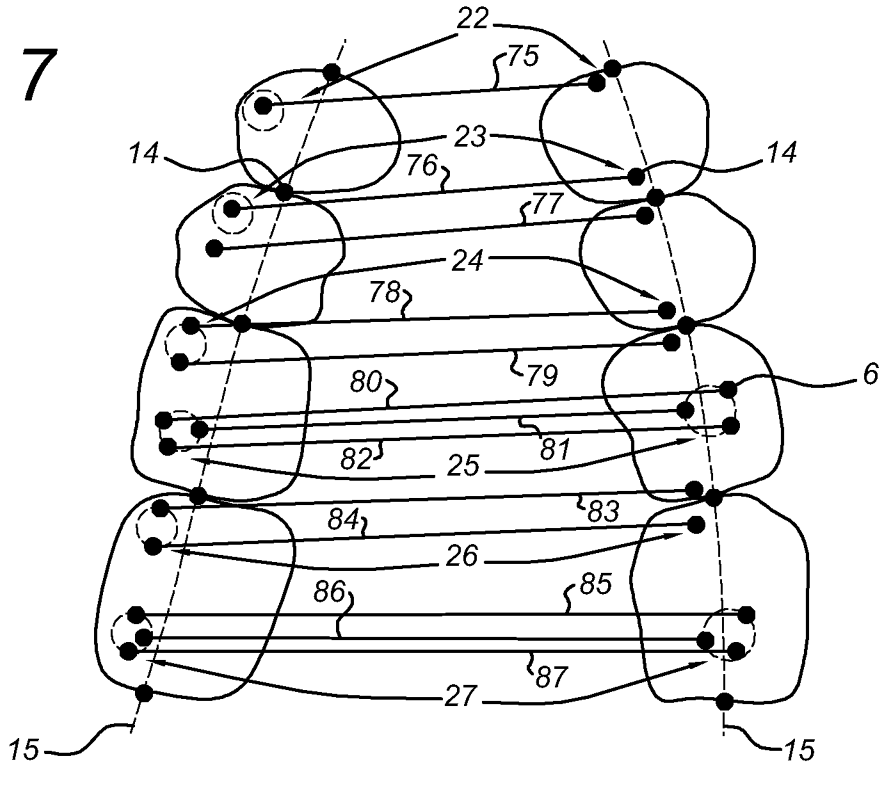
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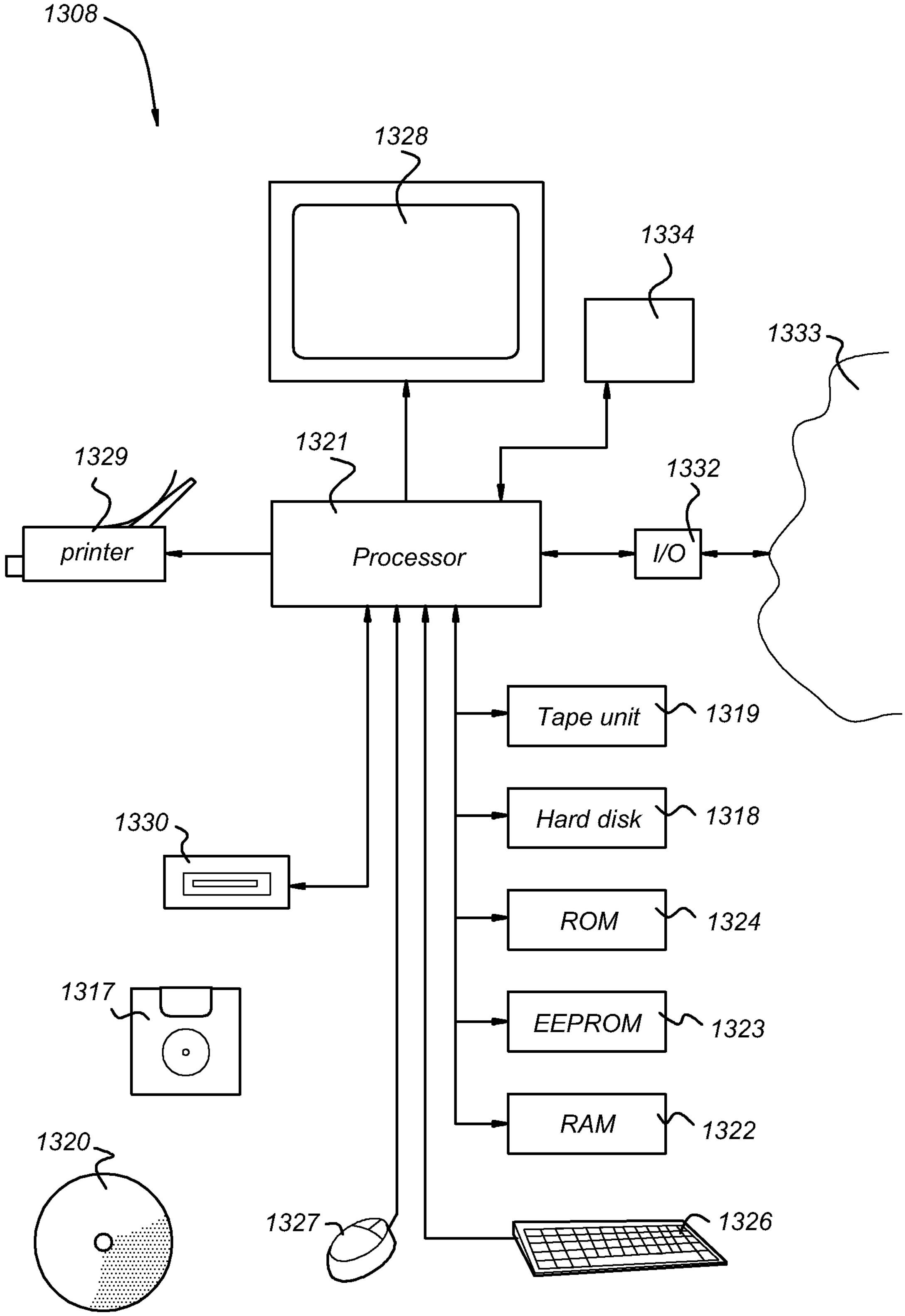
Fig 8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EEPROM
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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2007/050076

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61C5/10 A61C13/00 A61C13/08 A61C13/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 396 237 A (ELEPHANT DENTAL BV [NL]) 10 March 2004 (2004-03-10)	1,2,5,7, 8,10-15, 17,19,20
Y	the whole document	3
X	WO 02/076329 A (GLIDEWELL JAMES R [US]) 3 October 2002 (2002-10-03)	1,2,5,7, 8,14,19, 20
Y	the whole document	3,10-13
X	EP 0 051 704 A1 (BUTLER MELVYN PETER) 19 May 1982 (1982-05-19)	1,2,5,8, 19,20
Y	the whole document	3,10
X	US 2006/115795 A1 (MARSHALL MICHAEL C [US] ET AL) 1 June 2006 (2006-06-01)	1,2,4,5, 7,8,17, 19,20
Y	the whole document	3,10-13

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2007	26/02/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Salvatore, Claudio

4

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2007/050076

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 184 306 A (ERDMAN ARTHUR G [US] ET AL) 2 February 1993 (1993-02-02)	1,2,4,5, 7,17,19, 20
Y	the whole document	3
X	EP 1 568 335 A (CADENT LTD [IL]) 31 August 2005 (2005-08-31)	1,2,4,5, 7,8,10, 17,19,20
Y	the whole document	3,11-13
Y	US 2003/207235 A1 (DER ZEL JOSEPH MARIA VAN [NL] VAN DER ZEL JOSEPH MARIA [NL]) 6 November 2003 (2003-11-06) the whole document	3
A	US 5 702 514 A (PETTICREW RICHARD W [US]) 30 December 1997 (1997-12-30)	

4

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claim 9 does not exist and hence could not be searched. It has been assumed that this was due to a mistake in the numbering of the claims and hence all claims whcih dependen on claim 9 were interpreted as depending on claim 8.

Continuation of Box II.2

Claims Nos.:

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NL2007/050076

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 9
because they relate to subject matter not required to be searched by this Authority, namely:

Claim 9 does not exist and hence could not be searched. It has been assumed that this was due to a mistake in the numbering of the claims and hence all claims whcih dependen on claim 9 were interpreted as depending on claim 8.

2. [X] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:

4. [X] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

see annex

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-17,19,20

   Method of manufacturing a dental restoration having the specified charachteristics as well as the intermediate product and final products of the method.

   ---

2. claim: 18

   Computer software suitable for designing and manufacturing a dental restoration, characterized in that the software performes the steps specified in claim 18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2007/050076

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 1396237	A	10-03-2004	AT	319384	T	15-03-2006
			AU	2003261027	A1	29-03-2004
			BR	0313998	A	19-07-2005
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			CN	1678251	A	05-10-2005
			DE	60303964	T2	07-12-2006
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