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PART I: PRESENTATION

The Fiber Force CST **concept**

FLASH CV

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Classic implant solutions can mitigate the psychological and physical difficulties related to the loss of teeth, but they are expensive. A reliable, safe and affordable alternative should be offered to patients. An explanation.

Further information

• BEDROSSIAN E. : « Implant Treatment Planning for the Edentulous Patient, a graftless approach to immediate loading » - Ed. Mosby, 1st Edition, 16 Apr 2010. • BABBUSH A., KUTSKO G., BROKLOFF J. : « The All-on-Four Immediate Function Treatment Concept With Nobel Active Implants : a Retrospective Study ». • BROOKS A., R. CARR, STEWART R.-B. : « Full-Arch Implant Framework Casting Accuracy : preliminary In Vitro Observation for In Vivo Testing » ; Journal of Prosthodontics, Volume 2, Issue 1, pages 2–8, 8 Mar 2005. • LAW C., BENNANI V., LYONS K., SWAIN M. : « Article first published online » ; 1 Nov. 2011 ; Journal of Prosthodontics, Vol. 21, Issue 3, pages 219–224, April 2012. • ZARONE F., APICELLA A., NICOLAIS L., AVERSA R., SORRENTINO R. : « Mandibular flexure and stress build-up in mandibular full-arch fixed prostheses supported by osseointegrated implants » ; Clinical Oral Implants Research, Volume 14, Issue 1, pages 103-114, Feb 2003. • BYRNE D., HOUSTON F., CLEARY R., CLAFFEY N. : « The fit of cast and premachined implant abutments » ; Department of Restorative Dentistry and Periodontology, School of Dental Science, Trinity College, Dublin, Ireland. J. Prosthet Dent. ; 1998 Aug ; 80 (2) : 184-92. • NATALI N., PIERO G., PAVAN, ANDREA L. : « Evaluation of stress induced in peri-implant bone tissue by misfit in multi-implant prosthesis » ; Centre of Mechanics of Biological materials, University of Padova, Italy, Dental Materials, volume 22, Issue 4, April 2006, Pages 388–395. • CHEN C., PAPASPYRADAKOS P., GUZE K., SINGH M., WEBER H., GALUCCI G. : « Effect of misfit of cement retained implant single crowns on crestal bone changes » ; International journal of prosthodontics, 2013 ; 26 : 135-137. • DUPUIS V. : « La prothèse immédiate : une technique au service des patients » ; ADF, Quintessence Prothèse - 1999. • TISCHLER M., GANZ, PATCH C. : « An Ideal Full-Arch Tooth Replacement Option : CAD/CAM Zirconia Screw-Retained Implant Bridge » ; Dent today, Thursday, 09 May 2013. • NARVA K.-K., LASSILA L.-V., VALLITTU P.-K. : « Fatigue resistance and stiffness of glass fiber-reinforced urethane dimethacrylate composite » ; Prosthet Dent. 2004 Feb ; 91 (2) : 158-63. • BONENFANT L., MANEUF B. : « Ingénieur matériau, Bio Composants Médicaux, Matériaux composites » ; édition Hermes. • NARVA K.-K., LASSILA L.-V., VALLITTU P.- K. : « Fatigue resistance and stiffness of glass fiber-reinforced urethane dimethacrylate composite » ; J Prosthet Dent. 2004 ; 91 (2) : 158-63. • K. EKSTRAND K., RUYTER I.-E., ØYS H. : « Adhesion to titanium of methacrylate-based polymer materials » ; Niom, Scandinavian Institute of Dental Materials, Forskningsveien 1, 0371 Oslo 3, Norway.

Cable Stayed Technology (CST) consists of a high-strength fiber–resin bridge implant with absolute passivity in terms of its mechanical effect on implants and their fittings (tension-free adjustment) and interference with the free play of mandibular or maxillary bone pieces *(Fig. 1)*. A self-supporting structure is produced by simple means wherein stability is assured solely by the strength of its shape. A three-dimensional fiber structure is made using photopolymerizable fiberglass braid, secured to the implant abutments *(Fig. 2)*. The structure is encapsulated by injection with a methacrylate resin.

METAL–RESIN SINGLE CAST PROSTHESES

These prostheses are screwed onto four or five to six implants and spread out in the symphyseal or maxillary anterior areas (forward of the sinuses) and simplify surgical protocols *(Fig. 3)*.

ADVANTAGES

The metal–resin prostheses allow nonalignment between the sites of implant emergence and future prosthetic teeth. The supragingival implant/prosthesis connection facilitates prophylaxis with a lack of fibromucosal prosthesis support, as well as conservation of lip support. Above all, the cost of implementation is less than that of a metal–ceramic bridge or zirconia implant reinforcement.

Metal-resin prostheses allow for disjunction between the sites of the implant emergence and the future prosthetic teeth.

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Fig.1: *CST is high-resistance fiber-resin implant bridge with absolute passivity in terms of its mechanical effect on implants and their fittings, as well as on its interference with the free play of mandibular or maxillary bone pieces.*

FIBER–RESIN PROSTHESES

Controversies related to the concept may be noted

• Regarding its construction

The structural fragility of resins requires them to be supported by a framework that is usually metallic, cast in lost-wax, or recast using digital milling.

• Milled bars: extremely accurate but bear a significant cost due to digital milling. Many laboratories rarely have the equipment and the fabrication time does not allow for immediate or even rapid delivery.

• Wax casted bars: adjustment and passivity problems compared to the casting technology.

• Issues related to the design of the metal–resin prosthesis

The metal bar does not directly reinforce the resin material; it is not chemically bound to the resin and even acts as a concentrator of stress factors at the

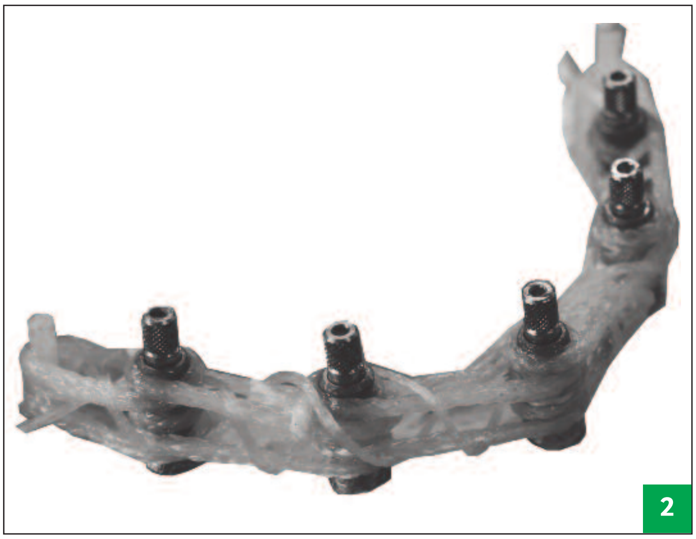
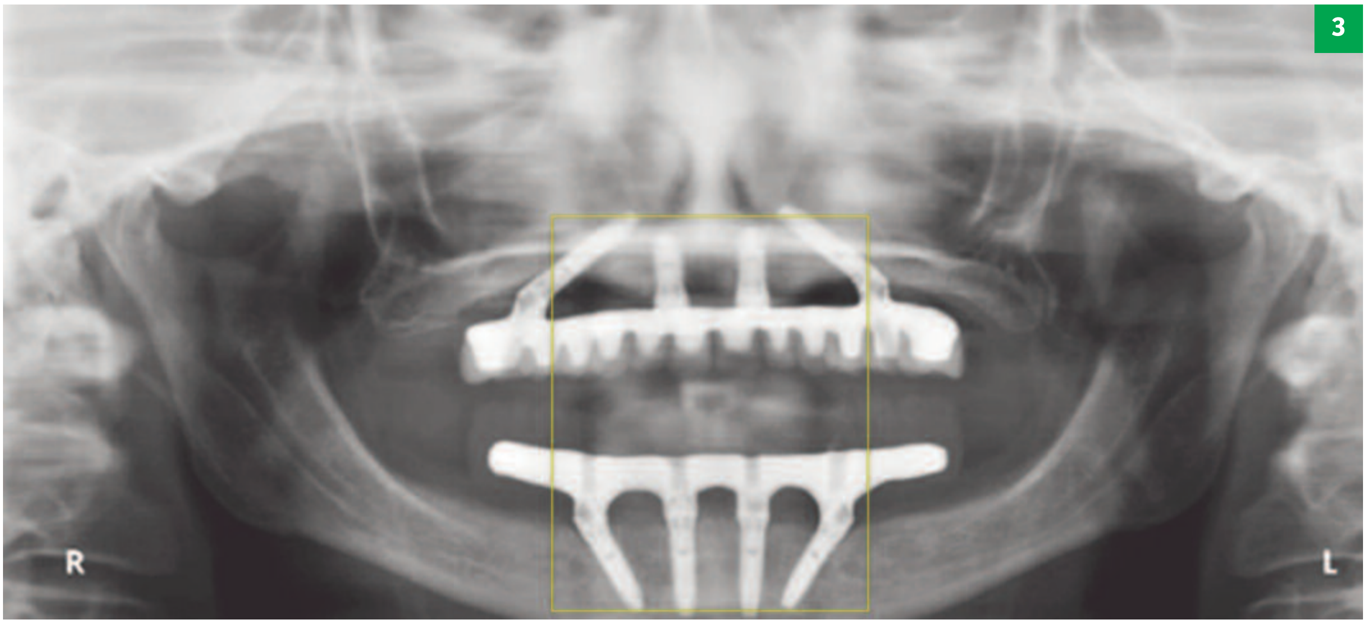


Fig. 2: *A three-dimensional fibrous structure is constructed using photopolymerizable fiberglass braids, firmly secured on the implant abutments.*

All studies agree that the absolute passivity of a prosthesis on implant heads is indispensable to achieving long-term results.

Fig. 3 : *These prostheses are screwed onto four or five to six implants and spread over the symphyseal or maxillary anterior areas (forward of the sinuses) and simplify surgical protocols.*



interface of two materials with differing characteristics.

The metal bar prevents the resin from bending excessively, ultimately leading to breakage; however, it remains a foreign body encased in resin. If a section is too thin, it will deform, and if the elastic limit of the metal is exceeded the deformation will be permanent.

• Issues related to the metallic characteristics of the reinforcements

Metal is unattractive and has potential corrosion and galvanic corrosion problems.

• Issues related to the metal's rigidity

The more rigid a prosthesis is, the more uncomfortable the patient will feel, even if the relative viscoelasticity of the set attenuates shocks and reduces sensations when the rigid bar is covered with resin.

• Issues related to partial passivity

PASSIVITY CONSIDERATIONS

All studies agree that absolute passivity of the prosthesis on the implant heads is essential to achieving long-term results. This is particularly important for immediate loads. In this regard, bars made using digital milling allow for particularly passive fittings. With cast bars, however, passivity is more difficult to obtain in most small dental laboratories. However, it is worth considering the concept of passivity. In a toothless mandible, where five implants are inserted, the bar will fit perfectly passively onto the implant cones in the closed position. However, upon opening, it can be seen that the mandible deforms through the action of the levator muscles, to the point that the molars can move approximately 1.5 mm closer together *(Fig. 4)*.

As a result, when connecting the implants using a metal bar that is very rigid to prevent flexing of the resin, and if the mandible deforms in three dimensions, the bar becomes active and leads to repeated stresses on the implants, notably on the weakest component of the system, the mounting screw. An even more rigid zirconia framework actually accentuates this problem. Therefore, it seems preferable that the implant bridge be able to handle the inevitable bone deformations without putting pressure on the fittings or causing irreversible deformations.

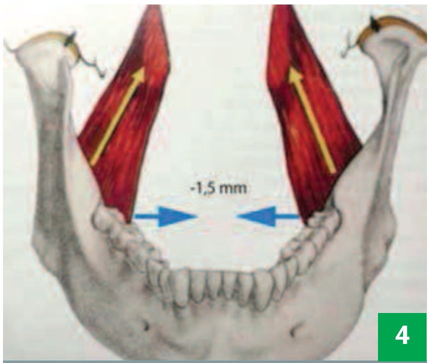


Fig. 5 : *It is possible to observe absolute passivity in terms of its effect on the implants and their fittings, in all circumstances.*

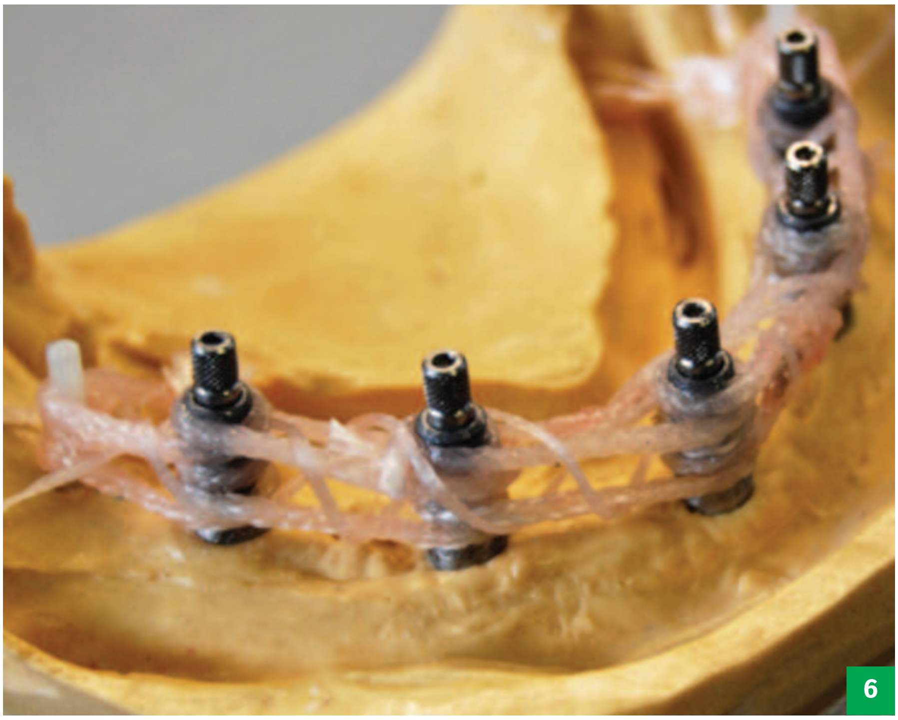


Fig. 6 : *A three-dimensional architectural fibrous structure is created, encapsulated by secondary injection with a methacrylate resin to produce a fiber–resin composite material that is self-supporting and ensures its rigidity and strength.*

• Issues related to crown fittings

Digital milling is carried out from a traditional or optical print, which may be a source of error. Although studies show similarity in industrial crown fittings with casted crowns, crown fitting naturally varies to a greater degree, because it depends largely on the crown technique utilized. If the fit is imperfect, bone crestal resorption is significantly greater than the norm. It therefore seems preferable to use industrial-grade posts.

• Issues related to the durability of the temporary and final dentures

Despite the use of nano-charged composite teeth that can remedy the excessive wear of conventional acrylic teeth, it is known that the screw-retained prosthesis (completely pure resin) is temporary, given that the structural fragility of acrylic resin does not ensure medium-term length of performance without breakage: microfissures are created under stress that tend to expand and the denture inevitably breaks. Each titanium implant post acts as a foreign component, becoming the most common site for stress concentrations and a likely fracture zone. With the metal–resin prosthesis, the metal frame plays the role of preventing the resin from flexing excessively so that the onset and progression of microfissures is delayed. However, the incorporation of the metal component in the resin contradicts its damping capacity related to its viscoelastic character; the relative elasticity of the system is involved in the mitigation of shocks, and the expulsion of a prosthetic tooth is a relatively common occurrence. Nevertheless, this type of prosthesis is accepted as a usable occasional denture or as a long-lasting temporary denture.

AN INNOVATIVE CONCEPT

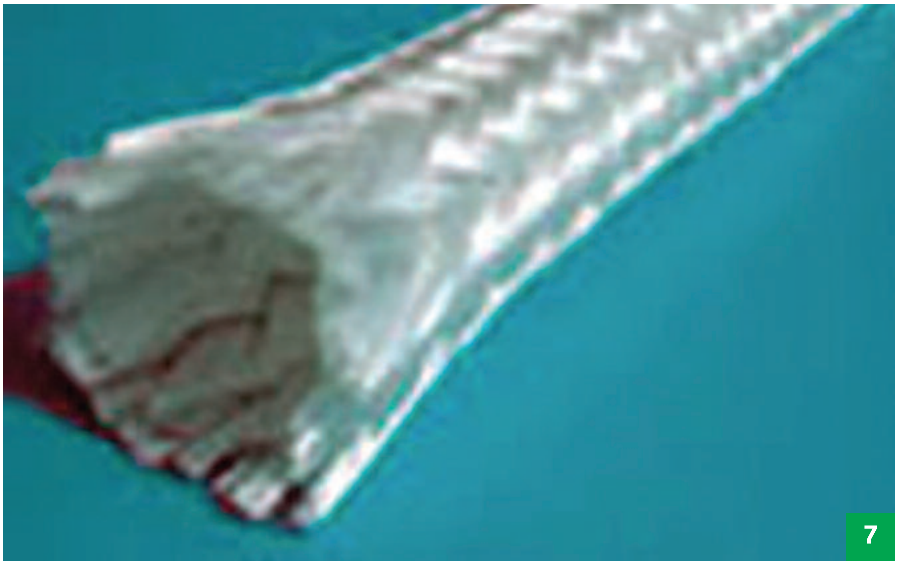
This innovation arose in response to the disadvantages of the metal–resin prosthesis, thus providing:

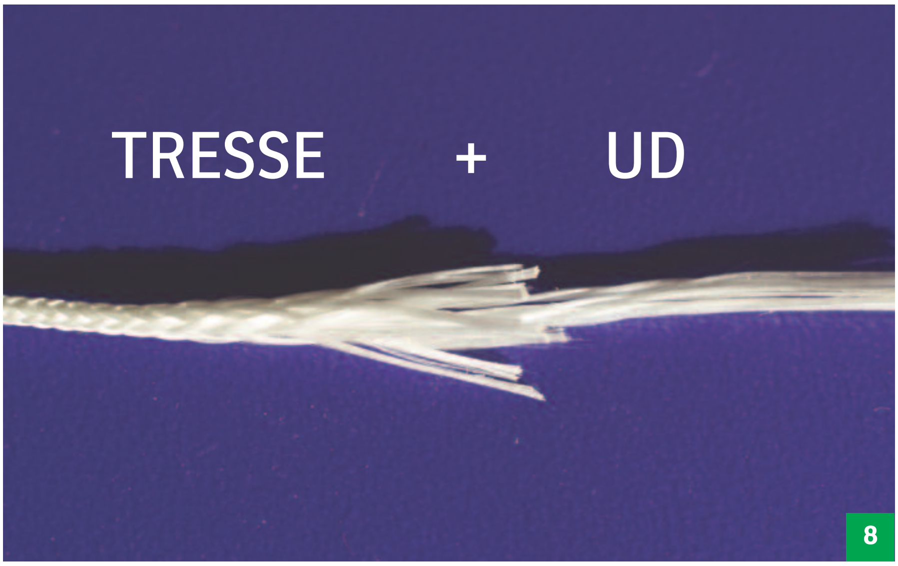
- *a metal-free prosthesis that is lightweight, durable, and resistant.*
- *a secure connection between the fiber-resin composite material and the industrial quality implant post.*
- *absolute passivity in terms of its mechanical effect on implants and their fittings under any circumstances (Fig. 5).*

A DIFFERENT APPROACH

The mechanical approach differs fundamentally from the usual practices in dental prosthetics. Today's metal–resin prostheses (milled or cast bars) are designed based on a support beam model, i.e., as a structural component, such as those used for the construction of buildings, ships, and other vehicles, wherein a metal beam is fabricated to support or stiffen a fragile component. In the CST concept, a beam is not incorporated to stiffen or support the fragile resin; instead a three-dimensional architectural fibrous structure is created and coated with a secondary injection of methacrylate resin in order to manufacture a new self-supporting composite fiber–resin material, ensuring its rigidity and strength *(Fig. 6)*.

The fibrous structure is firmly secured to the implant connections. As with all fiber composite materials, the material shows a degree of elasticity somewhat Different from that of the base resin, thus retaining its viscoelastic qualities of damping and comfort. The grid is made of fiberglass braid, chemically bound to the methacrylate resin. It is invisible and highly resistant.





Figs. 7 et 8 : *The architected framework is fabricated from fiber weaves of tubular fiberglass preimpregnated with photopolymerizable methacrylate resin.*

The tube interior is filled with continuous long fibers. This configuration triples the tensile strength reinforcing the fiber elements.

CST shows excellent mechanical properties, both in terms of fatigue as well as flexing.

MECHANICAL PROPERTIES

CST shows excellent mechanical properties, both in terms of fatigue and flexing, due to its fibrous structure as well as its secure connection at the implant abutments.

Hybrid fiber reinforcement

The architected framework is fabricated from fiber weaves of tubular fiberglass preimpregnated with photopolymerizable methacrylate resin.

The tube interior is filled with continuous long fibers. This configuration triples the tensile strength, thus reinforcing the fiber elements *(Figs. 7 and 8)*.(UD : uni directional).

STRENGTH IN DISTAL EXTENSION

Tests have been conducted in the harshest conditions, subjecting the distal extension of a sample CST-type implant to a cantilever flexion test *(Fig. 9)*. Figure 10 shows what happens if a non-reinforced resin extension breaks at about 30 daN *(Fig. 10)*. The breaking force for a CST-type reinforced sample is clearly higher, with an average of 92.47 daN.

FATIGUE RESISTANCE

Increased security is required for an acrylic prosthesis screwed onto implant heads. Composite materials with long fibers are used in applications where lightness and resistance to alternated stresses are indispensable.

Internal testing showed that a pure resin sample lost its flexibility and was permanently deformed, on the order of 0.3 mm, after 150,000 3-mm flexes, while a fiber-architected skeleton-reinforced resin sample reacted elastically and retained its dynamic characteristics under the same stresses *(Fig. 13)*.

SECURE BOND

Even the best composite material would not be functional if it were not securely bonded to the implant abutment. Under the CST concept, the architectural three-dimensional fibrous structure is mechanically and chemically bound to each abutment *(Fig.14)*.

Figs. 11 and 12 : *The breaking force for a CST-type reinforced sample is clearly higher with an average of 92.47 daN (appearance of fissure without detachment of the implant abutment).*

Fig. 13: *Internal tests showed that a pure resin sample lost its flexibility and was permanently deformed on the order of 0.3 mm after 150,000 3-mm flexes, while a fiber-architected skeleton-reinforced resin sample reacted elastically and retained its dynamic characteristics under the same stresses.*

Fig. 14: *Under the CST concept, the architectural three-dimensional fibrous structure is mechanically and chemically bound to each abutment.*

Fig. 9 : *Tests were conducted in the harshest conditions by subjecting the distal extension of a sample CST-type implant to a cantilever flexion test.*

Fig. 10: *The result of a non-reinforced resin extension breaking at about 30 daN.*

Dental prostheses

FYI

ORIGINS

From the most primitive to the most advanced techniques, whether for functional or esthetic purposes, humans have always been preoccupied with replacing missing teeth. It was in Egyptian sarcophagi where the first traces of dental prostheses were discovered.

At that time, they were carved from ivory or sycamore (a variety of maple also called the false plane tree) and were bound by gold wire. Fillings were made of solid gold. The Phoenicians, skilled merchants and frequent travelers, spread the Egyptian techniques throughout the Mediterranean. This is how dentistry developed in Greek civilization. Hippocrates was one of the pioneers and contributed significantly to progress in the field. In the Middle Ages, however, progress was slow. It was not until the sixteenth century, with Ambroise Paré, that new technologies emerged, including the removable prosthesis; at that time, it was made from a cow femur. In the seventeenth century, Pierre Fauchard published the first treatise on dental surgery, originating the tooth implant. At that time and for the first time, the technique of imprinting was described by Purman. It was not until almost two centuries later that the plaster model was introduced. In the eighteenth century, metal and porcelain teeth appeared. Methodologies and techniques continued to evolve in the nineteenth century when the occlusion appeared, facilitating the efficient assembly of teeth. The technique of imprinting was becoming common practice. The Richmond technique, also known as the pivot-mounted tooth, was improved. The development of the lost wax casting process then allowed for the construction of bridges. In the twentieth century, the use of prosthetics increased enormously. Techniques and materials expanded rapidly. Today, the focus is on the biocompatibility of materials used in the manufacture of prostheses, patient comfort, and esthetics. New materials continue to appear to reduce the use of metal in the mouth.

Source : laboratoire-dentaire-sinard.com

The concept Fiber Force CST

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Further information

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TREATMENT OF THE POSTS

The industrial-grade titanium post is sanded with a SiO_2 powder at 110 µm *(Fig. 15)* and silane is applied to promote adhesion to the methacrylate resin *(Fig. 16)*. The resistance of this binding is estimated at 25 MPa, a value that is insufficient in terms of the forces experienced while in use. The post is coated with dental adhesive (bonding) *(Fig. 17)*. Under the CST concept, each photopolymerizable hybrid braid is wrapped 360° on the post and photopolymerized. The three-dimensional fibrous structure is thus securely bound to each post *(Fig. 18)*.

Traditional responses to implant issues can mitigate the psychological and physical discomfort related to the loss of teeth, but they are expensive. It is appropriate to offer patients a reliable, safe, and moderately priced alternative. Solution.


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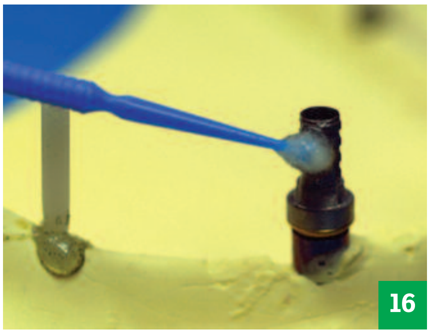
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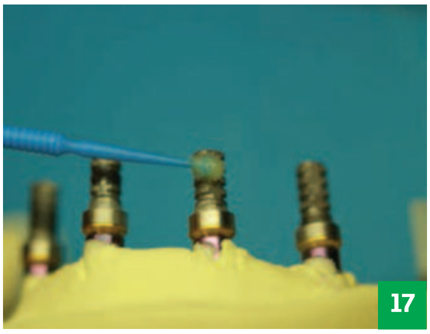
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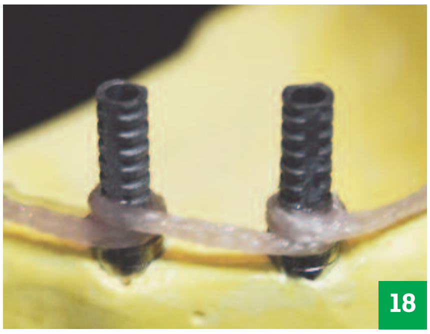
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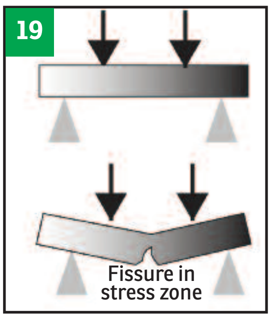
Fig. 15 : *The industrial grade titanium post is sanded with a SiO_2 powder at 110 µm...*

Fig. 16: *...and silane is applied to promote adhesion to the methacrylate resin.*

Fig. 17: *The post is coated with dental adhesive (bonding).*

Fig. 18: *The three-dimensional fibrous structure is then securely bound to each post.*



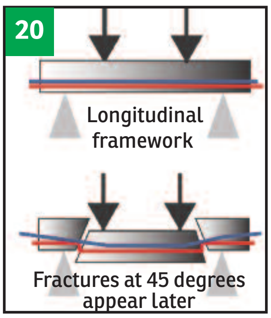


Fig. 19 : *Breaking comes from the propagation of these fissures.*

Figs. 20 and 21: *The three-dimensional fibrous structure will primarily resist stresses, with microfissures forming much later, or not widening further.*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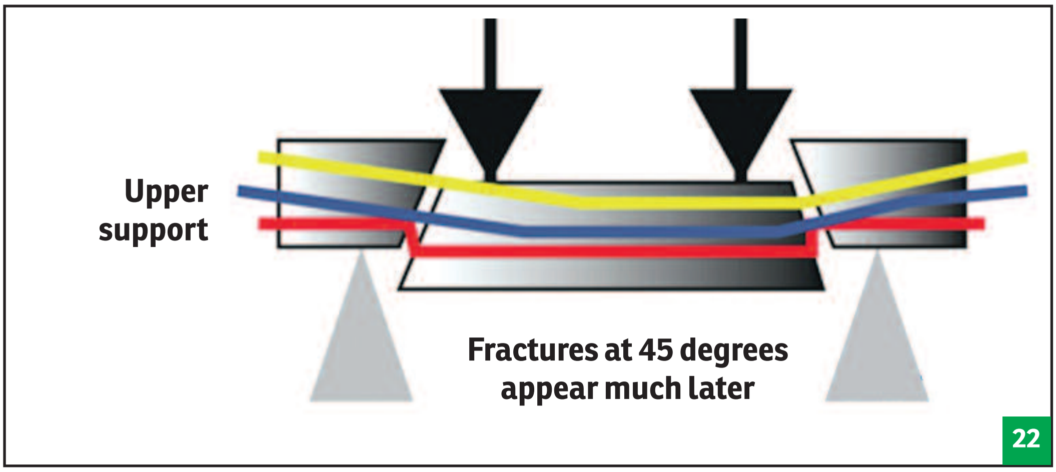

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Fig. 22 : *Now a transverse braid is added, most particularly at the supports. The breach occurs much later than in the previous two cases*

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Fig. 23 : *The frames that are present, both longitudinal and transversal, limit the formation and propagation of fissures.*

Fig. 24: *Two fiber composite pillars are located distally to the most distal implants. They serve to put tension on the hybrid braids.*

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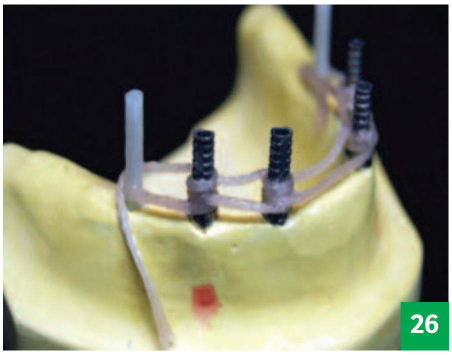

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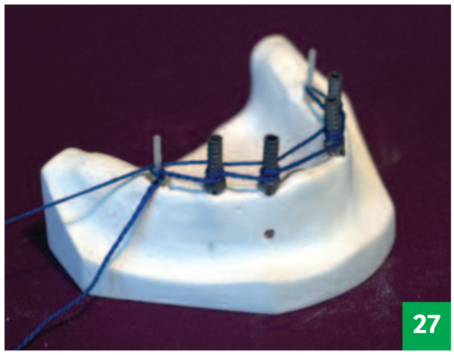

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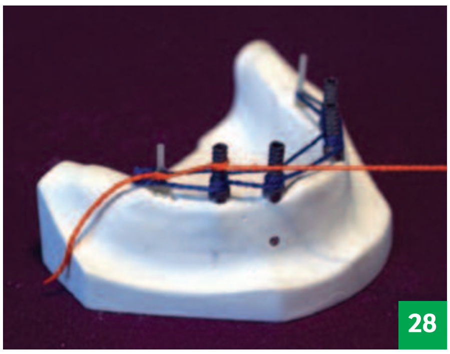

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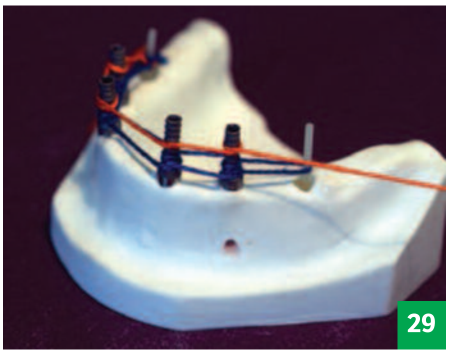

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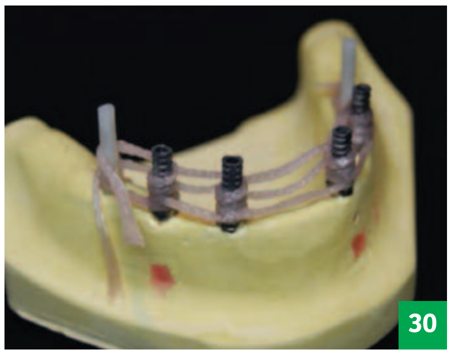

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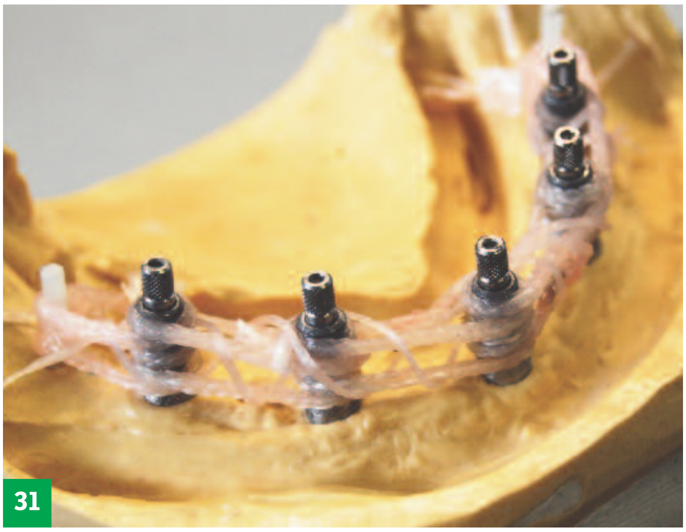
Figs. 25 - 27 : *A hybrid braid, 450 mm long and 2 mm in diameter, is wrapped closer and closer in f360° turns starting from the stress post on the right, going to the stress post on the left where it is wrapped around again. Maintainingtension, it returns, in 360° turns, to the stress poston the right. It is then photopolymerized by blue-light curing.*

Figs. 28 - 30 : *The hybrid braid starts again, always under tension, on the upper level, wrapping in 360° turns around each implant post.*



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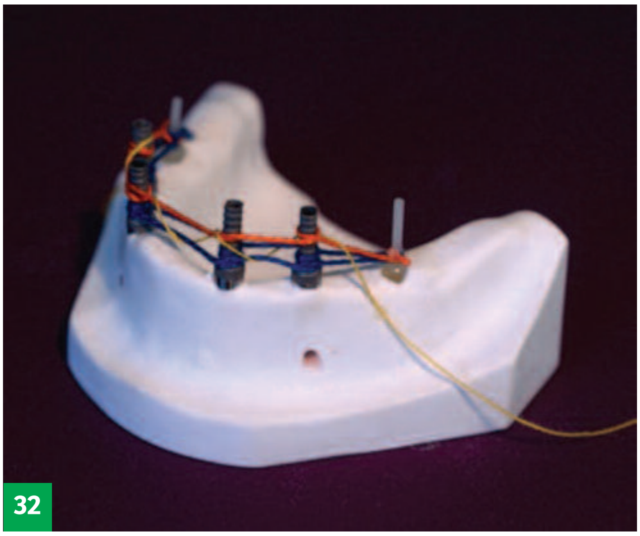

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Figs. 31 and 32 : *Finer hybrid braids 300 mm long, Ø 1.4 mm, are then wound under tension, enveloping the framework, and photopolymerized.*

Two fiber composite posts are distally installed on the most distal implants.

THEORY

Considering a sample consisting of unreinforced resin, arranged on two supports, it can be noted that under load, microfissures appear at the base of the specimen, primarily in the central portion when the tensile stress exceeds the internal resistance of the resin. By increasing the applied loads, cracks are created at 45° at the two support zones, due to a lack of resistance to bending stresses combined with the shear force. Breakage occurs because of the propagation of these fissures *(Fig. 19)*.

THE BASE BRAIDS

Considering a sample based on the CST technique, always arranged on two supports, with the base reinforcement positioned where tensile stresses are developed (i.e., where the resin has deficiencies, but where the fibers contribute to ideal "tension", with a second offset base braid), the three-dimensional fibrous structure will primarily withstand the stresses and microfissures will form much later or will not widen further *(Figs. 20 and 21)*.

Note: *If, for example, the frameworks are made of metal, they will slide in the resin and no longer resist the widening of fissures. The functioning of this type of bond is tempered by perfect adhesion between the metal and the resin, which does not allow for the very different nature of the materials when the frameworks are in metal.*

LIMITATION OF FISSURES

Now a transverse braid is added, especially at the supports. The breach occurs much later than in the previous two cases *(Fig. 22)*. The frames, both longitudinal and transversal, limit the formation and propagation of fissures *(Fig. 23)*. We now turn to the construction of the three-dimensional architected fibrous fiberglass structure of the stress posts. The architected framework is constructed and polymerized on the model. Two fiber composite pillars are located distally to the most distal implants. They serve to put tension on the hybrid braids *(Fig. 24)*.

THE BASE REINFORCEMENTS

A hybrid braid, 450 mm long and 2 mm in diameter, is wrapped closer and closer in 360-degree turns starting from the stress post on the right, going to the stress post on the left where it is wrapped around again. With tension constantly maintained, it returns, in 360-degree turns, to the stress post on the right. It is then photopolymerized by blue-light curing *(Figs. 25–27)*. The 360-degree turns are made in opposite directions on each post:

• *The upper support*
The hybrid braid starts again, under tension, on the upper level, wrapping in 360-degree turns around each implant post *(Figs. 28–30)*. The three braids are photopolymerized.

• *Connecting braids*
Finer hybrid tresses of 300 mm in length, Ø 1.4 mm, are then wound under tension, enveloping the framework created, and photopolymerized. (Figs. 31 and 32). Their purpose is to limit fractures from offset forces.

• *Resin injection*
An open architectural frame has thus been created, which is intended to receive, by pressure or injection, an acrylic resin according to the techniques available *(Figs. 33 and 34)*. The acrylic resin, after polymerization, also contributes to the cohesion quality of the assembly.

• *Perfect passivity*
Built on the basis of the master model, the CST three-dimensional fibrous structure adapts naturally and without any tension to the implant cones *(Fig. 35)*. In this X-ray of a lower CST bridge, we find that after injecting the resin on the master model, the adaptation of the post on the implant cones still remains perfect *(Fig. 36)*.

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CLINICAL CASE

Note the presence of implant cones *(Fig. 37)* and their protection *(Fig. 38*) and then the dressing of the CST skeleton *(Fig. 39)*. The clinical view is also shown *(Figs. 40 and 41)*.

A three-dimensional architected fibrous structure is easily implemented in less than 30 minutes, presenting the realistic possibility of providing a long-term bridge implant within a single day.

ADVANTAGES AND BENEFITS OF THE CST SOLUTION

The concept was designed to provide an esthetic prosthesis that would be very comfortable for the patient, metal-free, and quickly made in any dental laboratory.

For the dental technician

The bridge provides a simple and reproducible solution accessible to all dental professionals. A three-dimensional architected fibrous structure is easily made in less than 30 minutes, presenting the realistic possibility of providing a long-term implant-supported bridge within a single day, once the esthetic characteristics and clinical validations have been planned.

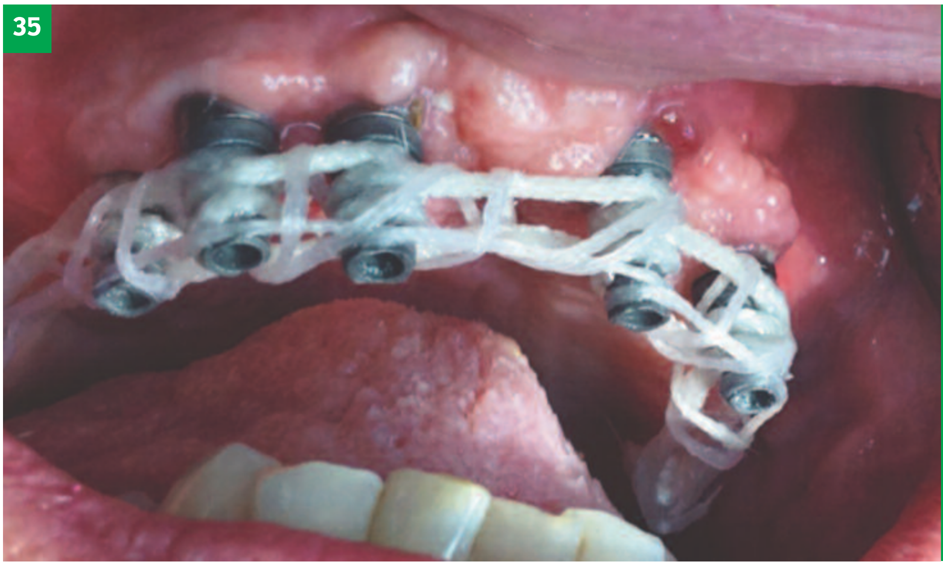
• For the practitioner

The technique used is state-of-the-art, with traditional and proven imprint technology. The astonishing reproducibility and passivity of the prostheses make it unnecessary, in the majority of cases, for the practitioner to validate the three-dimensional fibrous structure (assuming confidence in the imprint). The fixed prostheses can be proposed at a more affordable cost, making the technology affordable for patients. Maintenance can be performed periodically by simply unscrewing the posts, and any repairs are no more complicated than repairs on completely ceramic–metal bridges or a zirconia framework.

Figs: 33 and 34 : *An open architectural frame has thus been created, designed to receive, by pressure or injection, an acrylic resin according to the techniques available.*

• For the patient

The patient receives a long-term denture the same day or within 24 hours for immediate use *(Fig. 42)*. The bridge is lightweight and very comfortable; its rigidity (adapted to the patient's oral physiology) means it is quickly forgotten. The patient is reassured when he understands that the expulsion of a tooth or a repair is no longer a problem.



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The astonishing reproducibility and passivity of the prostheses make it unnecessary, in the majority of cases, for the practitioner to validate the three-dimensional fibrous structure.

Fig. 35 : *Built on the master model, the CST three-dimensional fibrous structure adapts to the implant cones naturally and with no tension.*

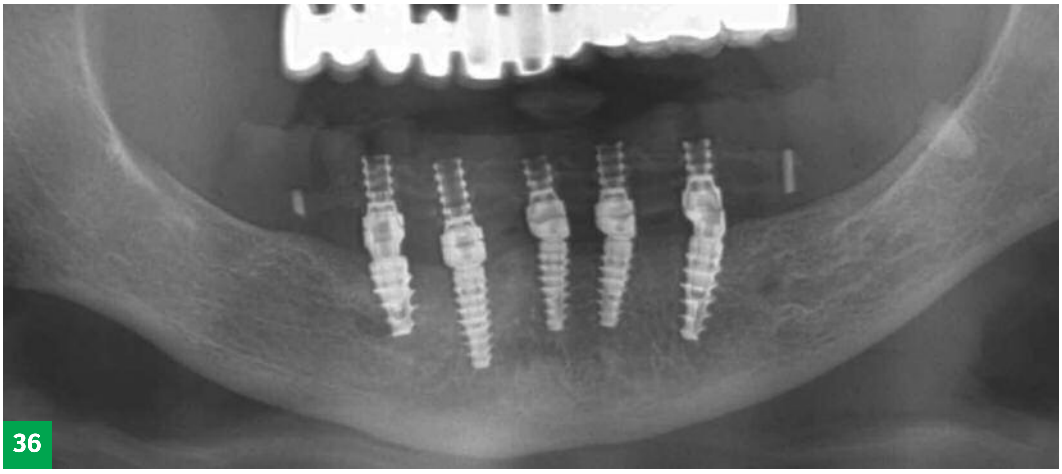

Fig. 36 : *In this X-ray of a lower CST bridge, after injecting the resin on the master model, the adaptation of the post on the implant cones remains perfect.*

Fig. 37 : *Implant cones...*

Fig. 38: *...and their protection.*

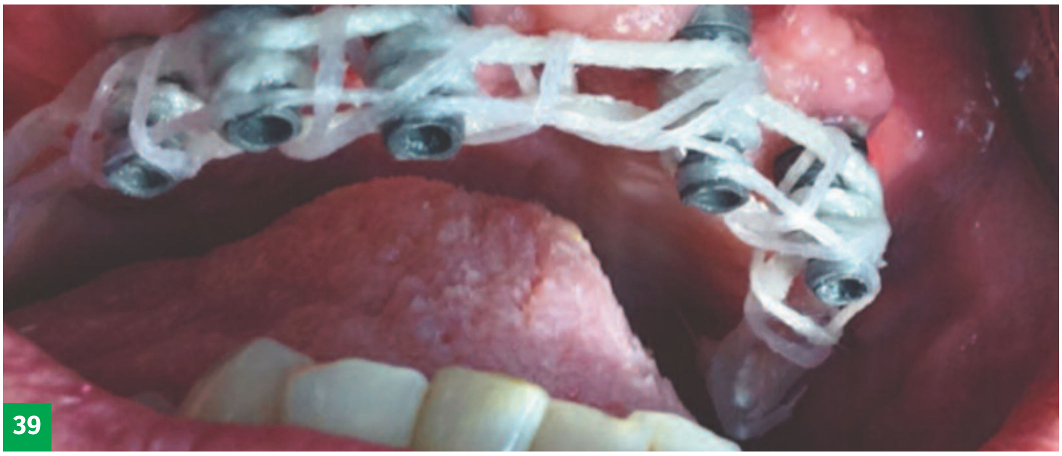

Fig. 39 : *CST skeleton fitting.*

Fig. 40 : *Panoramic view*

Further information (end)

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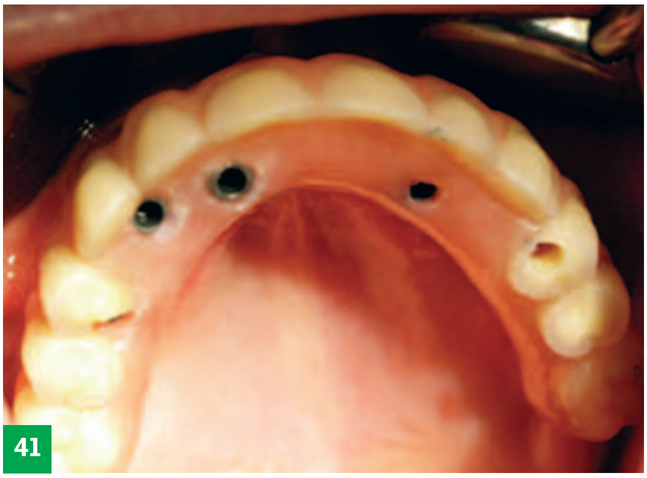

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REPRODUCIBILITY OF THE TECHNIQUE

When fiber reinforcements are integrated into the dental resins in accordance with modern industrial methods, the results in terms of esthetics, durability, comfort, and biocompatibility rival even the most advanced techniques in the dental world. The impregnation of the fibers, the organization of threads in the reinforcements, their spatial organization, the implementation method, as well as the inclusion of the oral musculoskeletal context all contributed to the CST innovation. A new rigorous and precise method ensures that the technique is reproducible, using means that are simple and accessible to all dental laboratories *(Figs. 43 and 44)*.

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Figs. 41 and 42 : *Clinical view.*

Fig. 43 : *The patient receives a long-term prosthesis the same day or within 24 hours for immediate use.*

Fig. 44 : *A new rigorous and precise method makes the technique entirely reproducible, using means that are simple and accessible to all dental laboratories.*

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Medical device for dental treatment, reserved for healthcare professionals. Please read the instructions on the leaflet or on the label carefully before use. Class: IIA (CE marking certified by SGS) CE0120.

PART III: CST PROSTHETIC IMPLANT TREATMENT

How can removable prostheses **be stablized?**

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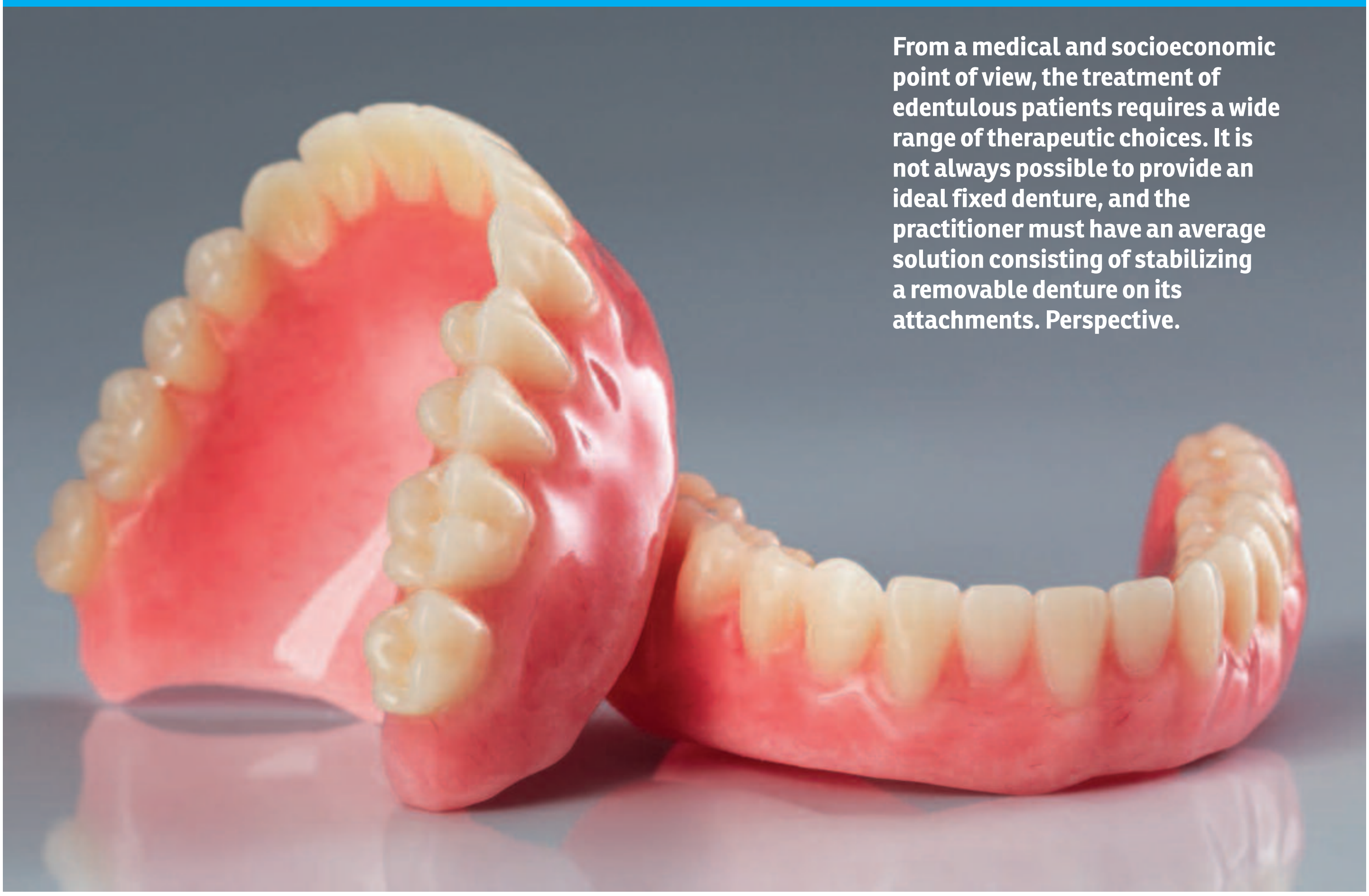
From a medical and socioeconomic point of view, the treatment of edentulous patients requires a wide range of therapeutic choices. It is not always possible to provide an ideal fixed denture, and the practitioner must have an average solution consisting of stabilizing a removable denture on its attachments. Perspective.



The implant-supported attachments significantly improve prosthetic fitting, combining comfort and esthetic properties unique to the fixed prosthesis, with the ease of serviceability of removable solutions. A systematic review of the literature has revealed no strong evidence supporting a single treatment approach for all issues regarding edentulous mandibles and maxilla. The anatomical and physiological factors, the patient's psychology, as well as the patient's demand and financial resources are limitations that make a conventional fitted prosthesis or a prosthesis that is stabilized or fixed on dental implants the best choice.

Removable prostheses supported by screw attachments are subject to deformations and significant stresses given their conditions of use.

REMOVABLE PROSTHESES STABILISED ON IMPLANTS

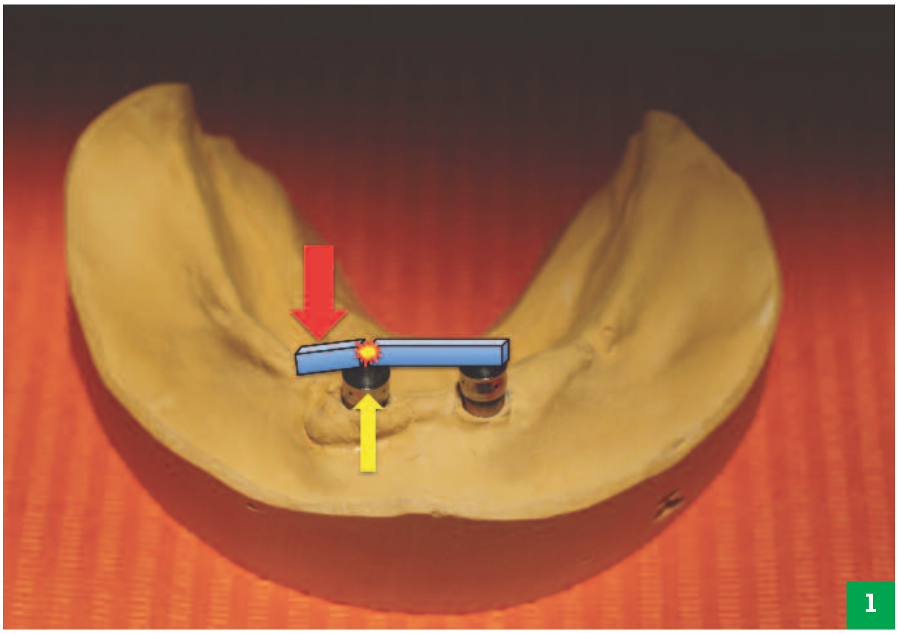


Fig. 1 : *On the upper surface of the resin plate the appearance of a fissure can be clinically observed, caused by shear and fatigue failure, which enlarges to a fracture.*

During use removable dental prostheses retained by screw attachments on dental implants are subject to deformations and significant stresses, notably with regard to the posts and attachments. On the upper surface of the resin plate, one can clinically observe the appearance of a fissure caused by shear and fatigue failure, which enlarges to a fracture *(Fig. 1)*. The solution generally provided is a cast metal framework, which stiffens the dental prosthesis, preventing it from deforming but also from following the physiological deformations of the osseous and osteo-mucous foundations: the patient experiences this as a loss of comfort *(Fig. 2)*. By integrating a Fiber Force woven grid into the center of the acrylic material, a high-strength, Sturdy, and attractive material is easily obtained *(Fig. 3a and 3b)*. Particular attention is paid to the critical area around the female attachments: a hybrid braid 1.6 mm in diameter is wound in 360-degree

Fig. 2 : *The solution generally provided is a cast metal framework, which stiffens the dental prosthesis, preventing it from deforming yet is also able to tolerate the physiological deformations of the osseous and osteo-mucous foundations: the patient experiences this as a loss of comfort.*

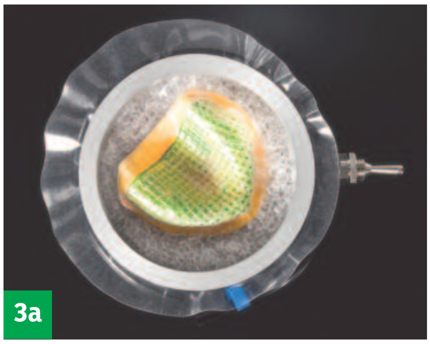


Fig. 3a: *A Fiber Force grid is formed and photopolymerized under pressure on the plaster model in the EZ Vac shaping machine.*

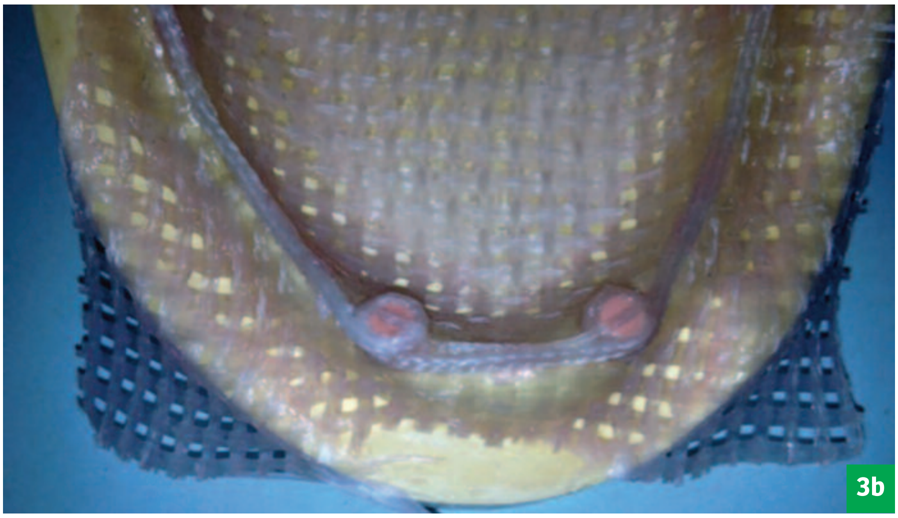


Fig. 3b: *By integrating a Fiber Force woven grid into the center of the acrylic material, high-strength, sturdy and attractive material is easily obtained.*

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turns around each cup and is extended distally. It can be complemented by a finer occlusal braid *(Fig. 4)*. After pressing or the injection of PMMA resin, the Fiber Force framework is totally and invisibly integrated into the center of the prosthesis *(Fig. 5)*.

SYSTEM LIMITATIONS

Patient D.-M consulted in 2007 with two remaining incisors bearing center-root attachments. The following problems had accumulated:

- *He did not tolerate the presence of the resinous base in the palate.*
- *He did not tolerate the rigidity induced by a stellite and the rotation of the apparatus around the attachments.*
- *Medical implants were medically and unconditionally contraindicated for him.*

A reinforced prosthesis with a grid and Fiber Force reinforcements was implanted, which was perfectly operational, comfortable, and accepted by the patient. After 6 years, the resin seemed particularly abraded and the attachment rose to the surface. A fissure on the upper surface had appeared opposite the female part of the attachment, but was blocked from going deeper due to the presence of the fiber grid. Thus, even the very thin resinous base had not broken (Fig. 6). Note a second crack starting next to the attachment on tooth 11. Despite the highly unfavorable clinical conditions, the patient could be fitted with a functional denture that was esthetically acceptable and comfortable, matching his appearance profile. The patient's indication presented substantial limitations, and the acrylic base fissured due to fatigue at the location of greatest tensile stress. It was therefore necessary to propose a different reinforcement system to counter these tensile forces causing the fissure.

A system of countervailing reinforcement should be proposed to counteract the tensile forces causing the fissure.

Fig. 4 : *Particular attention is paid to the critical area around the female attachments: a hybrid braid 1.6 mm in diameter is wrapped in 360° turns around each cup and is extended distally. It can be complemented by finer occlusal braid.*

Fig. 5: *After pressing or injection of the PMMA resin, the framework is invisibly integrated in the center of the prosthesis.*

Fig. 6: *A fissure on the upper surface has appeared opposite the female part of the attachment, but is blocked from going deeper due to the presence of the fiber grid. Thus, even the very thin resinous base did not break.*

Fig. 7: *A three-dimensional architected fibrous structure is formed using photopolymerizable fiberglass braid, solidly bound on the implant abutments. A system of countervailing reinforcement should be proposed to counteract the tensile forces causing the fissure.*

THE CONCEPT

The CST (Cable Stayed Technology) concept consists of a high-strength implant-supported resin fiber bridge with absolute passivity in terms of its mechanical effect on implants and their fittings (tensionless adaptation) and its interference with the free play of mandibular or maxillary bone pieces. It is produced by simple means as a self-supporting structure whose stability is ensured from the strength of its form. A three-dimensional architected fibrous structure is formed using photopoly-merizable fiberglass braid, solidly bound to the implant abutments *(Fig. 7)*.

The structure is encapsulated by injection with a methacrylate resin *(Fig. 8)*.

Experience with implant bridges (Fiber Force CST) adapts the concept to dentures on implant attachments, since the freestanding structure was developed specifically to address the high stress generated in relation to the implant abutments.

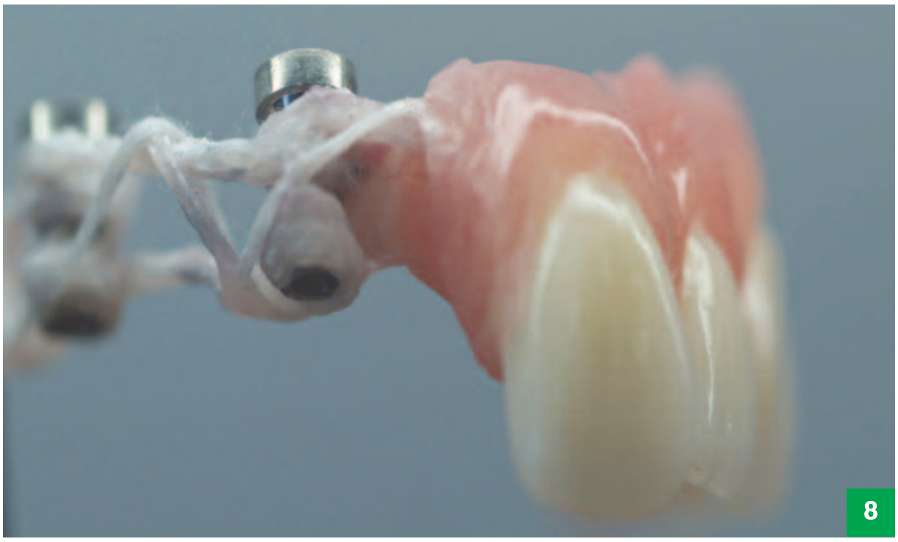

Fig. 8 : *The structure is encapsulated by injection with a methacrylate resin.*

CLINICAL CASE

PRESENTATION OF THE CASE

Mrs. R had bridges on certain teeth that could no longer receive prostheses, despite a removable denture on a metallic base plate. Extraction of the remaining teeth was indicated *(Fig. 9)*. The patient had been operated on in her infancy for two cleft palates and the bone volume usable for implants was limited to sectors 13, 16, 24, and 26. She refused any bone apposition graft because she had not had convincing results *(Fig. 10)*. Implants were placed in the above areas, and the bridging bars made on tapered posts with four welded ball Dalbo Z-type attachments. The prosthesis envisaged is removable and will be stabilized on the bar constructions *(Fig.11)*.

Fig. 9 : *Panoramic view.*

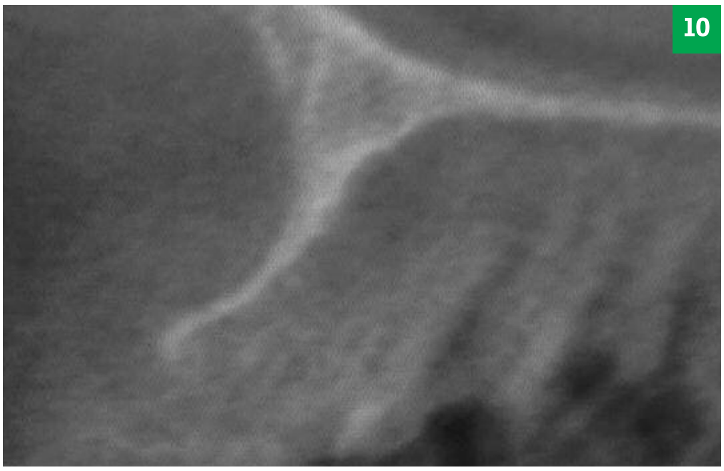

Fig. 10: *The patient had been operated on in her infancy for two cleft palates and the bone volume that could be used for implants was limited to sectors 13, 16, 24, and 26. She refused any bone apposition graft because she had not had convincing results.*

Fig. 11: *The prosthesis envisaged is removable and stabilized on the bar constructions.*

Another stress post was installed at the incisor to allow the replacement of the CST framework at the incisor, instead of higher bone and mucosa resorption.

THEORETICAL DESIGN OF THE FRAMEWORK

A framework is made in accordance with standard protocols *(Fig. 12)*. Composite stress posts are arranged distally and on the crest trajectory. A UD Fiber Force hybrid base reinforcement 1.6 mm in diameter is installed in the lower part, wrapped 360 degrees around the attachment cups. Two reinforcements are extended on the path, without winding needed around the attachment cups. The supporting reinforcements are then wound around the open structure thus formed. The unit is photopolymerized by blue-light curing.

EXECUTION

Fabrication of the framework

The attachment bars and replicas (red Dalbo Z-type cups) are installed in the mouth and an imprint is made with elastomers and cast in plaster. The CST framework will be made on this imprint *(Fig. 13)*. The stress posts are installed distally to the bars. Another stress post is installed at the incisor, allowing a shift of the CST framework to the incisor instead of the higher bone and mucosa resorption, so that it is properly centered in the prosthesis. The base reinforcements are extended, wrapping the fiber 360 degrees around the cups and then polymerized *(Figs. 14 and 15)*.

Fitting in the mouth

The passivity of the structure and its perfect adaptation are tested in the mouth *(Fig. 16)*. In the laboratory, the framework is injected or pressed with the methacrylate resin in accordance with laboratory protocol *(Fig. 17)*. A laminate material is then appropriately constituted (architected fiber acrylic resin skeleton), which is able to specifically meet the high stresses generated by its functioning in terms of the fixed points established by the implant attachments *Fig. 18)*. The removable prosthesis retained on the attachments is esthetic, lightweight, and comfortable; it is not stiffened by a metal base plate, the only alternative to state-of-the-art technology *(Fig. 19)*.

The architected framework does not alter the viscoelastic character of the resins, a feature that the patient will appreciate in terms of comfort.

Final stage

The attachments are secured and the prosthesis installed.

In a composite structure, the reinforcements generally contribute more rigidity to the resin, especially blocking the spread of inevitable microfissures created by use, however on the strict condition that the reinforcements are bonded and remain permanently bonded to the resin.

Fig. 12 : *A framework is made in accordance with standard protocols.*

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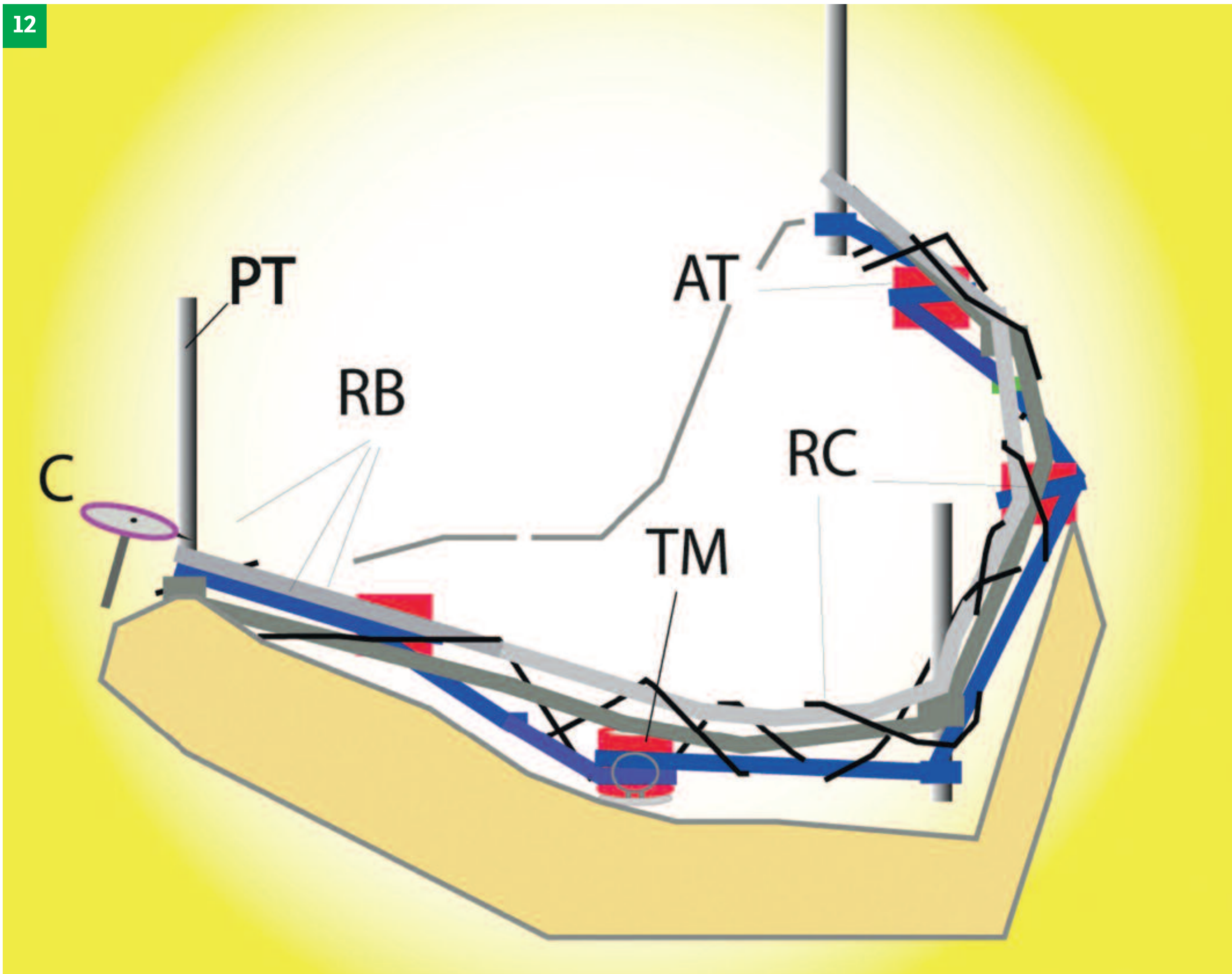


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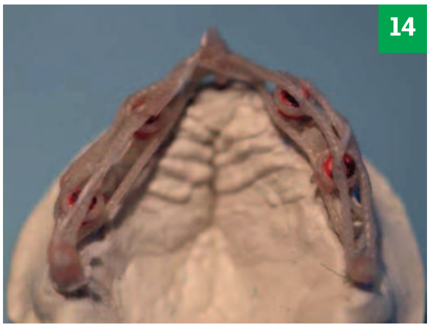
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The removable prosthesis on the implant attachments is esthetic, lightweight, and comfortable.


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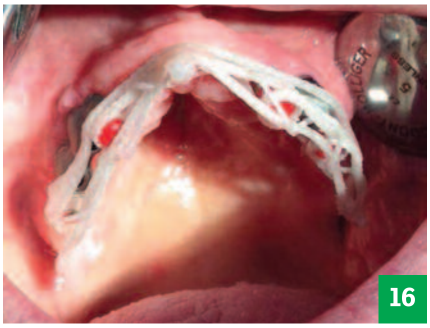
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Fig. 13 : *The CST framework will be made on this imprint.*

Figs. 14 and 15: *The base reinforcements are extended, wrapped 360° around the cups, and then polymerized.*

Fig. 16: *The bars are reinstalled in the mouth. The passivity of the structure and its perfect adaptation are tested in the mouth.*

Fig. 17: *In the laboratory, the framework is injected or pressed with methacrylate resin in accordance with the laboratory protocol.*

Fig. 18: *A laminate material is then appropriately constituted (architected fiber acrylic resin skeleton), which is able to specifically meet the high stresses generated by its use in terms of the fixed points established by the implant attachments.*

Fig. 19: *Finally, the attachments are secured and the prosthesis installed.*

Fig. 20: *Check-up in 24 months.*

In this condition only, impossible with a metal reinforcement, can fiber acrylic prostheses resist stresses even in the extreme configuration in distal extension of an implant, as in Figure 20 *(Fig. 20)*. It should be remembered that the allowable maximum extension is 11 mm for fixed CST technology.

A three-dimensional architected fibrous structure is therefore constructed by simple means, using hybrid braids of photopolymerizable fiberglass, securely bound to implant posts.

It is essential to note that the organization of reinforcements (internal distribution of the fibers in the reinforcements and the spatial arrangement of reinforcements) has been calculated to limit the fracturing of the acrylic, even when off-center forces are applied.

The strength of the self-supporting structure obtained after inclusion in an acrylic resin results specifically from the careful aplication of fabrication protocols *(Fig. 20)*.


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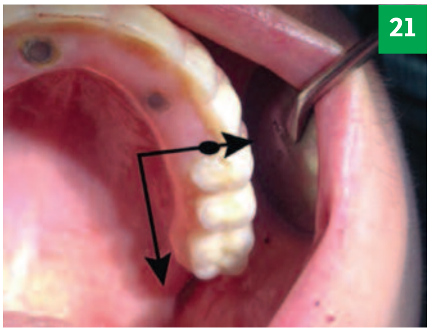
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The organization of reinforcements (internal distribution of the fibers in the reinforcements and the spatial arrangement of the reinforcements) was calculated to limit acrylic fractures.

IMPLANT TRANSFERS

Rapid fastening **with fiber splints**

Supra-implant fixed prostheses present clear functional and psychological advantages. Demonstration.

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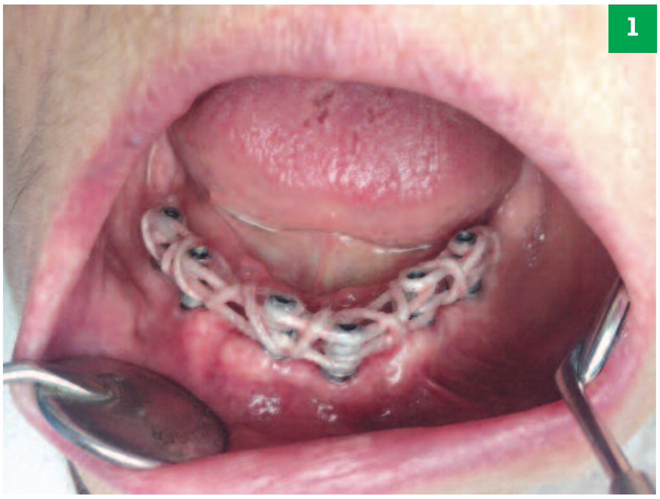
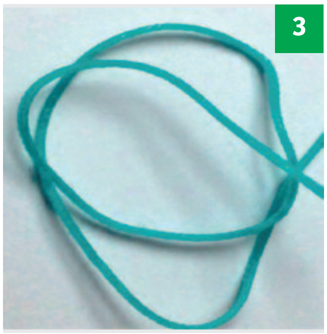




Attachment is indispensable in the context of immediate loading where time is reduced and error is impermissible.

In the "CST" concept, a three-dimensional architected fiber structure is created, infiltrated by injection or by secondary pressing with a methacrylate resin in order to manufacture a new fiber-resin composite material that is self-supporting and ensures its own rigidity and strength *(Figs. 1 and 2).*

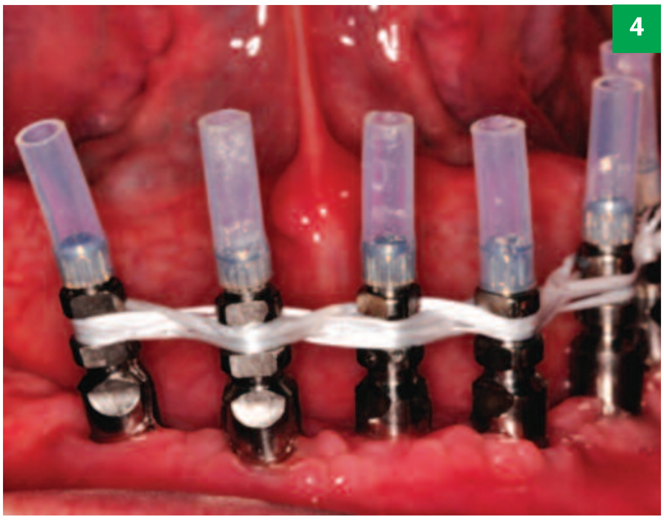
The fibrous structure is firmly secured to the implant connections. The material shows a low modulus of elasticity, and the prosthesis maintains its viscoelastic qualities of damping and comfort. The network, consisting of fiberglass braid, chemically binds to the methacrylate resin; it is invisible and highly resistant.

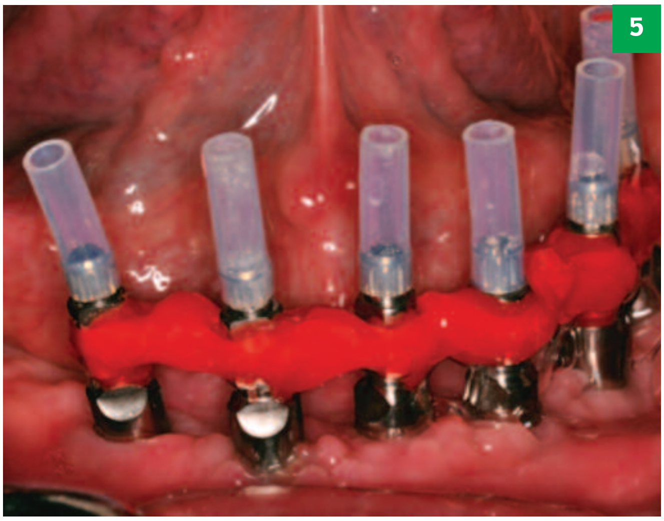
In the mandible, maximum strength is sought, whether using the bone-anchored technique with four implants described by Malo or the technique described by Brånemark using stilts with five implants placed in the inter-foraminal zone. Conventionally, a resin prosthesis and ready-made teeth were mounted on a cast or a machined metal frame. For the maxilla, Malo also described a technique with four implants to replace techniques augmenting maxillary sinuses. The distal two are angled at 45° and the mesial two are straight-mounted. For maxilla with five to six implants, a Brånemark prosthesis can also be used.

« FIBER FORCE » ARCHITECTED FIBER BRIDGES

The anatomy and physiology of the mandible are such that during up and down movements, multifactorial bending occurs. Although its effects on the mechanical implants themselves are not clear, the proposed solutions either increase the number of implants or separate the bridge into as many components as possible. Although there are few detailed studies on the effects of mandibular flexion and the rate of success or failure of the implant treatment in relation to mandibular flexion, adopting a metal–resin prosthesis has been suggested, one that is particularly passive while remaining able to withstand these inevitable distortions, using fiber-reinforced skeletons instead of rigid metal bars.

It should also be remembered that the originality of this approach differs fundamentally from the usual practice in dental prosthetics. Milled or cast bars are designed on the model of the support beam, as a structural component; a metal beam is fabricated to support or stiffen a more fragile component.





IMMEDIATE LOADING

Immediately loading the implants saves time and increases patient comfort. A passive rigid framework is created in a prosthetic laboratory that will act as an external fixator and be retained without being removed throughout the bone-healing phase. This technique is narrowly limited by the reliability of the three-dimensional repositioning of the implant replica in the laboratory model. It is possible for the laboratory to make this passive bar and to mount the denture within the same day. The experience accumulated in the design, manufacture, and use of bridges (Fiber Force CST) and the results of in vitro studies validating the spatial stability of a three-dimensional framework (Fiber Force CST) led us to propose a method for imprinting using fiber components similar to those used in the CST technique *(Fig. 3)*.

An optical imagery study on the reliability of spatial positioning depending on whether the implants were transferred in a single piece or several pieces before imprinting, concluded that when the transfers are joined together before imprinting, the imprints generated are more accurate than those using the unjointed technique. Transferring the implants together is essential in the immediate loading context where time is reduced and error is impermissible.

A conventional technique for connecting implant transfers in the mouth in a single rigid bar consists of connecting the posts with dental floss for example, and by successive deposits, coating the result with self-polymerizing acrylic resin material (Courtesy Dr. Chris Salierno, DDS) *(Figs. 4 and 5)*.

Spatial coordinates of implants

The polymerization shrinkage of this resin deposited in significant quantity was estimated at 7.9% (μ), generating a risk of distortion in the three dimensions of the spatial data recording.

However, the technique is tedious, time-consuming, and its implementation requires practitioner expertise, within a context where time is limited, with a patient requiring the prosthesis by the end of the day. Therefore, it is necessary instead to use a rapid and reproducible technique that can render stability tests unnecessary. Photopolymerizable hybrid fiber reinforcement is proposed to connect the implant transfers and create a nondeformable free-standing three-dimensional CST structure, firmly attached to the transfers. The structure is sufficient to preserve the spatial coordinates of the position of the implants.

IN VITRO STUDIES

Structure of the blue 1:4 « CST » braid

This consists of parallel unidirectional strands of fibers, enclosed in a woven sheath, with each fiber of each strand coated in an industrial environment with a photo-resistant film, which allows the assembly to be attached in a fixed position without shape memory *(Fig. 6)*. After forming on a substrate and photopolymerization, the element is fixed without deformation. Spatial stability tests (CST Fiber Strength 1:4) before and after polymerization of a braid were undertaken according to CST protocol.

Materiel and methods

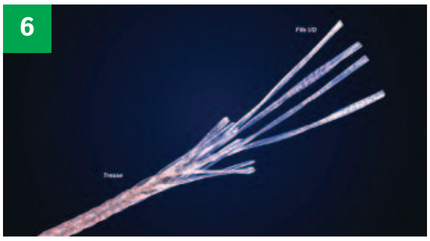
Four similar MUA conical posts are set in an aluminum plate, and the imprint transfer Multi posts are screwed above *(Fig. 7)*.

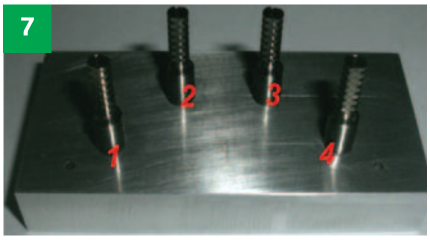
The posts are attached by winding the braids according to the CST protocol, and the reinforcement is polymerized by blue-light curing *(Fig. 8)*.

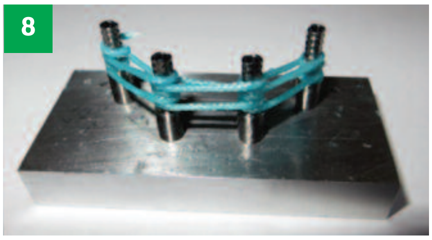
The assembly is enclosed in translucent imprint paste, without an imprint tray *(Fig. 9)*.

The Multi posts are unscrewed and a plaster replica is cast in the laboratory, including new conical copies *(Fig. 10)*.

Deviations are measured with a profile projector and a three-dimensional camera.







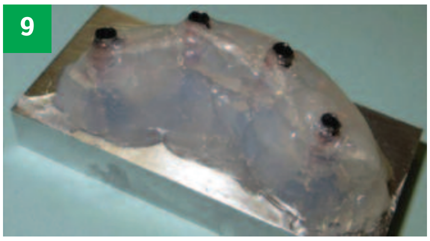


Fig. 1 : *Three-dimensional structure of the CST concept.*

Fig. 2: *The CST concept in the methacrylate resin*

Fig. 3: *Blue CST imprint braid.*

Figs. 4 and 5: *Attachment of the implant transfers with dental floss, then coated with autopolymerizing acrylic resin.*

Fig. 6: *Structure of the 1:4 CST braid.*

Fig. 7: *Aluminum plate with analogs and posts.*

Fig. 8: *Wrapped and photopolymerized braid.*

Fig. 9: *CST structure encased in paste.*

Fig. 10: *Replicated in plaster.*

Fig. 11: *Validation of the result in plaster with fragility zones.*

The plaster validation solutions are fabricated by the dental technician with fragility zones *(Fig. 11)*.

They are transferred onto the aluminium model *(Fig.12)*. A Sheffield test is then performed on the five plaster solutions, manufactured by screwing only on the distal post, then all the posts, measuring the distances between each post and its analog.

The steps

For the first series of measurements, made at the profile projector, the distance between each post and its analog (1 and 2; 2 and 3; 3 and 4; 1 and 3; 1 and 4, and 2 and 4) is measured as follows *(Fig. 13)*: For the second series of measurements taken using a three-dimensional camera, the distance between the axes of the posts is measured according to Figure 14. The two types of measurements are made before taking the imprint, then on the plaster solution.

RESULTS OF TESTS OF «CST» SPATIAL STABILITY		minimum AVERAGE	maximum AVERAGE
Profil projector	Deviation in % Deviation in mm Posts measured	0,075 % 16 µm 43 µm 2 and 4	0,698 % 43 µm 3 and 4
three-dimensionale camera	Deviation in % Deviation in mm Posts measured	0,07 % 19 µm 1 and 3	0,68 % 99 µm 1 and 2

Résults

The deviations are measured using a profile projector and a three-dimensional camera; they represent the measurement deviation between the pillars alone and the pillars with plaster solutions, in percentages and in micrometers; (see picture above).

We observed that the Multi posts were easily inserted without tilting, given that the framework was not tilted as a result of polymerization constraints and no gap occurred. Plaster validation solutions did not fracture. According to the literature, deviations less than 30 µm are clinically undetectable and an adjustment default less than 100

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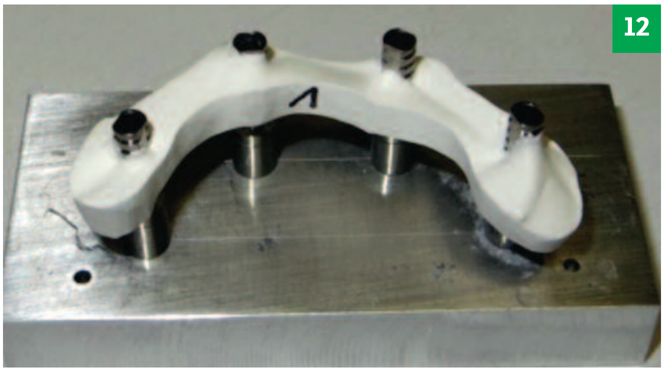

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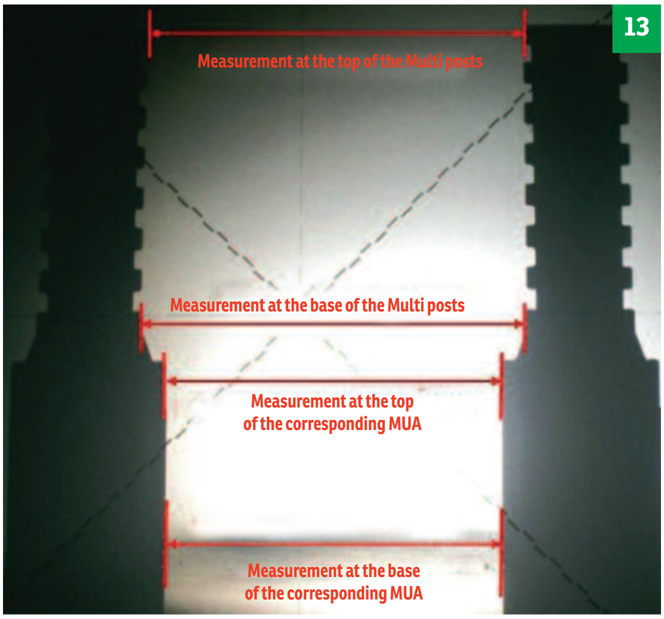

Fig. 12 : *Plaster solution repositioned on the aluminium model.*

Fig. 13: *Photo of two MUA analogs and Multi posts and measurement indicators.*

Fig. 14: *Diagram from measurements taken with the three-dimensional camera.*

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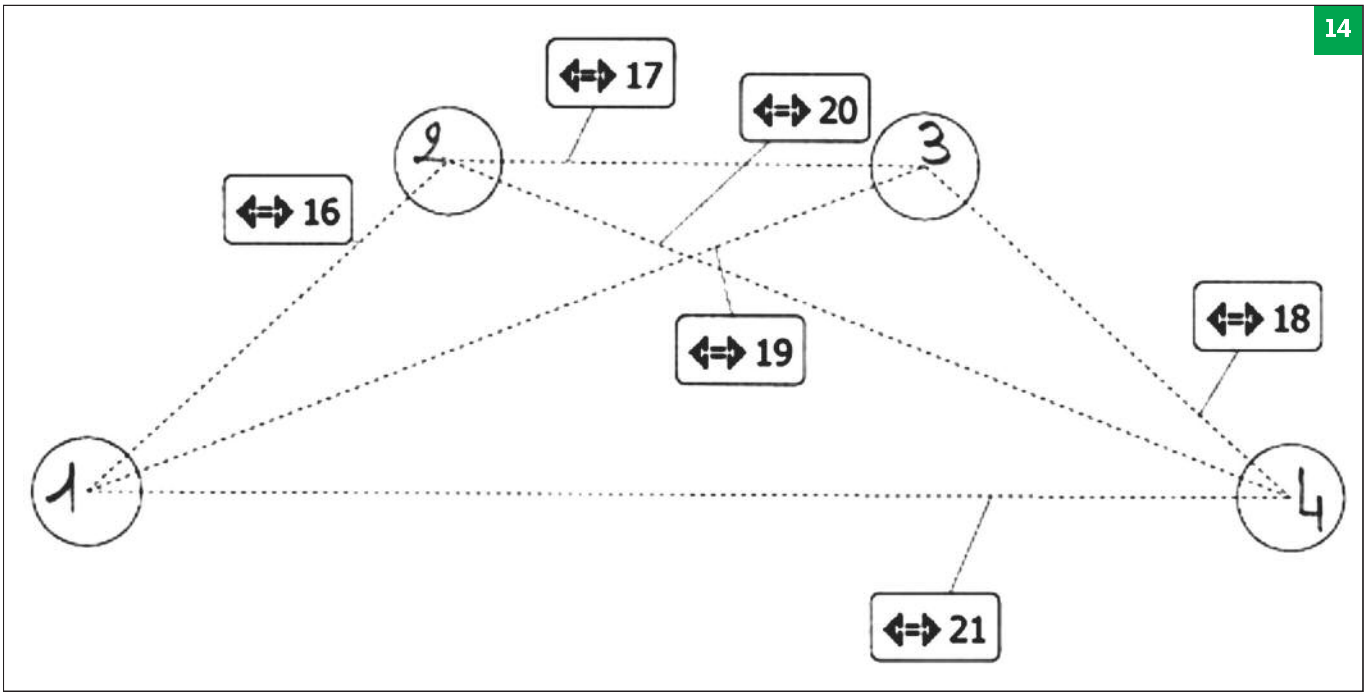
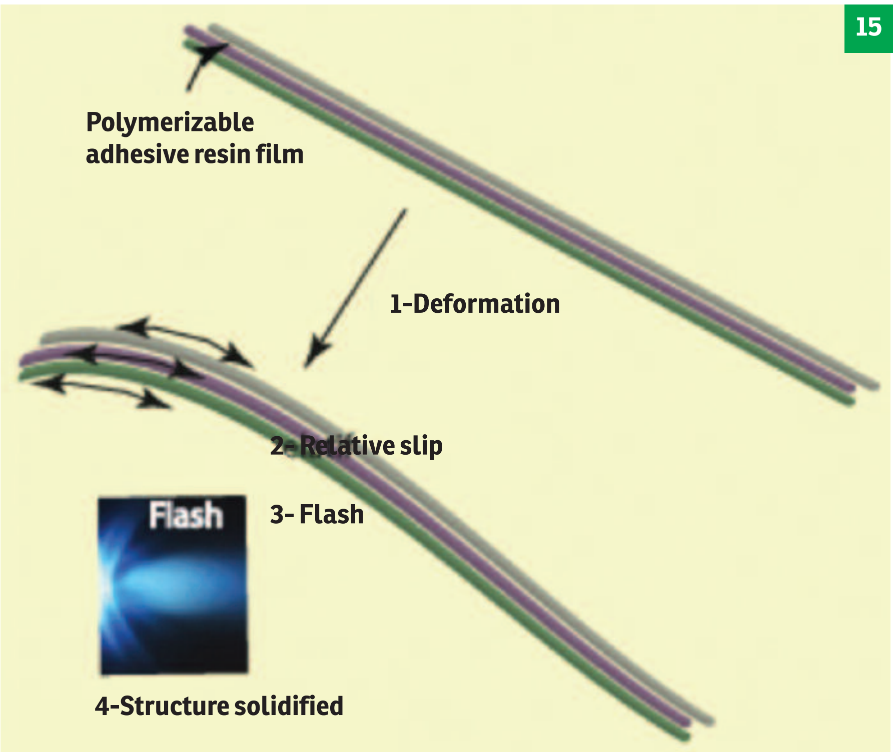




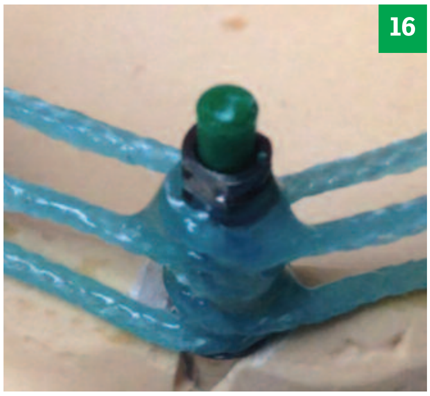


Fig.15 : *Principle of fiber deformation.*

Fig. 16: *CST structure wrapped in 360° turns around an implant transfer.*

Fig. 17: *Construction of the CST imprint.*

Fig. 18: *Structure of the CST imprint.*

Fig. 19: *Securing the reinforcement–implant post connection.*

µm is acceptable for long-term dental restoration. Therefore, the average values reported in the table (see previous page) are acceptable and meet clinical requirements. The results show clinical passivity in accordance with CST literature data on the implant heads.

HYPOTHESES: WHY DOES IT WORK?

Several hypotheses can explain this spatial stability.

The structure of a hybrid reinforcement

A hybrid braid consists of strands, which are themselves made of long glass fibers. Glass is by nature an incompressible material. It can be deformed by bending or breaking. A bundle of glass fibers bent and bonded together will become a nondeformable structure *(Fig. 15)*.

The three-dimensional framework

A reinforcement is wrapped 360° around each implant transfer in constitute an offset three-stage framework *(Fig. 16)*.

A very small amount of resin

The function of the photopolymerizable resin is to adhere the glass reinforcements prior to putting them under tension. The very small amount of UDMA resin minimizes the effect of polymerization shrinkage, which is higher when the resin volume is greater. The volume contraction of the UDMA resin used is between 5 and 9%, compared with 21% with PMMA resin.

Gradual polymerisation

The polymerization protocol of the assembly UDMA resin, performed gradually, allows for stress relaxation of the polymerization.

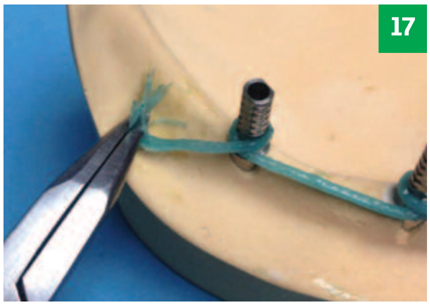
THE TECHNIQUE

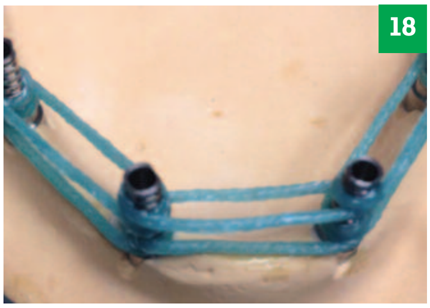
By its construction, a frame (Fiber Force CST) does not deform, within the clinical tolerance limit accepted in the literature. It is sufficient in itself to record the spatial position of implants and, if it deforms, it returns by design to its original geometry. Therefore, a simple coating with imprint material is suitable for recording gingival anatomy. An imprint tray may be used to confine the imprint fluid and prevent it from spreading within the oral cavity.

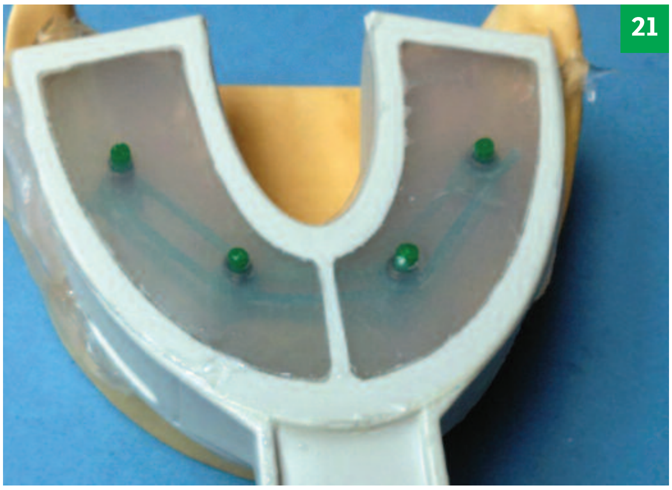
Construction of the frame

The blue reinforcement is locked using a clamp clip and wrapped in 360° turns around each transfer *(Fig. 17)*.

A brief blue "flash" of light sets the starting position. At this stage, the polymerization of the reinforcement is not complete. The procedure must move forward gradually, maintaining the assembly under tension. Photopolymerize the assembly briefly and then remove the distal excess *(Fig.18)*.







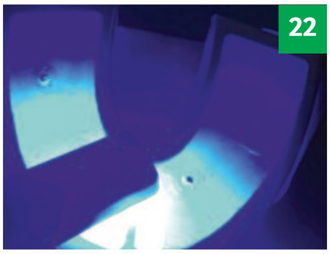


Fig. 20: *Membrane imprint tray with transparent silicone.*

Fig. 21: *Plastic rods on the implant transfers.*

Fig. 22: *Photopolymerization of the structure.*

Fig. 23: *Detachment.*

Fig. 24: *CST imprint finished.*

Secure the reinforcement–implant post connection by adding more photopolymerizable resin (Fig. 19). Photopolymerize.

Recording soft tissues

A membrane imprint tray filled with translucent silicone is used *(Fig. 20)*.

The transfer implant pits are covered with the plastic rods, using the Sage technique *(Fig. 21)*.

The imprint tray is inserted, and a setting time of 2½ minutes should be respected.

Final photopolymerisation

The choice of translucent silicone allows for irradiation through the transparent membrane of the entire reinforcement, which is now included in the silicone *(Fig. 22)*. The final solidification of the CST skeleton is completed in this stage. Any polymerization stresses have been diluted over time.

Detachment

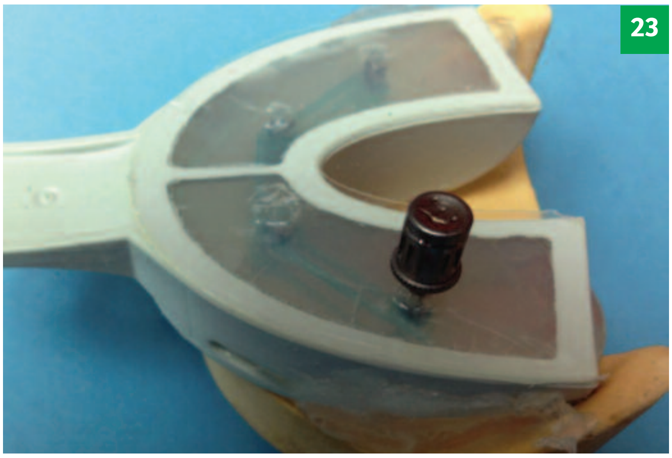
The plastic rods are easily removed because they are easily identified through the translucent silicone *(Fig. 23)*.

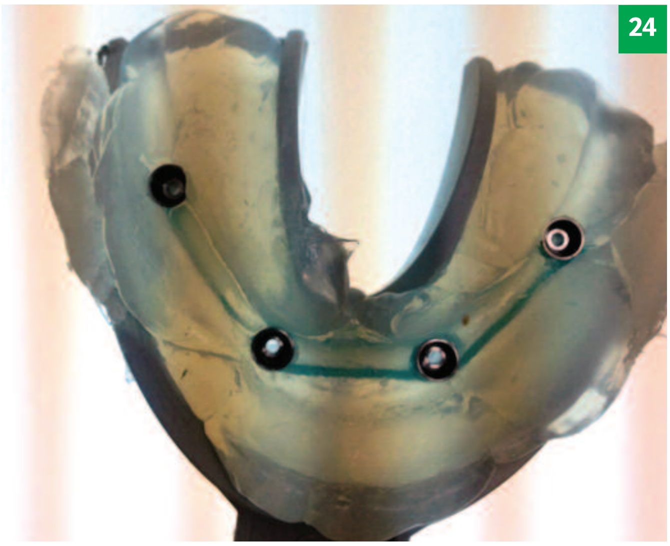
The screws are removed. After detachment, any prosthesis laboratory will be able to build the immediate denture *(Fig. 24)*.

An imprint (CST LINK) is completed in less than 15 minutes with a very accurate data recording.

Avoid time-consuming tests

It can no longer be contested that the best results in terms of imprint precision have been obtained. The technique utilized, which consists of quickly blocking the different components, reliably replaces time-consuming validation tests (Sheffield test) and thus gives more flexibility to the prosthetics laboratory and the practitioner to perfect the finishing of an immediate prosthesis.





Any possible polymerisation stress is diluted over time.

CST LINK – A FIBERFORCE PRODUCT

INCREASING EFFICIENCY

Bio Composants Médicaux

: 04 76 07 79 57 - : contact@biomedicaux.com - : dental-fiber-force.com

This rapid and reproducible technique of recording the spatial position of implants bypasses stability tests.

The use of a photo-fiber can connect implant transfers to construct a nondeforming self-supporting three-dimensional Fiber Force CST structure, solidly attached to the transfers.

The structure is sufficient in itself to maintain the spatial coordinates of the implant positions without deforming. For immediate use, the best results in terms of imprint precision are obtained when the implant transfers are joined together. Due to its reliability, the technique used, consisting of rapidly blocking the different components, can bypass time-consuming tests and give more flexibility to the prosthetics laboratory and the practitioner to perfect the finishing touches to a prosthesis for immediate use.

PROTOCOL

Initial case

An implant after extraction and immediate loading is planned using AccuGuide software.

Medical device for dental care available to health professionals, not reimbursed by France's social security.
Carefully read the instructions in the manual or on the label before use.
"CST Link" Class: I (CE Marking) I

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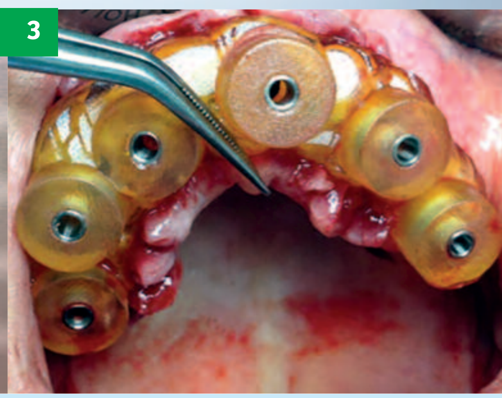

Fig.1 : Extractions. **Fig.2 :** AccuGuide planning. **Fig.3 :** The implants are put in place by means of the "AccuGuide" surgical guide.

Medical device for dental care available to health professionals. Carefully read the instructions in the manual or on the label before use. "CST Link" Class: I (CE Mark).

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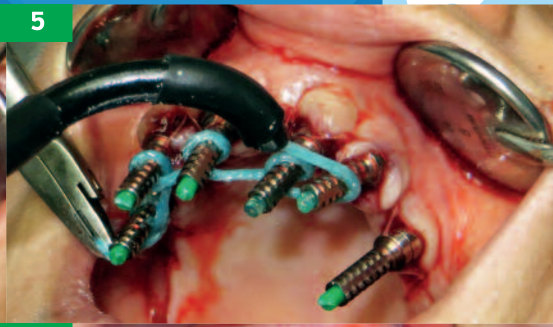
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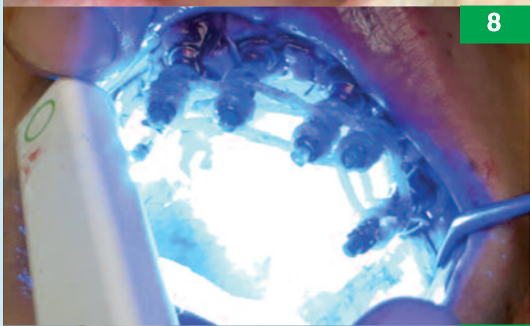
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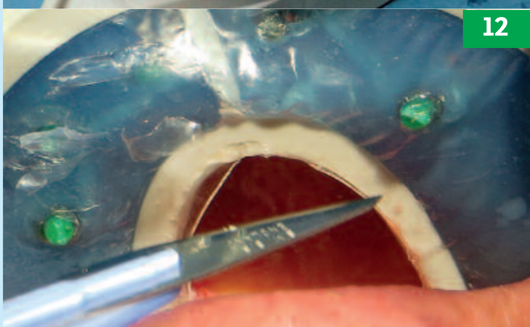
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Fig. 4: *The Multi posts intended to receive an immediate screwed prosthesis are mounted on the implants, and the screws are covered with a plastic rod for quick dismantling.*

Fig. 5: *Attachment of the implant transfers: the CST Link braid is maintained by a 360° turn on the most distal right implant transfer, then held under tension to progress towards the most distal left implant, each post being wrapped using a 360° turn.*

Fig. 6: *The most distal left implant is wrapped and then it returns back in the same direction towards the right implant.*

Fig. 7: *The most distal right implant is wrapped in a 360° turn, continuing towards the left implant to finish in a 360° turn.*

Fig. 8: *The entire assembly is polymerized using blue-light curing.*

Fig. 9: *To complete the solidification of the structure, a small amount of CST Link resin is deposited on each post.*

Fig. 10a and 10b: *A membrane imprint tray is filled with translucent silicone, and inserted into the preparations. During the imprint (2½ minutes), the polymerization is completed by illumination through the translucent silicone.*

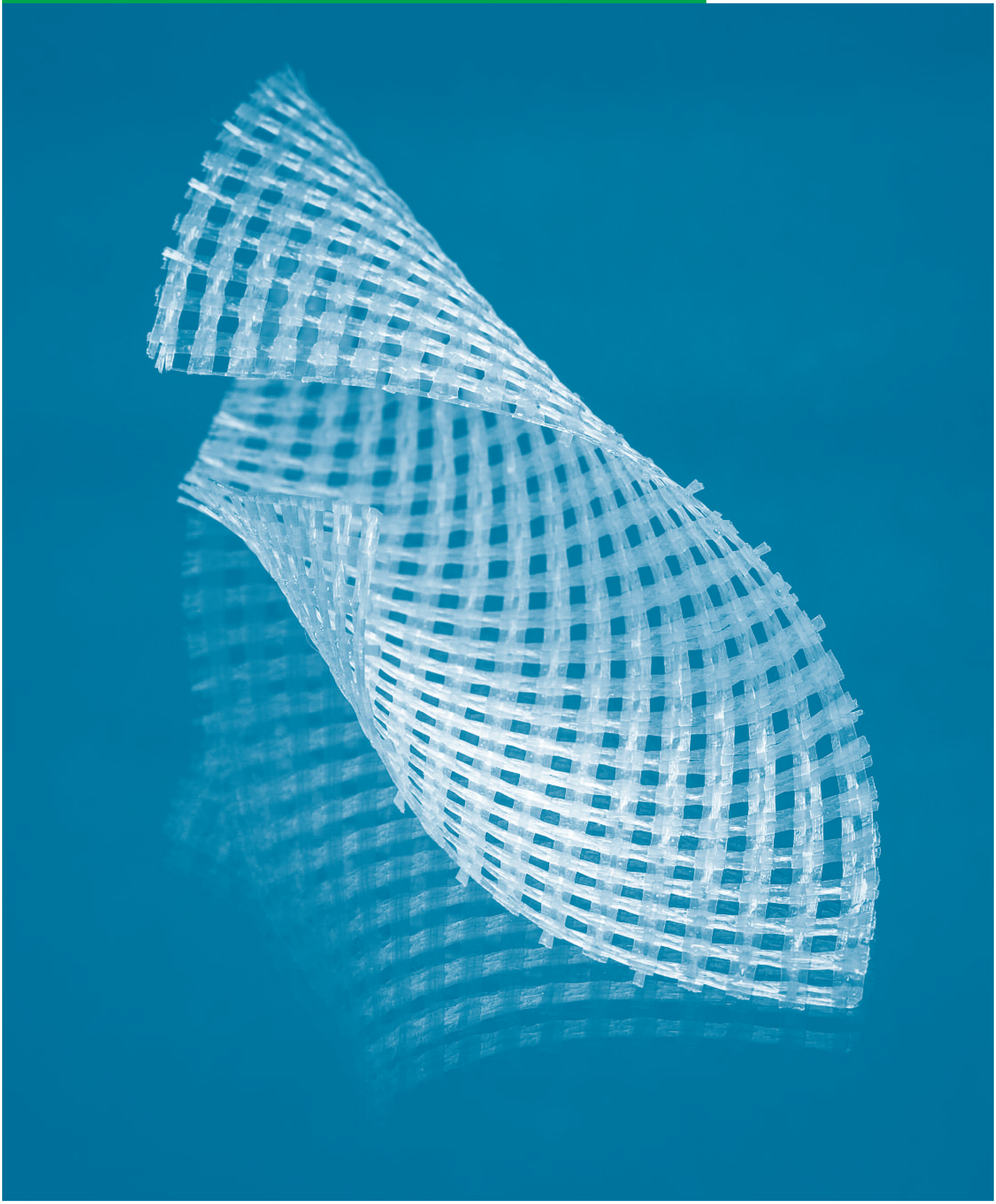
Fig. 11: *The translucent membrane is pierced, the plastic covering rods are removed.*

Fig. 12: *The screws are removed.*

Fig. 13: *The imprint is detached.*

Fig. 14: *The imprint is cast in the laboratorywith perfect positioning for the implant pieces.*

Implant is planned



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