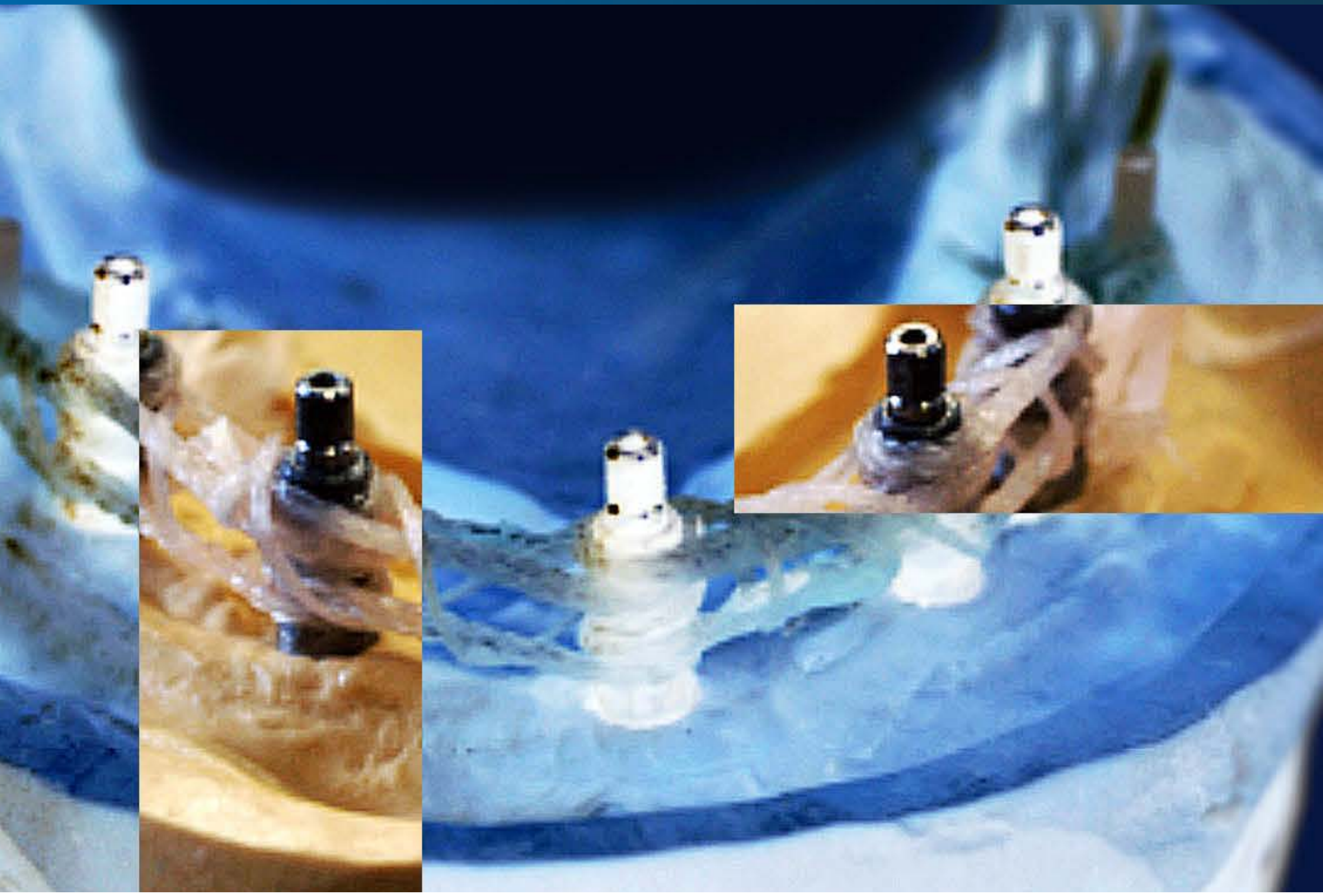
Materials & Products



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"… tailored to its purpose, reliable, comfortable, and aesthetic."

CST Fiber Force

A visitor passing along the aisles at the ADF or IDS is struck by the marketing circus surrounding digital data, dental impression taking and diagnostics, through to computer-aided design and manufacture (CAD/CAM).

This diverges from the reality of the dental surgeon's and dental prosthetist's daily work, for which it is not simply a matter of knowing how to capture excellent images, to place an implant, to fabricate superb but expensive infrastructures using increasingly fashionable new materials.

What is actually required is a truly functional implant-supported prosthesis, that is to say, tailored to its purpose, reliable, comfortable and aesthetic.

The screw-retained, implant-supported bridges known as "Swedish" (Bränemark) or All-on-4 (five, six...) (Paolo Malo)(1)(2) are still relevant because they allow the completely edentulous patient to regain function and aesthetics at reasonable cost, using technology accessible to all laboratories.

Conventionally used materials

To compensate for the structural deficiencies and fragility of resins, a reinforcing support is integrated in the prosthesis which gives improved strength and durability. These bridges are fabricated by integrating a metal infrastructure, made of cast or machined titanium or other metal, in PMMA resin, in which commercially available denture teeth are mounted (photo 1).
The technique has several advantages:

- The cantilevered interarches and the decentring of the implant abutments are easy to manage,
- The occlusion is easy to adjust,
- Worn or broken teeth can be replaced easily,
- Cost is reduced.

Metal-ceramic and all-ceramic bridges are also used, but present a significant risk of fracture. All of the studies advise the greatest of caution in using them, especially as their fabrication and repair require greater expertise and are more expensive.

A 2012 study of 280 implant-supported bridges in all types of materials found 33% suffered cosmetic fractures at 5 years and 66% at ten years. Only 6% of implant-supported bridges had no complications (Papaspyridakos et al 2012)(3).

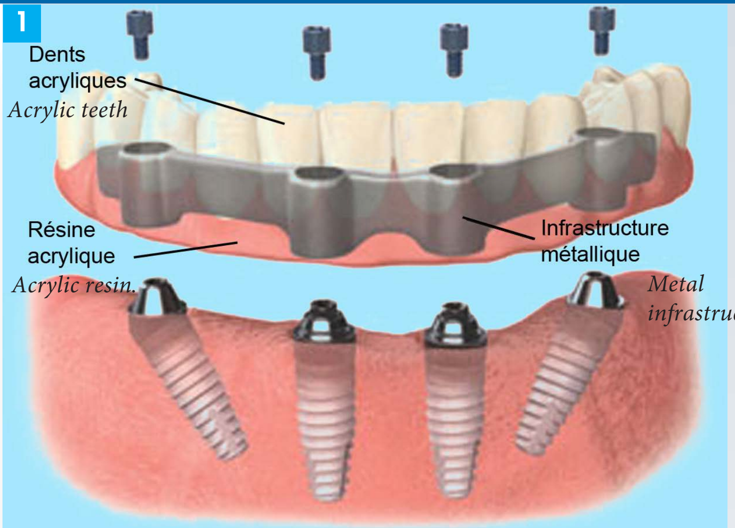
Nevertheless, the same study discovered that patient satisfaction remained high (it is always better to have an implant-supported bridge, even if chipped, than a removable prosthesis).

How is this failure rate explained?

Studies (Lindquist 1988, Fishman 1990, Apicella 1990, Jemt 1996) have demonstrated that the mandible is subjected to significant complex deformations in the three axes during function because of its horseshoe shape and the anisotropic* nature of the bone under the action of the elevator muscles or the bolus.

From a biomechanical point of view, a rigid metal infrastructure subjects the bridge abutments to torsional stresses, which can be compensated for by the ability to adapt of the ligament on the natural teeth.

This adaptation does not exist with implant abutments. They become the locations of significant constant stress peaks acting on the bone, the implant, the fixing screws, and the prosthesis itself (McCartney 1992).

1


Metal-ceramic bridge.

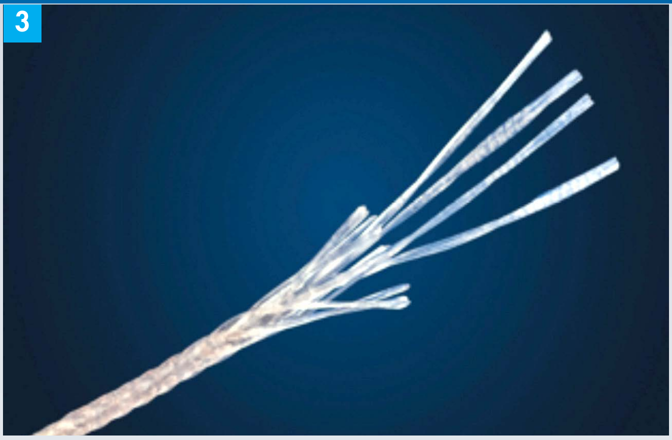
2


Various fractures.

The weakness of these prosthetic constructions results in fractures in the resin, the expulsion of teeth, fracture of connecting screws… (photo 2).
The Fiber Force CST system is designed to enable the implant-supported prosthesis to remedy these drawbacks by accommodating the inevitable deformations, and to provide a prosthesis that is comfortable, aesthetic, and strong.

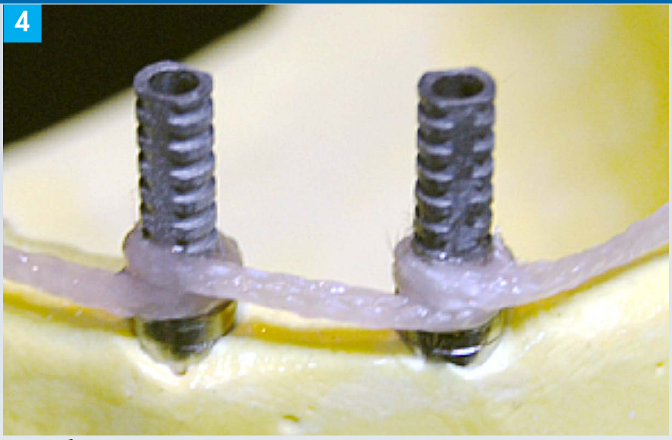
**Isotropy characterises the uniformity of the physical properties of a material as a function of direction. The opposite of isotropy is anisotropy.*

3



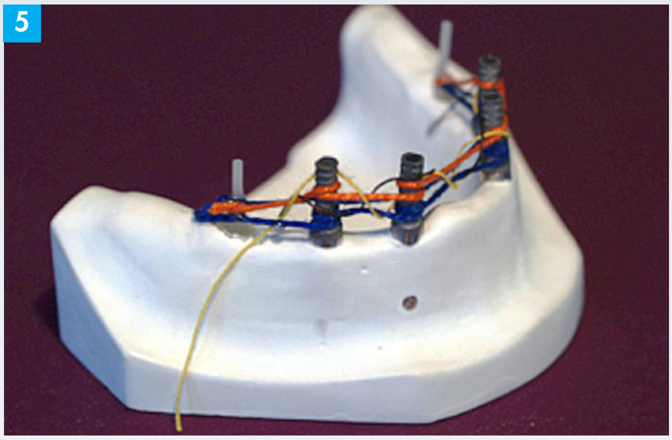
Hybrid braid.

4



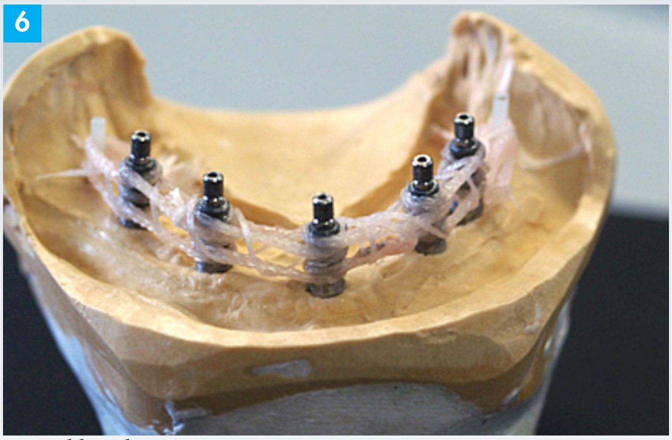
Round turn.

5



Theoretical braiding..

6



Actual braiding.

7

Injection.

8

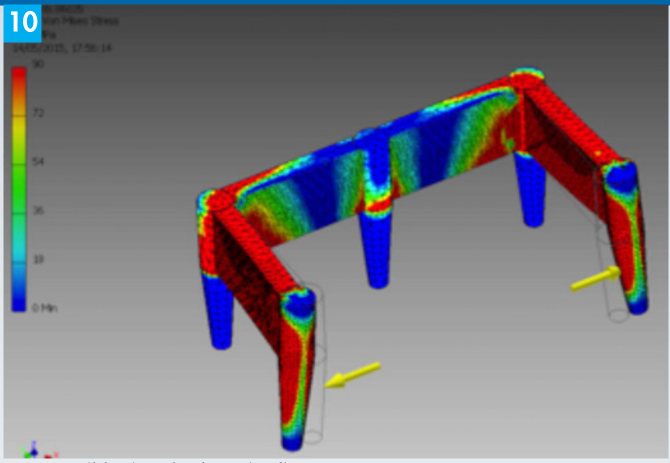
Fibre-resin implant-supported bridge.

The FiberForce CST bridge :

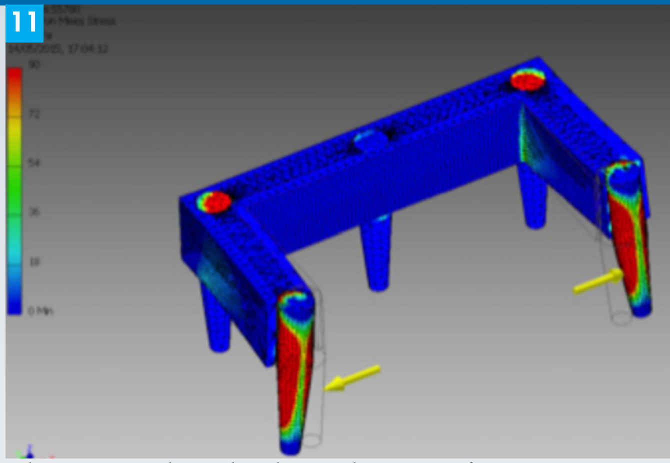
A three-dimensional fibrous architectured structure composed of simply formed using 1.4 mm or 1.6 mm diameter hybrid photopolymerisable glass fibre hybrid reinforcements (photo 3) secured on the implant abutments following a rigorous protocol (photos 4-6). After injecting a methacrylate resin, the final assembly is then composed of a strong, self-supporting structure that is particularly passive and stable (photos 7-9).

9

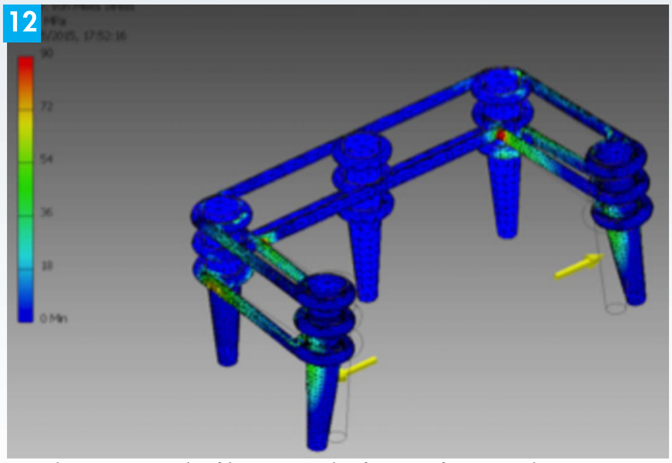
Lower surface.



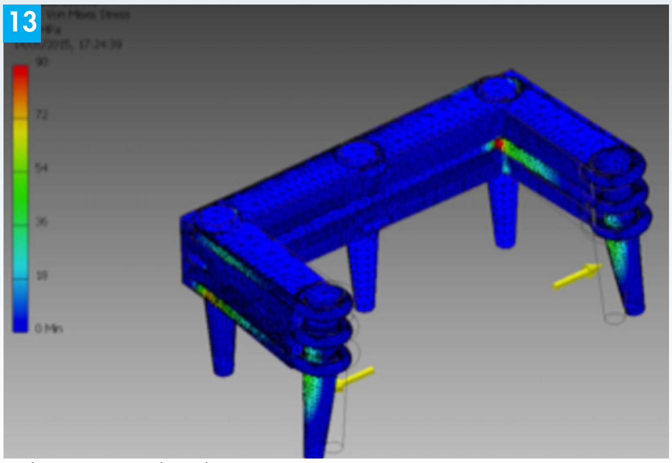
Lowest (blue) to highest (red) stresses.



The stresses are located at the metal-resin interface.



Weak stresses on the fibre network of a CST framework.



Fibre integrated in the resin.

And the strength and durability of such a structure?

During the design of a fibre composite structure (for example, the wing of an aeroplane), the engineers use finite element simulation software, and this was also used to define the CST Fiber Force structure (Dassault Systemes ABAQUS) (R. Richert(4)).

The stresses on the implants, the system to connect the implants, and above all at the resin/reinforcement interface are three times lower with the CST system than with a metal bar, which explains the drawbacks revealed in the Papaspyridakos study.

Metal bar system: high stresses on the metal bar and the implants (photos 10 and 11) (high stresses in red, low stresses in blue).

More flexible CST system: stresses are three times smaller (photos 12 and 13).

Damage to metal-resin bridges occurs because of a well-known process. There is no stable chemical bond between the metal and the resin, and during function, the alternating stresses are concentrated on the metal/resin interface, which always yields sooner or later (fatigue failure of a tooth with expulsion of resin, fractures, colourations…)

Another study (Lila Bonenfant,(5)) found that a Fiber Force CST bridge did not deteriorate at all after 5,000,000 cycles, corresponding to 5 years' functioning.

An 11 mm cantilever extension resists static forces of 93 daN (93 kg), forces rarely met in clinical practice, whereas an unreinforced resin fails at 32 daN.

This strength is the result of strong adhesion of the reinforcements distributed in the resin and an effective system of locking the implant abutments (photos 14 and 15).

The studies lead to the following conclusions :

- The implant and its superstructure do not seem to be less stressed when the structure can accommodate the deformations and the resin/infrastructure interface is subjected to lower stresses when the system is less rigid (60 Mpa compared to 330 Mpa)

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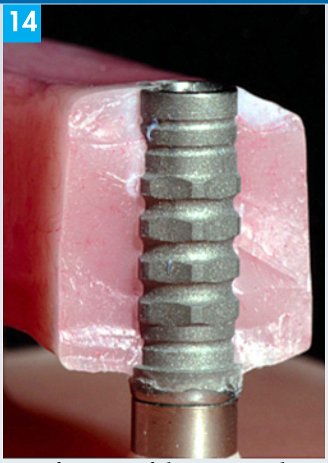
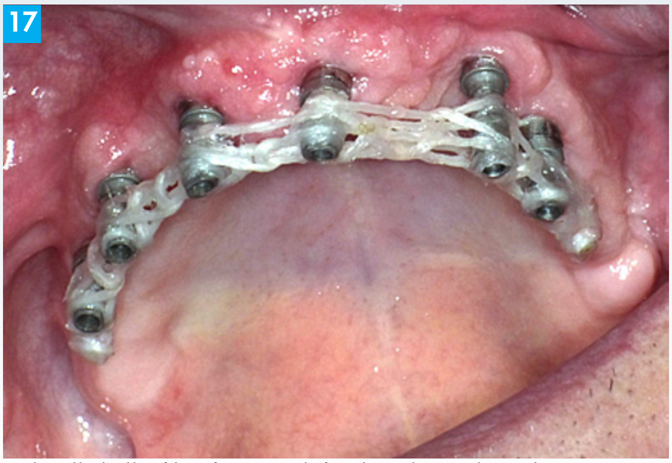

Dry fracture of the resin at the metal-resin bond at 32 kg..

15

The fiber-resin laminate resists up to 93 kg.

16

More fibres for more strength..

17

A hardly bulky fibre framework fixed on the implant abutments.

18

A prosthesis of the usual size.

- The stress on the fragile element (resin) diminishes when a larger number of reinforcements is distributed in the volume.
- If the number of reinforcements is increased, their diameter will be smaller (0.9 mm hybrids)
- It is imperative for the reinforcements to be tensioned during construction of the infrastructure.
- Lastly, it is better to use abrasion-resistant composite teeth.

… and the bulk?

Smaller diameter reinforcements (0.9 mm) are used by the prosthetist if the preservation of phonation or the occlusal conditions demand a reduction in the volume of the prosthetic elements. In this case, as a function of the desired bulk, there are at least 4 full turns in accordance with the usual protocol so that the reinforcements are distributed throughout the whole of the resin volume (photos 16 and 17).

In this way, a true fibre-resin laminate is created that combines all the advantages of resin and those of the fibre reinforcements to make a new material stronger than either of its components.

The self-supporting glass fibre-resin laminate obtained will have dimensions comparable with conventional metal-resin fabrications.

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Bibliographie :

1. Maló P, Nobre MD & Lopes A. The rehabilitation of completely edentulous maxillae with different degrees of resorption with four or more immediately loaded implants: a 5-year retrospective study and a new classification. Eur J Oral Implanto (2011) 4: pp. 227-43.
2. Maló P, Rangert B & Nobre M. All-on-4 immediate-function concept with Brånemark System implants for completely edentulous maxillae: a 1-year retrospective clinical study. Clin Implant Dent Relat Res (2005) 7 Suppl 1: pp. 88-94.
3. Papaspyridakos P, Lai CJ et all, a systematic review of biologic and echnical complications with fixed implants rehabilitations for edentulous patients. Int J oral Maxillofac. Implants. 2012jen-feb; : 27 (1) : 102-10
4. Richert R, Simulation du comportement mécanique par éléments finis d'un bridge fibro résineux de type Fiber Force ™ CST. (Doc Bio composants médicaux, Tullins (38)
5. Bonenfant L., Détermination de la résistance à la flexion en fatigue de matériaux composites renforcés par un réseau fibré organisé de type Fiber-Force CST (Doc Bio Composants Médicaux, Tullins (38)