Passive fit in the treatment of fully edentulous jaws with implant-supported prostheses: clinical and biomechanical aspects of a fixed hybrid prosthesis

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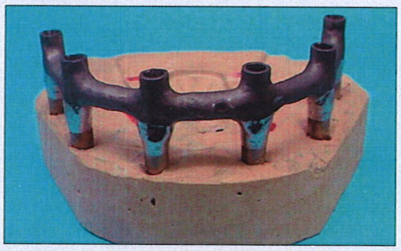
INTRODUCTION

Passive fit of implant-retained frameworks is the essential requirement for the achievement and maintenance of osteointegration, especially in screw-retained prostheses and immediate loading procedures. Complications in osseointegrated, implant-supported prostheses are repeated screw loosening, fractures of aesthetic coating material, screw fractures, fracture of the metal framework and bone resorption underneath the first implant thread and finally implant loss. The two main reasons for complications in osseointegrated, implant-supported prostheses are destructive occlusal contact and lack of passive fit between the restoration and the implant(1,2). Prosthesis misfit influences the pattern and the magnitude of stress distribution in the prosthesis, in the implant components, and in the surrounding bone with static constant stress. Occlusal loading exercises an additional dynamic and discontinuous stress, and the presence of a cantilever amplifies the effect of the misfit(3). The framework misfit in association with functional loading creates stress at the interfaces prosthesis-implant and bone-implant with subsequent mechanical and biomechanical complications. There is no evidence of a clinically acceptable degree of misfit and no statistical correlation between changes of marginal bone level and different parameters of prosthesis misfit(4). The inability of consistently achieving a passive fit with screw-retained implant prostheses is higher than with cement-retained implant frameworks(5). The framework misfit directly influences the screw-in torque, which depends on the geometry and material of the screw. It is composed of pre-load, bedding and longitudinal deformation, and is about 75% of the necessary breaking force. Progressive implant loading in immediate loading procedures should not interfere with the osteointegration process(2).

Transfer of the precise position of implants to a master cast is a prerequisite for accurate and passive fit of the superstructure(6). Furthermore, distortion of the metal framework during the casting procedure has been cited as a main cause of misfit(7). The impression(8,9) and construction accuracy(10,11) have to achieve the reproduction precision of the implant position in the model and the passive fit of the framework in situ. Furthermore, direct passivation procedures have to be evaluated, in situ.

6 implants in steel model								
Splinting of implant mounts + impression								
1. Tetric-Flow®			2. GC Pattern Resin®			3. GC Pattern Resin®		
Individual impression tray + Impregum®						–		
Model casting								
3 master models			3 master models			3 master models		
1A	1B	1C	2A	2B	2C	3A	3B	3C
Framework								
3 frameworks			3 frameworks			3 frameworks		
1A	1B	1C	2A	2B	2C	3A	3B	3C
CrescoTiPrecision System® (CTiP)								
Screw-in system OSSEOCARE®								
Measurements on master model								
1A	1B	1C	2A	2B	2C	3A	3B	3C
Measurements on steel model								
1AA	1BB	1CC	2AA	2BB	2CC	3AA	3BB	3CC

Tab.1: Method and material of the laboratory experimentation



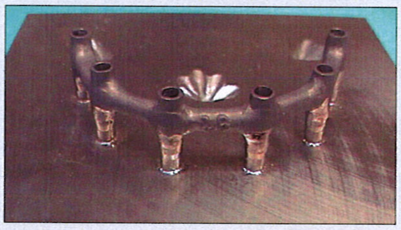


Fig. 1, 2: Framework on the master cast and on the steel model

MATERIAL & METHODS

Three different impression techniques were tested by splinting the mounts of 6 implants with external hexagon connection placed in an experimental steel model with (Tab. I):(1) photo polymerizing composite (Tetric-Flow®) and polyether (Impregum™),(2) auto polymerizing resin (GC-Pattern®) and polyether (Impregum™),(3) only auto polymerizing resin (GC-Pattern®). A titanium framework for fixed screw-retained hybrid prostheses was constructed for each impression with the CrescoTiPrecision System® (CTiP). The passive fit of the frameworks on the master cast and on the steel model (Fig. 1, 2) was analysed with the quantitative evaluation of the insertion torque with the OsseoCare® dental unit (Nobel Biocare

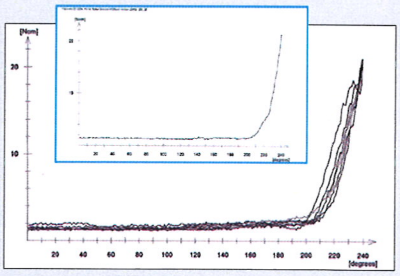


Fig. 3: Screw-in torque curves of a framework on the steel model compared to the screw-in torque curve of a single screw (small)

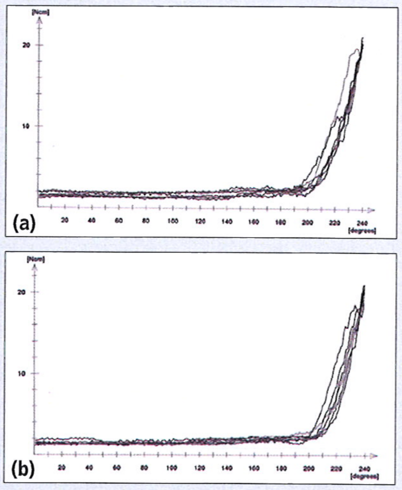


Fig. 4: Overlapping torque curves of a single framework on the master model (a) and on the steel model (b)

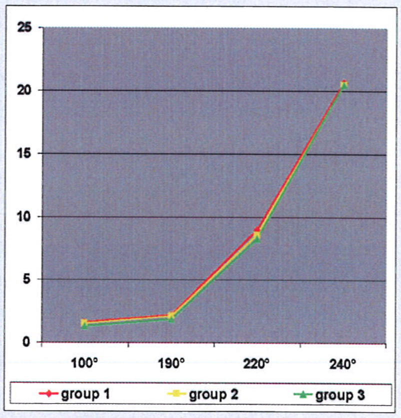


Fig. 5: Overlapping curves of the torque values of the 3 groups

AB) and compared with the screw-in torque curve of a single screw, therefore, passive by definition (Fig. 3 small). The screw-in sequence from right to left was chosen in order to amplify the possible effects of misfit.

Furthermore, the passive fit of an implant-screw-retained framework was tested in vivo in a direct passivation procedure. Seven CAMLOG® ROOT-LINE implants placed in an edentulous lower jaw (Fig. 6 a) were exposed after a two months´ submerged healing period and provided with titanium abutments with an external connection (Fig. 6 a). The impression was taken with reposition copying pick-ups, a normal impression tray and polyether. A single centralizing crown basis with gold platform for overcasting was fixed on the central analogue, passive-fit titanium caps and full casting crown basis were placed on the other implants (Fig. 6 b). A gold-palladium metal framework was constructed in a very slow and accurate one-stage casting technique (Fig. 6 c) and the hybrid prostheses fixed in situ using the CAMLOG® Passive-Fit System and the dual composite cement Panavia F (Kuraray Medical Inc.) (Fig. 6 d). Finally, the prosthesis was finished and polished in the laboratory (Fig. 6 e). The fit of the framework in situ was analysed using the quantitative evaluation of the insertion torque with the OsseoCare® dental unit (Nobel Biocare AB). The central screw was tightened first, torque curves were registered, tightening of the six screws subject-ed to the passive-fit protocol (Fig. 6 g).

RESULTS

The final 240° of the screw-in rotation of the single screw, by definition passive, is made of three essential stages (Fig. 3 small): until ca. 190°, the torque value is < 2 Ncm and corresponds to the friction of the screw with the internal implant thread, between 200° and 220°, the screw is subjected to elastic deformation and the torque value reaches ca. 8 Ncm, up to 240°, the screw is loaded to the fixed torque value of 20 Ncm, which corresponds to the plastic deformation and the final tightening. The screw thread runs ca. 360 µm in 360°, which means 1 µm for each rotational degree.

The torque curves of the frameworks of the three different groups registered in the laboratory experiment on the master casts and on the steel model appeared mainly passive (Fig. 3). The torque curves of each framework registered on the master model and on the steel model were mainly overlapping (Fig. 4). The torque values of the three groups at different rotational stages (100°, 190°, 220°, 240°) were overlapping (Fig. 5). Group(3) has a better passivity (8,24 Ncm, gap < 40 µm) than groups(1) and(2) (8,56-8,97 Ncm, gap 20-80 µm). The torque curves registered in vivo on the six screws of the hybrid prosthesis subjected to the CAMLOG® Passive-Fit System appeared passive and overlapping with values of 8,12 Ncm and a max. 35 µm gap width.

CONCLUSION

The quantitative evaluation of the insertion torque with the Osseocare® system (Nobel Biocare AB) represent a scientifically valid and clinically simple method to analyze the degree of passive fit of implant-supported, screw-retained superstructures. The system allows to screw in the prosthetic framework with a definite torque value and to record simultaneously the resistance and the rotational displacement of the fixation screw[12]. The system has a high standardibility, reproducibility and objectivity. Other methods to evaluate the passive fit like radiographic analysis, alternating digital pressure, tactile exploration, Periotest®, revealing pastes, single screw-in test have high subjectivity, low sensitivity and standardization[13, 14]. The laboratory experimentation analyses and validates three different impression techniques for implant-supported, screw-retained hybrid prostheses.

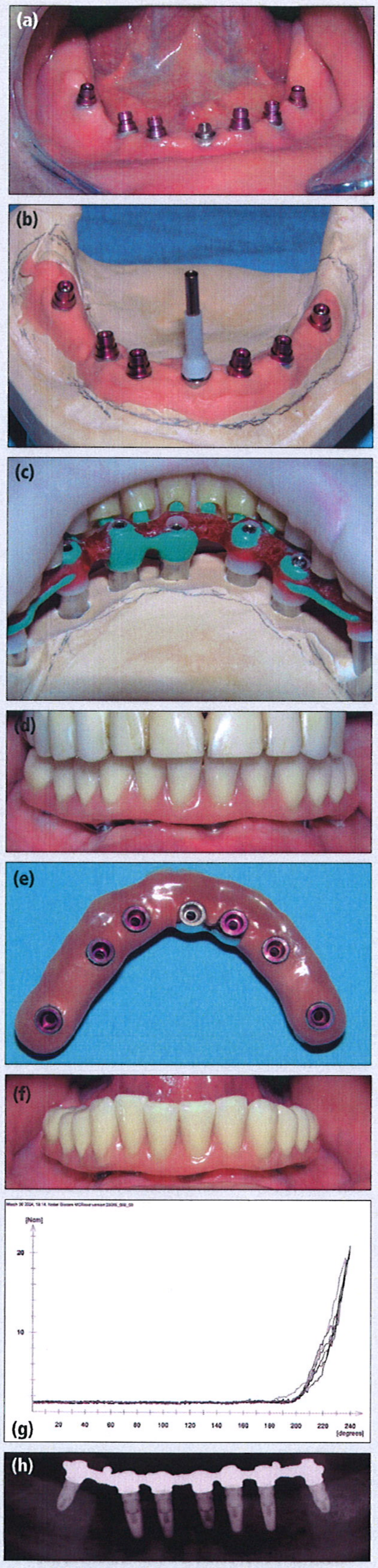


Fig. 6: Clinical and laboratory protocol of the CAMLOG® Passive-Fit System: (a) titanium abutments and titanium caps, (b) centralizing crown basis with gold platform for overcasting, (c) framework preparation, (d) in situ cementation, (e) final finishing and polishing, (f) final prosthesis in situ, (g) screw-in torque measurement, (h) radiographic control after 2 years.

The splinting of the implant mounts with resin material on the one hand, combined with the impression using a polyether material on the other hand, both provide the precise reproduction of the implant position in the master cast model. The superstructure construction with the CrescoTiPrecision System® (CTiP) is able to produce passive-fit frameworks. The CAMLOG® Passive-Fit System guarantees the passive fit of the prosthetic superstructure and has the following advantages:

- simple impression technique,
- no separating and weldering of the metal framework,
- screw-in torque of 20 Ncm,
- simple direct passivation technique, especially indicated for immediate loading procedures,
- favourable costs/benefits ratio.

Some clinical warning signals listed in ascending order of appearance in case of framework misfit may demand an intervention and may prevent complete prosthetic and implant failure:

1. screw-in pain,
2. repeated screw loosening,
3. repeated fractures of aesthetic coating material,
4. fixation screw fracture and
5. bone resorption underneath the first implant thread in a short time.

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