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Failure mode of implant-abutment connections after horizontal cyclic loading

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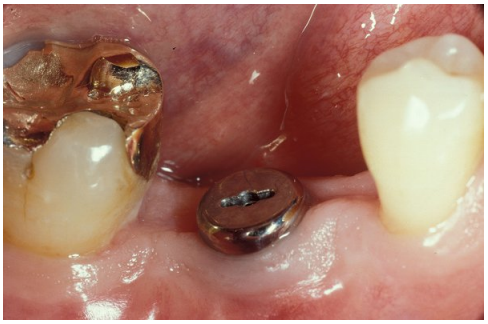
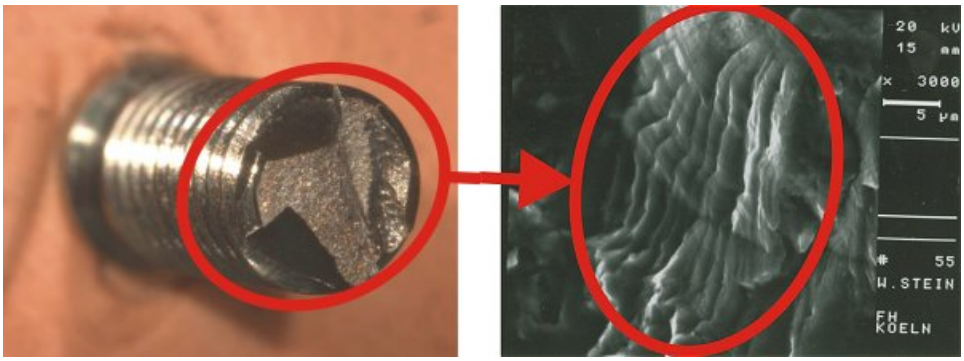
Introduction

The use of single tooth implant restorations in the lateral region is increasing. The clinical long term success of those restorations seems to be less dependant of a failure of the osseointegration, but rather more on the material fatigue of the implant's components.



Single tooth implant



In-vivo implant fracture with cycle loading caused fatigue striations

Objectives

The purpose of this study was to evaluate the mode of failure, as well as the reasons of failure resulting from constructional and manufacture weaknessed, after cyclic loading in a chewing simulator.

Material und Methods

For this experiment a chewing simulator (Fa. Willytec) was modified as follows in order to:

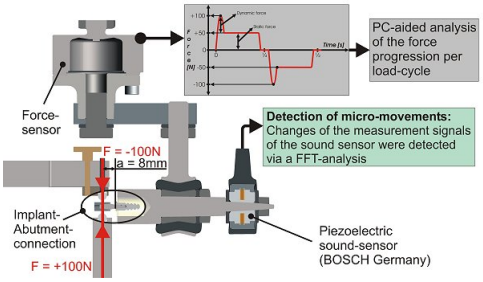
- a.) lead the horizontal cyclic load, which was exercised bilaterally (±100N, at a 8mm distance), on the implant-abutment connection.
- b.) measure the maximum of dynamical chewing force in each chewing cycle
- c.) to detect and register during the cyclic loading the interfering signal (coming out from a piezoelectric sound-sensor), which precedes any micro-movement/loosening, and to stop the chewing simulator at the time of detection.

The implant abutment connection was:

- a.) mounted with the suggested screw torque and
- b.) standardized V2A caps (Ø 5mm) were cemented on the abutments
- c.) embeded with "Knethartz, Metaflux" in accordance with DIN 148

Force [N]	Frequency [Hz]	cycle loadings n	loading weight [kg]	distance [mm]	speed [m/s]
± 100	2	1.000.00000	5	± 1.5	40

Experimental Parameters of the chewing simulator

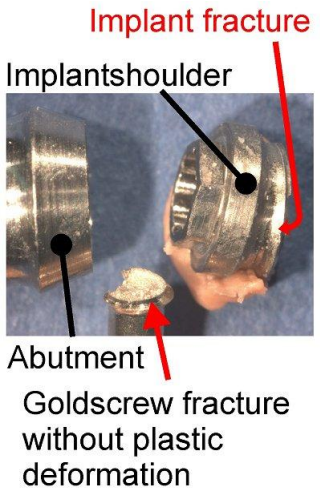


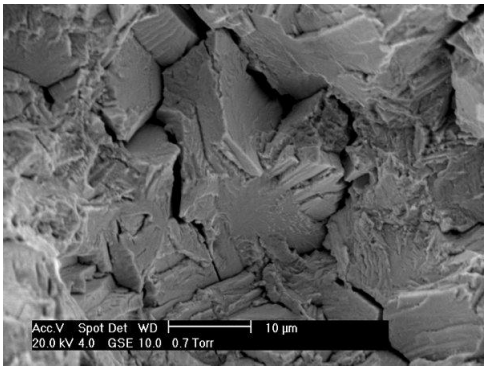
Results

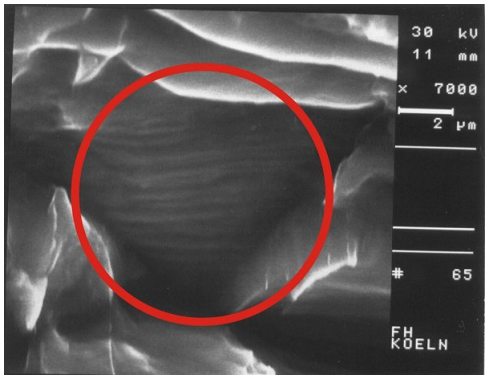
Implantat	diameter [Implant/Abutment]	average life [cycles]	failure rate [number]	failure mode
ITI-Synoktamilling cylinder	4,8 / 3,45	149.758	8 Suprastructure	8 micromovements / 8 lossenings
ITI-WN-massive abutment	4,8 / 3,45	395.699	8	6 screw- / 2 abutment fractures
Impla	4,2 / 4,2	524.714	6	6 screw fractures
Brånemark	4,0 / 4,0	599.495	8	8 screw- / 5 impant fractures
Camlog	4,3 / 4,3	822.656	3	1 loosening / 2 screw fractures
Frialit 2	4,5 / 4,5	968.813	1	1 screw- / 1 abutment fracture
Bio-Horizon	5,0 / 5,0	1.000.000	0	no failure to detected
Ankylos	4,5 / 2,5	1.000.000	0	no failure to detected

Failure modes

Brånemark



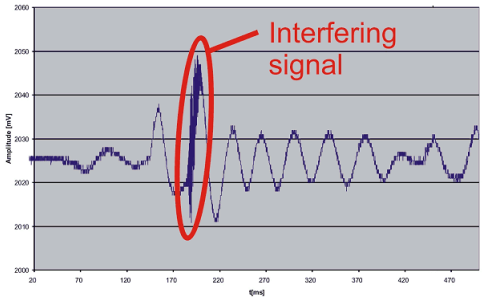




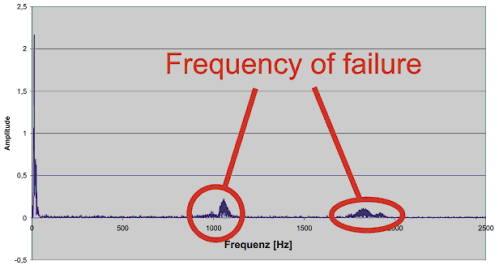
Embrittlement at fracture surface of the goldscrew

Cycle loading caused fatigue striations at fractrue surface of the Implant

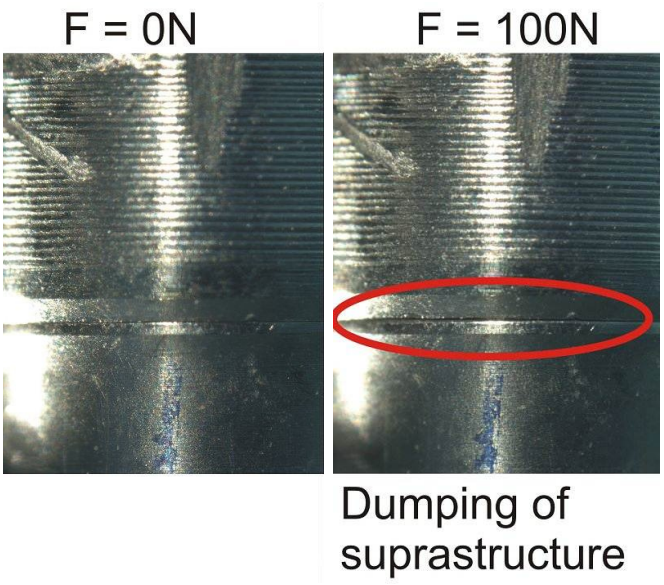
ITI-SynOkta
milling cylinder



Signal in course of time of a loosened ITI suprastructure

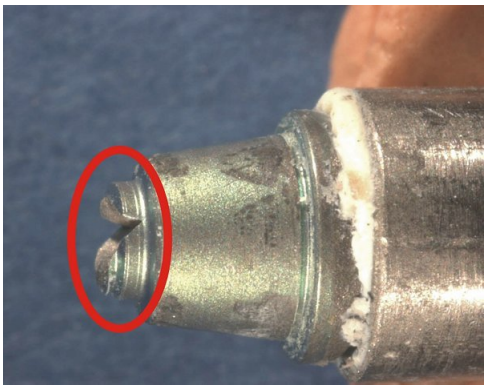


Frequency spektrum of a loosening ITI Supra structure

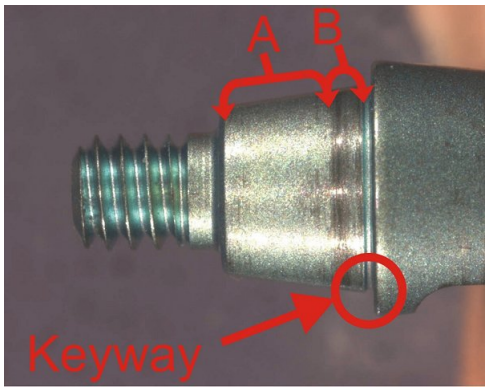


Virgin connection

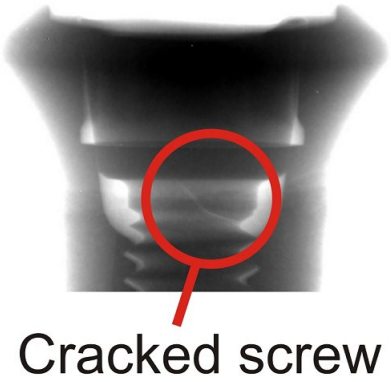
ITI-WN-massive Abutment
Screw fracture



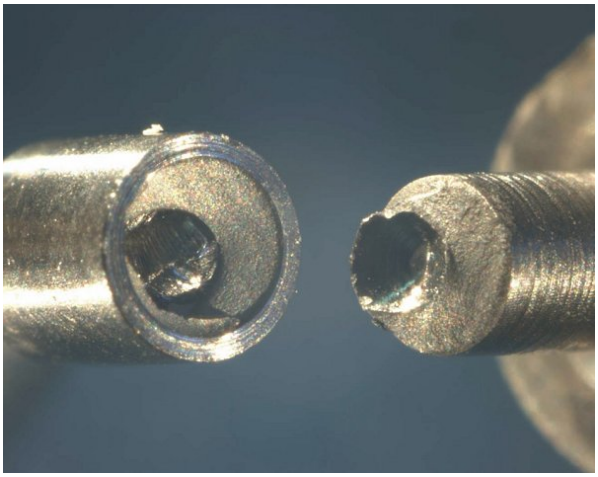
Caused by incongruent conical surface



= Flaw. ⇒ Abutmentfracture

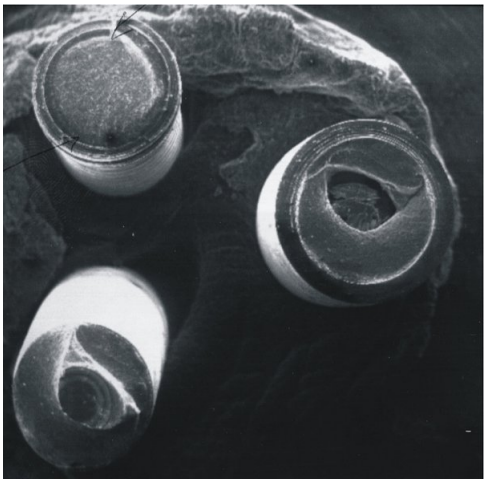


Impla
Screw fracture



Caused by undersized Screw

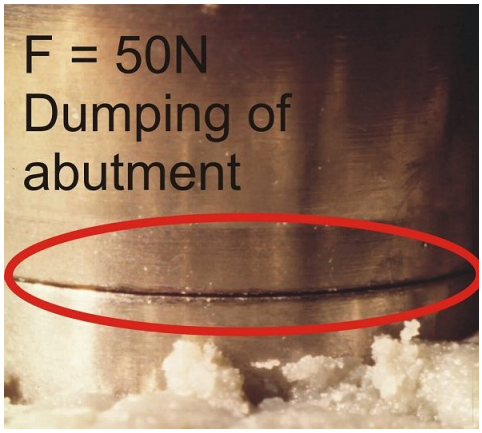
5 of 6 fracured screws are easy to remove

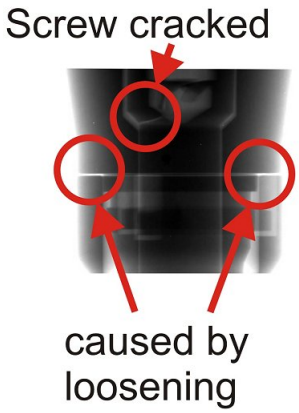


At 1 of 6 fractures second fracture at the beginning of thread

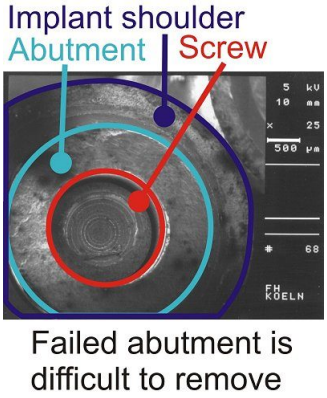
Camlog
Fracture of both Screws

Connection after 1.000.000 cycles

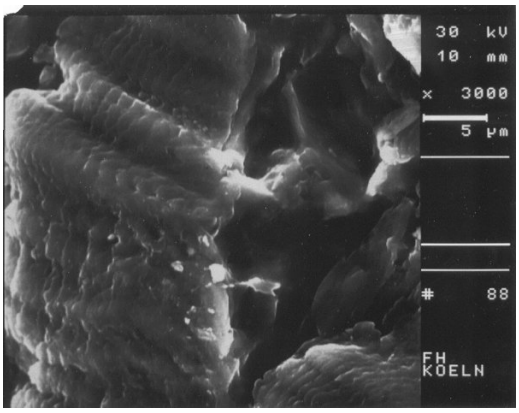


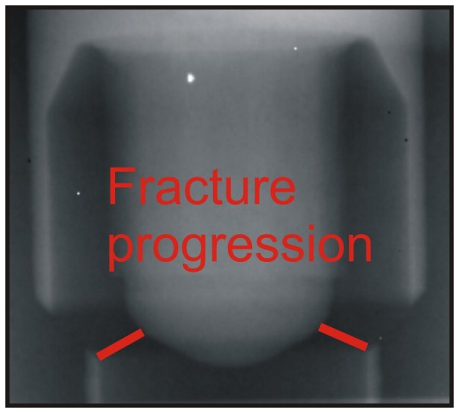


Frialit 2
Fracture of connection:



Failed abutment is difficult to remove

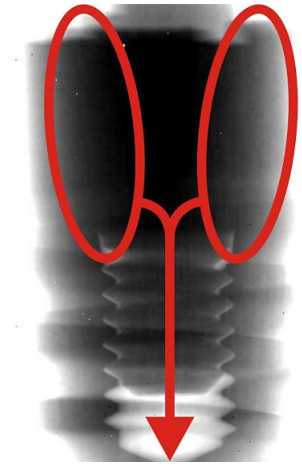




Cycle loading caused fatigue striations

Undersized screw

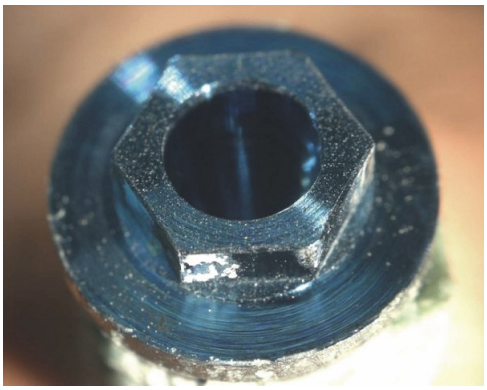
Ankylos
Before cyclic loadings



Congruent conical surface

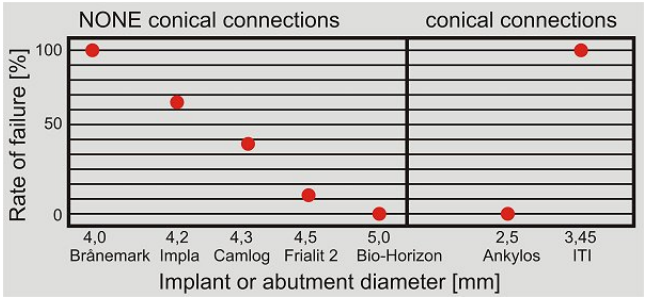
After 1.000.000 cyclic loadings

Bio-Horizons



Caused of Implant diameter (5mm) no failure detacted

Discussion and Conclusions



The material fatigue after horizontal cyclic loading depends on the intrinsic tolerance of the materials and the type of the connection between implant body and abutment. Force fit and form fit conical connections or none conical connections with a diameter up to 5mm, proved to have the minimal failure rate.

Abbreviations

- Implant-abutment connections (IAV)
- Loosening (L)
- Fractures (F)
- Micro movements (MM)

This poster was submitted by Dipl.-Ing. Holger Zipprich.

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Poster Faksimile: