

Int Poster J Dent Oral Med 2004, Vol 6 No 03, Poster 238

## Failure mode of implant-abutment connections after horizontal cyclic loading

**Language:** English

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**Date/Event/Venue:**

October, 16-18th, 2003  
 DGZMK  
 Aachen/Germany

Poster Award

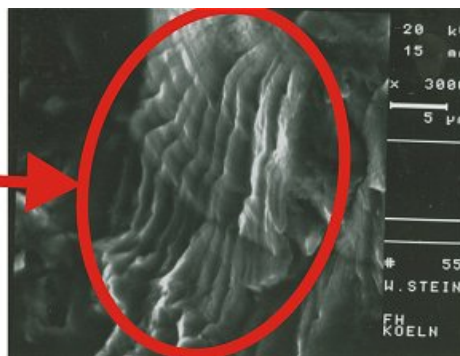
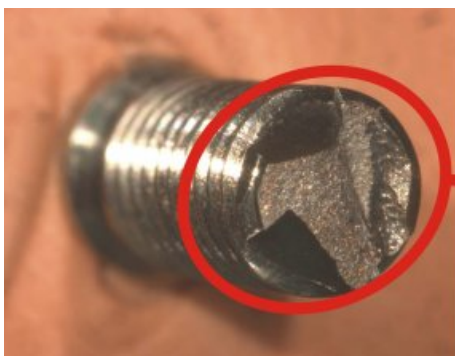
3. Platz des 17. DGZMK / BZÄK / DENTSPLY Förderpreises

**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 weaknesses, 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:

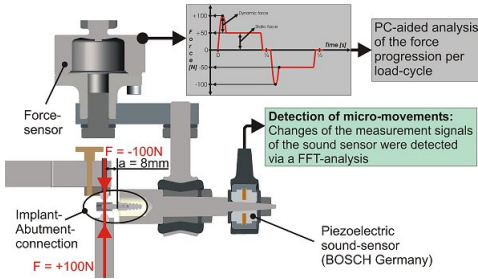
- a.) lead the horizontal cyclic load, which was exercised bilaterally ( $\pm 100N$ , at a 8mm distance), on the implant-abutment connection.
- b.) measure the maximum of dynamical chewing force in each chewing cycle
- c.) to detect and register during the cyclic loading the interfering signal (coming 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.) embedded with "Knehtartz, Metaflux" in accordance with DIN 148

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

Experimental Parameters of the chewing simulator

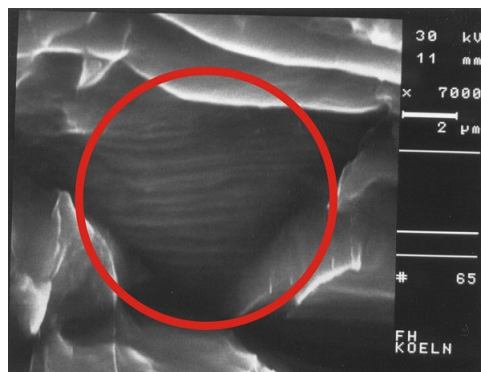
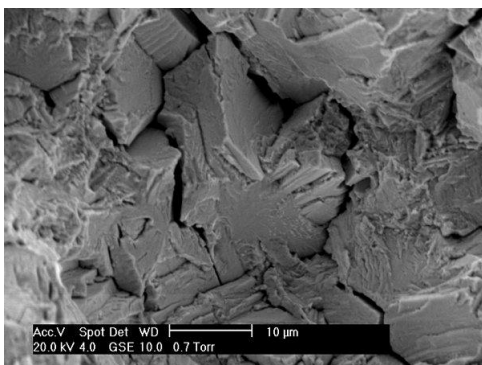
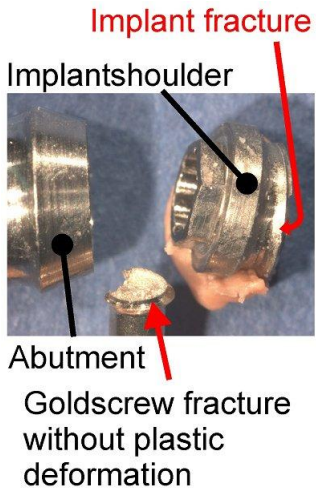


## Results

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 loosening
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 implant 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

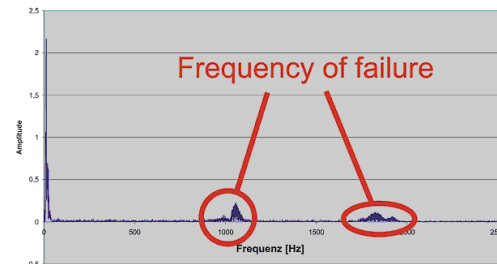
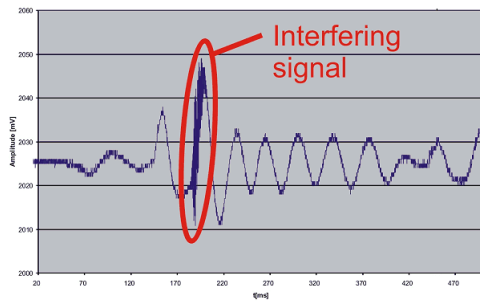
Brånemark



Embrittlement at fracture surface of the goldscrew

Cycle loading caused fatigue striations at fracture surface of the Implant

ITI-SynOkta milling cylinder

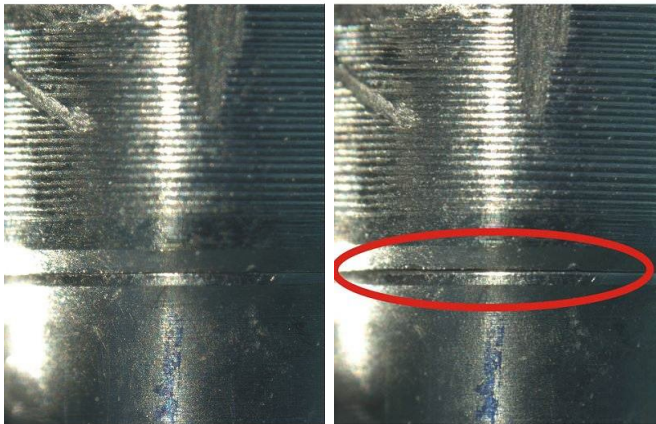


Signal in course of time of a loosened ITI suprastructure

Frequency spektrum of a loosening ITI Supra structure

F = 0N

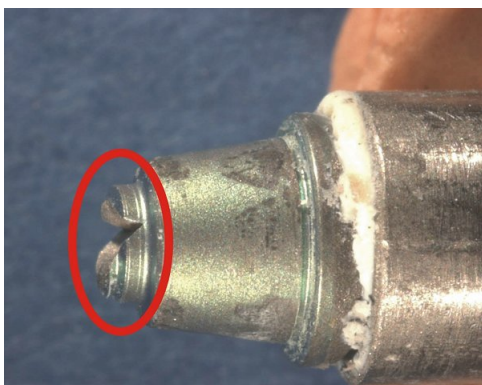
F = 100N



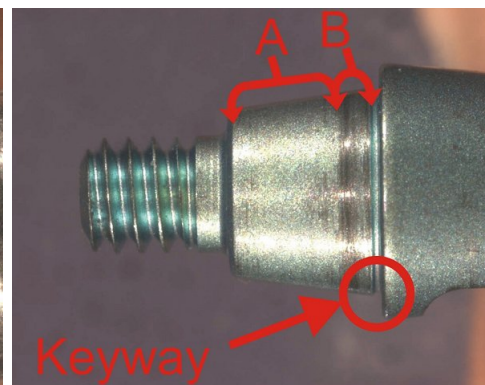
Dumping of suprastructure

Virgin connection

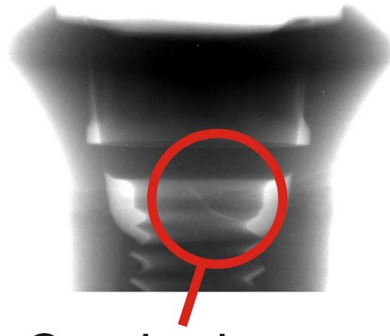
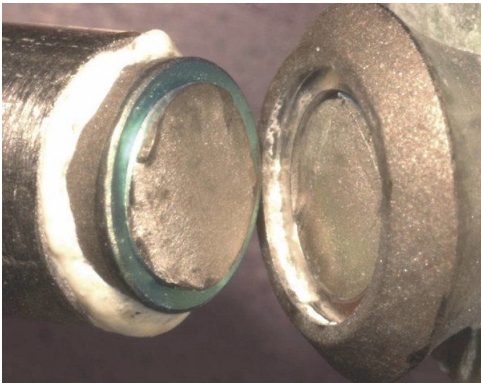
ITI-WN-massive Abutment Screw fracture



Caused by incongruent conical surface

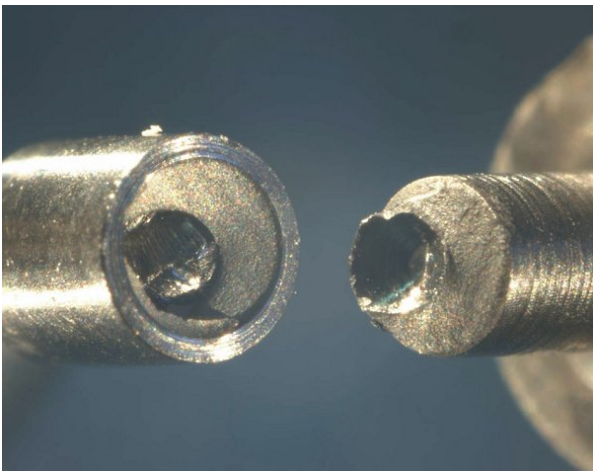


= Flaw. ⇒ Abutmentfracture



Cracked screw

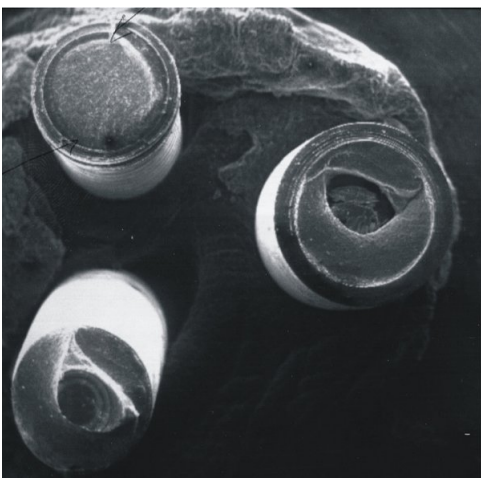
Impla  
Screw fracture



Caused by undersized Screw

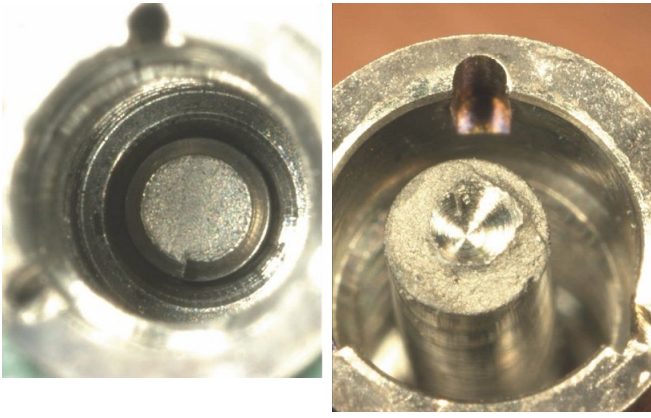


5 of 6 fractured screws are easy to remove

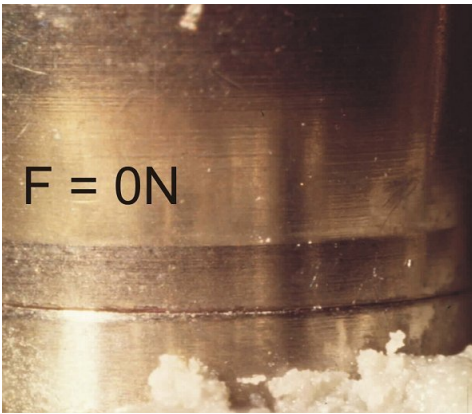


At 1 of 6 fractures second fracture at the beginning of thread

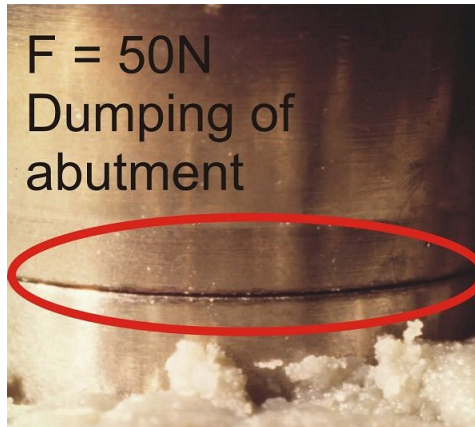
Camlog  
Fracture of both Screws



Connection after 1.000.000 cycles

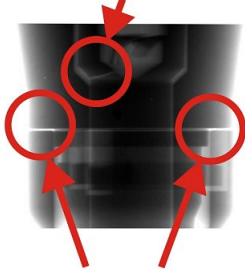


F = 0N



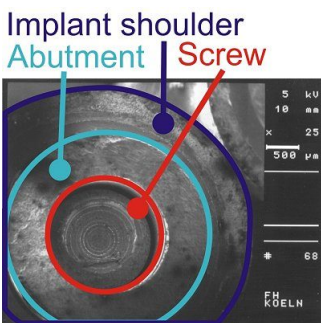
F = 50N  
Dumping of  
abutment

Screw cracked



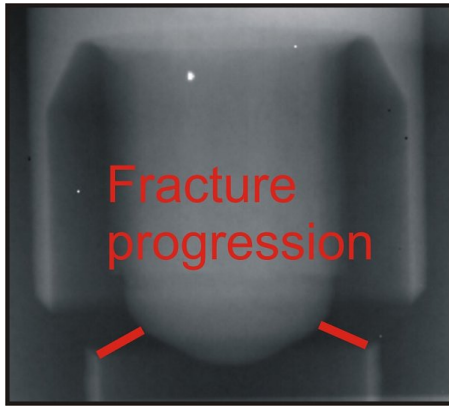
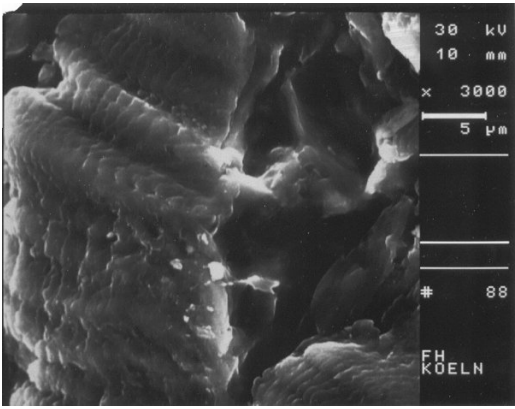
caused by  
loosening

Frialit 2  
Fracture of connection:



Failed abutment is  
difficult to remove

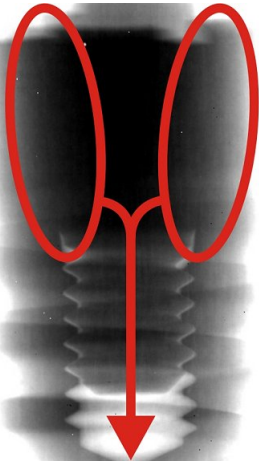
Failed abutment is difficult to  
remove



Cycle loading caused fatigue striations

Undersized screw

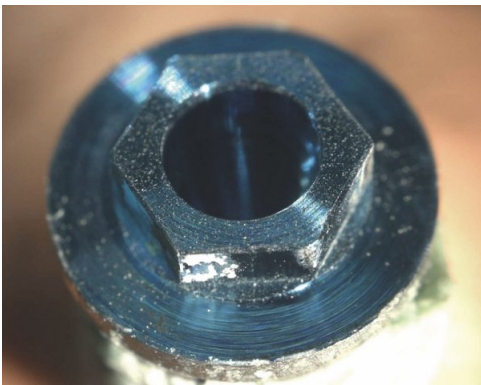
Ankylos  
Before cyclic loadings



Congruent conical surface

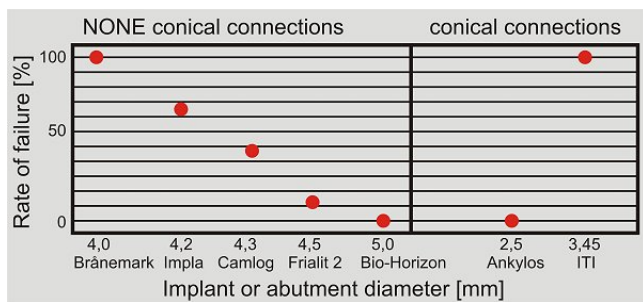
After 1.000.000 cyclic loadings

Bio-Horizons



Caused of Implant diameter (5mm) no failure detected

**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)

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## Poster Faksimile:





### Failure mode of implant-abutment connections after horizontal cyclic loading

H. Zipprich, P. Weigl, S. Sedlatschek, H.-Ch. Lauer

Department of Prosthetic Dentistry, J. W. Goethe-University Frankfurt am Main (Director: Prof. Dr. H.-Ch. Lauer)

#### Introduction and Objectives

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 dependent of a failure of the osseointegration, but rather more on the material fatigue of the implant's components.

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

#### Material and Method

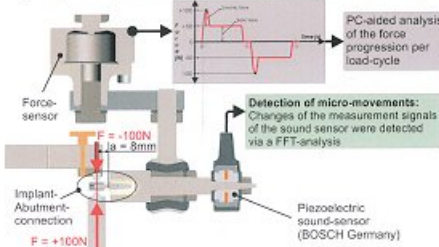
- For this experiment a chewing simulator (Fa. Wilyte) was modified as follows in order to:

- lead the horizontal cyclic load, which was exercised bilaterally ( $\pm 100\text{N}$ , at a 8mm distance), on the implant-abutment connection.
- measure the maximum of dynamical chewing force in each chewing cycle
- 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:

- mounted with the suggested screw torque and
- standardized V2A caps ( $\varnothing 5\text{mm}$ ) were cemented on the abutments
- connected with "Knechtart, Metaflex" in accordance with DIN 14801

Force [N]	Frequency [Hz]	Cycle loadings n	loading weight [kg]	distance [mm]	speed [mm/s]
$\pm 100$	2	1.000.000	5	$\pm 8$	60



**PC-aided analysis of the force progression per load-cycle**

**Detection of micro-movements:** Changes of the measurement signals of the sound sensor were detected via a FFT-analysis

#### Results

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#### Failure modes

**Brånemark**  
Implant fracture  
Abutment  
Gobdew fracture without plastic deformation  
Embedment at buccal surface of the gobdewCyclic loading caused fatigue striations at fracture surface of the implant.

**ITI<sup>®</sup> SynData milling cylinder**  
Signal in course of time of a loosened ITI substructure  
Interfering signal  
Frequency spectrum of a loosening ITI Substructure  
Frequency of noise  
Virgin connection P = 0N  
P = 100N  
Cycle loading caused fatigue striations at fracture surface of the implant.

**ITI<sup>®</sup> massive abutment**  
Screw fracture  
Caused by incongruent conical surface  
Flare  
=> Abutment fracture  
Virgin connection P = 0N  
P = 100N  
Dumpling of superstructure  
Drilled screw

**Impla**  
Screw fracture  
Caused by undersized screw  
5 of 6 fractured screws are easy to remove  
All 1 of 6 fractures second fracture at the beginning of thread

**Camlog**  
Fracture of both screws  
Connection after 1.000.000 cycles  
P = 0N  
P = 50N  
Dumpling of abutment  
Screw cracked  
Loosened by loosening

**Frialit 2**  
Fracture of connection  
Implant abutment connection  
Fractured 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  
Caused of implant diameter (dental) no failure detected

**Bio-Horizon**  
Caused of implant diameter (dental) no failure detected

#### Summary

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.

