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Evaluation of Floss Remnants After Implant Flossing in Three Different Implant Conditions: A Preclinical Study

This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

*Published Version:*

Montevecchi M., Valeriani L., Franchi L., Sforza N.M., Piana G. (2021). Evaluation of Floss Remnants After Implant Flossing in Three Different Implant Conditions: A Preclinical Study. THE INTERNATIONAL JOURNAL OF ORAL & MAXILLOFACIAL IMPLANTS, 36(3), 569-573 [10.11607/jomi.8350].

*Availability:*

This version is available at: <https://hdl.handle.net/11585/860120> since: 2022-02-17

*Published:*

DOI: <http://doi.org/10.11607/jomi.8350>

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1 **TITLE:**

2 Evaluation of Floss Remnants After Implant Flossing in Three Different Implant Conditions: A  
3 Preclinical Study

4  
5 **ABSTRACT AND KEYWORDS:**

6 Purpose. The aim of this preclinical study is to evaluate whether implant flossing could leave floss  
7 residues in three different implant-prosthetic conditions.

8 Materials and Methods. By mean of an anatomical model three different condition have been  
9 studied: correct connection between implant and abutment and complete insertion of the implant  
10 threads into the plaster (control group); misfit of about 220-230  $\mu\text{m}$  between implant platform and  
11 abutment in absence of any threads exposure (misfit group); partial exposure of implant threads  
12 but absence of misfit (threads group). Twenty-one micro-structured tapered threaded implants  
13 were divided among the three groups. Each sample was subjected to a flossing procedure using  
14 spongy floss, standardized in terms of movement, frequency, time and pressure. Subsequently, a  
15 stereomicroscope examination with a standardized magnification of 10x was performed in order to  
16 highlight the possible presence of floss residues on implant surface.

17 Results. No floss residue was ever detected for the control group. Both misfit and thread groups  
18 showed floss residues discernible in two different types: microfilaments and amorphous particles.  
19 Statistical analysis showed a significant difference for the presence of floss remnants between the  
20 control group and the other two experimental groups ( $p = 0.005$ ). No difference was observed  
21 between misfit and threads group.

22 Conclusion. This study shows that exposed threads and misfit can induce the release of floss  
23 residues during maintenance procedures.

24 Oral Hygiene, Dental Implants, Implant Flossing, Spongy Floss, Implant maintenance

25

26

27 **ARTICLE TEXT:**

28 INTRODUCTION

29 The clinical use of dental implants has become highly predictable in recent decades, improving the  
30 quality of life in patients by restoring both functional and aesthetic support.<sup>1,2</sup>

31 Between the high reliability, it is important to realize that not all implants that survive are  
32 necessarily successful. Successful implants are those that remain fully functional and healthy within  
33 the oral cavity.

34 Peri-implantitis is pathological condition associated with implant failure and is becoming rather  
35 prevalent. Several studies have shown that patients with poor plaque control and erratic  
36 maintenance display an increase risk of developing peri-implantitis.<sup>3,4,5</sup> It is therefore prudent to  
37 prevent bacterial colonization by having a very accurate oral hygiene. After implant placement, a  
38 strict follow-up regime with a dental professional should be implemented in order to monitor  
39 the implant and surrounding teeth for inflammatory disease.<sup>6</sup>

40 The dental professional should continually encourage the patient to adhere to consistent home oral  
41 care in order to prevent any peri-implant, inflammation and in turn increase the success of  
42 their implants.<sup>7</sup>

43 It is very important to underline that implant rehabilitation implicates new anatomic conditions.  
44 The relation among the implant and surrounding tissues, as well as the prosthetic rehabilitation,  
45 require specific considerations about hygienic care.

46 One of the most frequently prescribed hygienic devices for home oral care is the dental floss, in  
47 particular the stiffened-end spongy floss is quite commonly used thanks to its adaptability.

48 Narrow interproximal spaces, tilted structures and sub-marginal areas are only some of the  
49 anatomical situations where specialists suggest its use.

50 Very few studies have been published supporting this ordinary prescription, generally mutualized by  
51 the dental care or supported by strictly personal experience.<sup>8,9</sup> The evidence regarding implant care  
52 is indeed still sparse especially when compared to that for natural teeth.<sup>10</sup>

53 Some authors have recently raised some concerns about implant flossing.<sup>11,12</sup> Cases of trapped  
54 floss fibers around implants with clear signs of peri-implant disease have been reported suggesting  
55 a potential role for the clinical manifestation.

56 The presence of retained floss fibers could favor plaque retention acting like floss ligatures for  
57 experimental peri-implantitis on animal studies.<sup>13</sup> On the other side, eventual floss remnants can  
58 also induce a direct immune reaction by the host. Condition that potentially correlates to the peri-  
59 implantitis theory described by Albrektsson et al.<sup>14</sup> The authors emphasize the primary role of the  
60 immune system imbalance in peri-implant marginal bone loss. By this theory, the dental implant is  
61 perceived by the immune system as a foreign body, and consequently the presence of additional  
62 foreign bodies, such as prosthetic cement or eventually floss remnants can lead to greater bone  
63 loss.

64 Several physical-mechanical aspects have been implicated in this clinical circumstance about  
65 implant flossing, such as the incongruous implant-abutment connection or the implant rough  
66 surface exposure.

67 According to these considerations, the aim of this in-vitro study was to evaluate whether the  
68 generally recommended use of spongy floss around dental implants could represent a dangerous  
69 procedure in unexposed or exposed implant surfaces and in implants with a wrong fixture to  
70 abutment connection. The null hypothesis is that no difference in remnants on the 3 implant-  
71 conditions herein evaluated is observed, i.e. the spongy floss works in the same way.

72

73

#### 74 METHODS

75 In this in-vitro pilot study twenty-one micro-structured tapered threaded implants with an internal  
76 trilobate connection (Replace Select Tapered TiUnite, NP 3.5 x 10 mm, Nobel Biocare®) were  
77 selected. This implant was chosen for its macro and microstructural characteristics, which can be  
78 considered representative of the most commonly used implants.

79 Implants were equally and randomly divided into three groups. According to the study group in  
80 which they were assigned, implants were differently immersed in dental plaster (picodent® quadro-  
81 rock® plus) contained into plastic boxes (6x5x3 cm).

82 Seven implants with the corresponding abutments correctly inserted were completely fixed in the  
83 plaster with the exception of the smooth neck (control group) (Fig. 1-A). Seven implants with  
84 corresponding abutments positioned to create a small misfit (inadequate adaptation of the  
85 abutment on the implant) of approximately 220-230 µm, with the limit of the stereomicroscope

86 resolution, were completely fixed in the plaster with the exception of the smooth neck (misfit  
87 group) (Fig. 1-B). Seven implants with a correct implant-abutment connection were fixed in the  
88 plaster leaving four threads exposed (threads group) (Fig. 1-C).

89 Subsequently, the implants of each group were exposed to the cleaning movement of the spongy  
90 part of the multifilament floss (Superfloss<sup>®</sup>, Oral-B). In particular, the spongy floss was manually  
91 adapted by forming a loop with the crossed ends at the implant-abutment connection or the  
92 eventual exposed implant surface. In this position, the circular criss-cross movement was induced  
93 by applying a controlled pressure of 150-200 Newton, which was measured with an appropriate  
94 stress and tension gauge (stress and tension gauge 25-250 g, Dentaureum, Germany) connected to  
95 one end of the floss. Standardized movements were made both in terms of speed, with a cadence  
96 dictated by a professional metronome (metronome Taktell small, Wittner, Germany), and in  
97 number of movements for a total of 10 tractions in a total time of 10 seconds carried out by a single  
98 researcher. Particular attention was placed during the floss movement in not approaching the  
99 plaster.

100 After this, in order to evaluate the possible presence or absence of floss remnants, an experimental  
101 stereomicroscope analysis (with a standard magnification of 10x) was carried out. The  
102 stereomicroscope (Carl Zeiss stereomicroscope Stemi 2000-C, FL S configuration with KL 1500  
103 electronic) connected to AXIO CAM MC system was used to collect pictures of eventual remnants of  
104 spongy floss fibres on the study samples after the simulated hygiene procedures. The outcome of  
105 the study, i.e. the floss residues, were dichotomously detected (presence\absence) and described  
106 on the basis of their shape. Measurements were performed by using a specific software (ImageJ1).

107 Sample size

108 A pilot sample of 3 implants reproducing the experimental conditions was used to estimate the  
109 non-inferiority margin.

110 At a significance level  $\alpha= 0.05$  for a one-sided test, an 80% power, a non-inferiority margin equal to  
111 40% and an allocation ratio equal to 1:1, a total sample size of 14 implants was needed (7 in each of  
112 the two experimental groups). A control group of 7 implants was also created.

113

114 Statistical Analysis

115 Cross tabulations were used to describe the observed results. Chi-square test and Fisher test were  
116 performed aiming to evaluate differences in material presence respectively among the three groups  
117 and between floss and amorphous floss particles in the two experimental groups. The level of  
118 significance  $\alpha$  was a priori set at 0.05.

119

120

121 RESULTS

122 After flossing, all implants were analysed (Table 1).

123 All dental implants in control group did not show any floss remnants both on the smooth surface of  
124 the neck than next to the implant-abutment connection.

125 Misfit group implants showed the presence of floss material remnants in 85.7% of cases. In  
126 particular, in the misfit space, spongy floss microfilaments were found only in 1 implant, another 1  
127 implant showed amorphous particles (ranging from 50 to 600 $\mu$ m), whereas 4 implants presented

128 both microfilaments and amorphous particles (Fig. 2). Only 1 implant was free of any spongy floss  
129 material.

130 Threads group showed remnants of spongy floss in 57.1% of the implants. In particular, spongy  
131 floss microfilaments were observed in 1 implant, whereas amorphous particles were present in  
132 other 2 (Fig. 3). Both microfilaments and amorphous particles of spongy floss fibres were observed  
133 on 1 implant. Differently, no microfilaments or amorphous particles were detectable on exposed  
134 surfaces, around the smooth neck or at the abutment-implant connection of 3 implants.

135 The observed differences about spongy floss remnants (microfilaments and amorphous particles)  
136 among the three groups were statistically significant (Chi-square test =10.691, p=0.005). The null  
137 hypothesis was therefore rejected.

138 No significant difference was found between samples of misfit and threads groups (Fisher's exact  
139 Test shows a value of  $p = 0.2861$ ).

140

## 141 DISCUSSION

142 From the present study no floss remnants have been detected on control group implants.

143 Therefore, presupposing a potential pathogenicity of this remnants to peri-implant surrounding  
144 tissues, the use of spongy floss seems to represent a safe procedure in a "regular state" implant.

145 Differently, the spongy floss left residues in 85.7 % of the misfit group's implants and in 57.1% of  
146 the threads group.

147 The misfit in a finalized implant rehabilitation can be due to several conditions such as mechanical  
148 inconsistency and anatomical impediment. In particular, it is represented by the incomplete



149 insertion of the abutment to the implant, as well as the absence of an ideal matching between the  
150 abutment and the prosthetic crown.

151 In order to limit the misfit occurrence, a combination of visual, tactile and radiographic  
152 examinations should be performed.<sup>15</sup>

153 The scientific literature about implant-supported fixed denture reports a wide range of values (from  
154 10µm to 160µm) to consider the misfit technically acceptable. However, as clearly stated by two  
155 recent systematic reviews,<sup>15,16</sup> it is still lacking the effective role of misfit on clinical outcome.  
156 Therefore, the extent at which it is considered tolerable remains unclear.

157 The present work used a standardized value of 220-230 µm and put in evidence a new negative role  
158 of the misfit. It is quite rational to think that, not only the presence of it, but also its dimension can  
159 influence on the effective ability to trap floss remnants. Further studies focused on different gap  
160 dimensions are consequently strongly recommended.

161 Threads exposure is the other clinical aspect investigated in this study. Its presence can be a  
162 consequence of either para-physiological or pathological conditions. The eventual bone remodelling  
163 (following implant placement)<sup>17</sup> as well as the bone resorption (caused by inflammatory peri-  
164 implantitis or foreign body response)<sup>14,18</sup> are the prevalent conditions.

165 Irrespective by its origin, the threads exposure is also the result of a clinical condition able to trap  
166 floss remnants. In this specific circumstance, macro and micro-texture of implant can play a role on  
167 the final result. It is therefore rational to suggest future investigations on this field.

168 In the present work a clear distinction between two kinds of floss remnants has been made:  
169 amorphous particles and microfilaments. This distinction comes for the assumption that the two  
170 forms of residues may have different clinical implications. The first consideration is that amorphous  
171 particles can be more prone to a spontaneous expulsion in respect to microfilaments. To support

172 the above consideration, it is necessary to remind that all clinical cases up to date described were  
173 characterized by the detection of filamentous remnants.<sup>11,12</sup> On the other hand, it must be taken  
174 into account that this is probably due to the fact that microfilaments display a more direct and  
175 intuitive correlation to the dental floss. Consequently, it is not known which is the real role of this  
176 particles, and investigations about this topic are strongly advocated.

177 In accordance to the manufacturer statements, the spongy floss used for this research is composed  
178 by nylon fibres covered by coloured and aromatized wax.

179 Amorphous particles herein detected could probably correspond to wax remnants, and this  
180 consideration is supported by the findings of van Velzen et al. (2016).<sup>12</sup> In a preclinical set, the  
181 authors analysed the implant surface after flossing and detected the presence of organic material  
182 through spectrophotometry, plausibly wax.

183 In this study, where the prevalence of microfilament and amorphous particles between the two  
184 investigated conditions has been observed, it could be speculated that flossing on exposed threads  
185 may tend to release more amorphous residues. Otherwise, sliding floss against misfit may tend to  
186 cause tearing and the consequent release of microfilaments. The absence of a statistically  
187 supported difference limits any further consideration, but it can be rational to deepen this aspect in  
188 further studies on broader samples. Other aspects that advocate for future investigations are the  
189 floss typology and the flossing movement.

190 To the best of our knowledge, the etiopathogenetic role of these residues has not yet been  
191 discovered. However, the presence of trapped floss remnants in subgingival area may be a fertile  
192 environment for bacterial invasion and proliferation. From this consideration, it can be assumed  
193 that dental floss residues can promote the retention of bacteria and have an action quite similar to  
194 that of experimental ligatures<sup>13</sup> or biofilm-retaining factor like are luting cementum residues.<sup>19,20</sup>

195 Among the pathogenic hypothesis, it can't be neglected the host response to those remnants acting  
196 as foreign bodies. This aspect finds an interesting correlation with the peri-implantitis theory  
197 described by Albrketsson et al.<sup>14</sup>

198 From the cases reported on the literature, it can be observed that the removal of these residues  
199 generally leads to clinical improvements. Van Velzen et al. (2016)<sup>12</sup> report that in the last 3 years of  
200 clinical practice they have encountered 10 patients with persistent peri-implantitis, previously  
201 treated with a non-surgical and surgical protocol for the maintenance of implants (to which all of  
202 their patients with peri-implantitis are treated). Among those 10 patients, after exploratory surgery,  
203 all implants showed the presence of remnants of dental floss adhering to the rough part of them.  
204 Interestingly, after a careful removal and debridement of the peri-implant site, nine of ten cases  
205 resulted in an improvement in peri-implant conditions 6 months later (i.e. absence of bleeding on  
206 probing and reduction of probing pocket depth).

207 These results are supported by long-term observations of a clinical case report describing a peri-  
208 implantitis treated with an endoscopic access. <sup>11</sup> Trapped filaments around several implants were  
209 thoroughly removed leading to a complete resolution of the peri-implantitis with a 6-years stable  
210 result.

## 211 **CONCLUSION**

212 This preclinical study has clearly demonstrated how implant treads exposure and abutment-implant  
213 misfit can both favour the release of remnants from a spongy floss.

214

215

216

217 **ACKNOWLEDGMENTS:**

218 We thank Dr. Maria Rosaria Antonella Gatto (University of Bologna) for statistical assistance.

219 No financial and material supports have been received.

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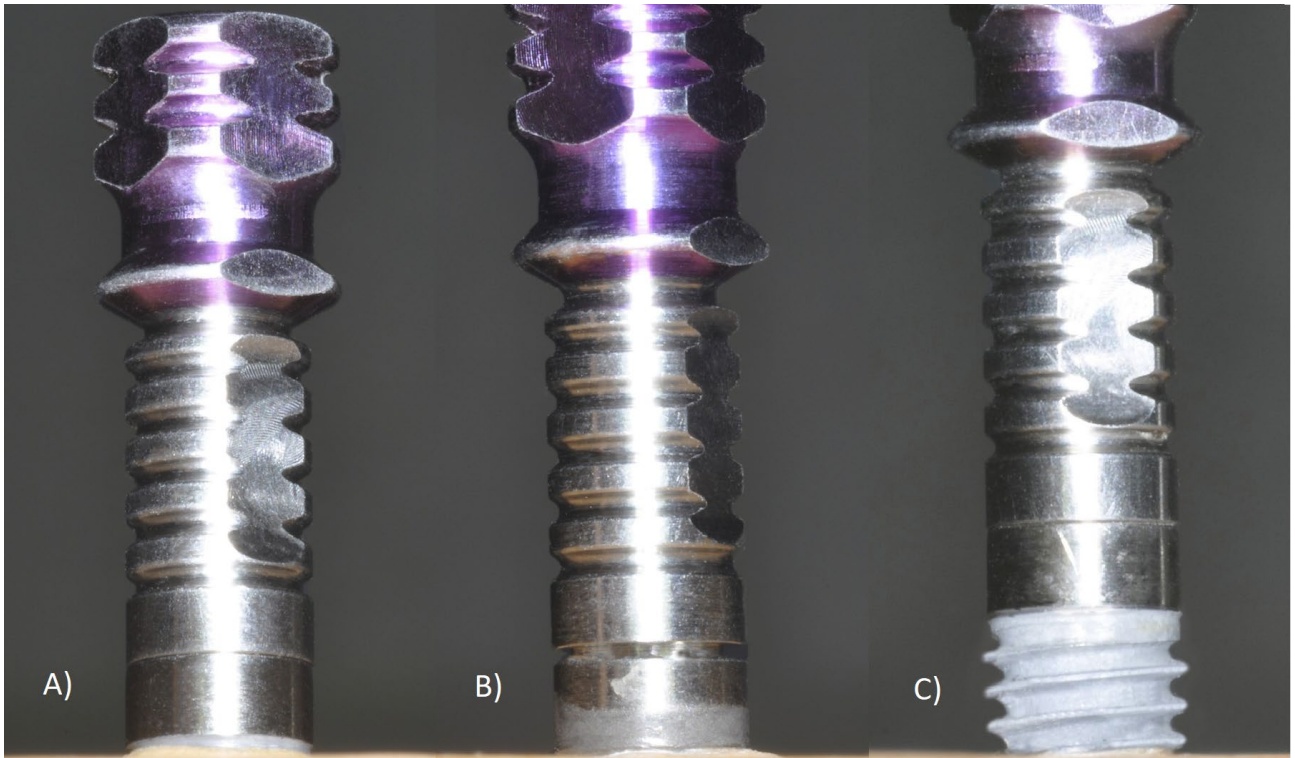
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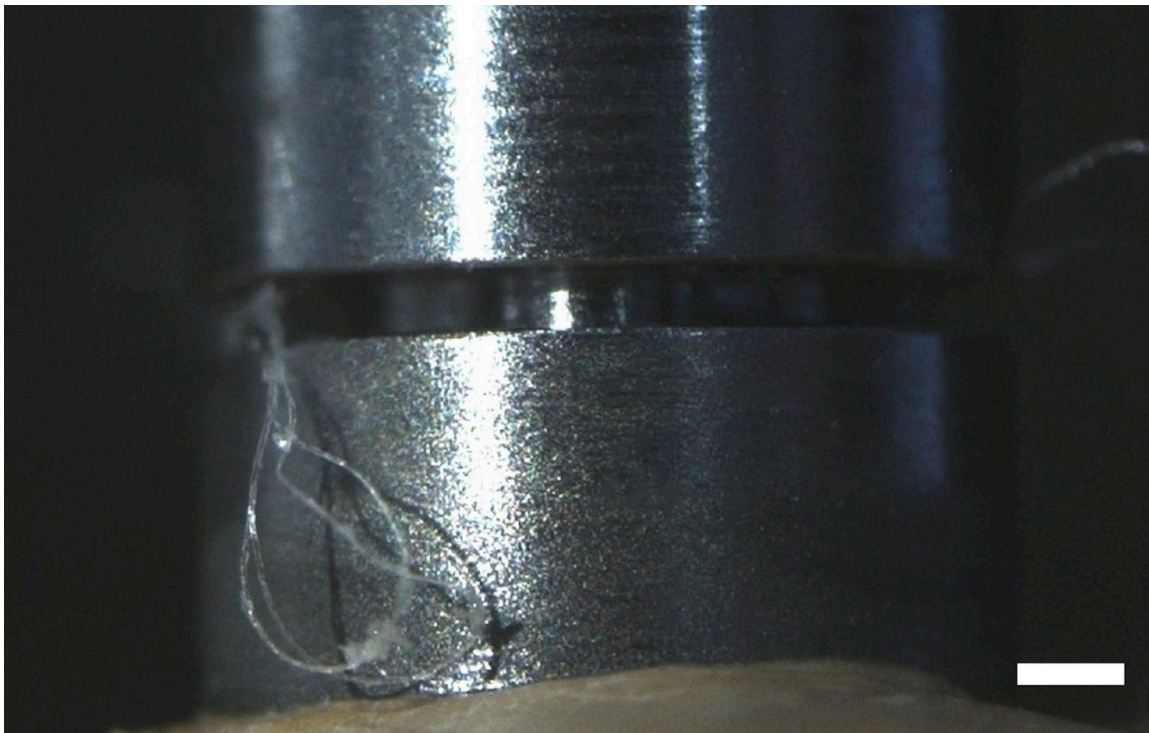
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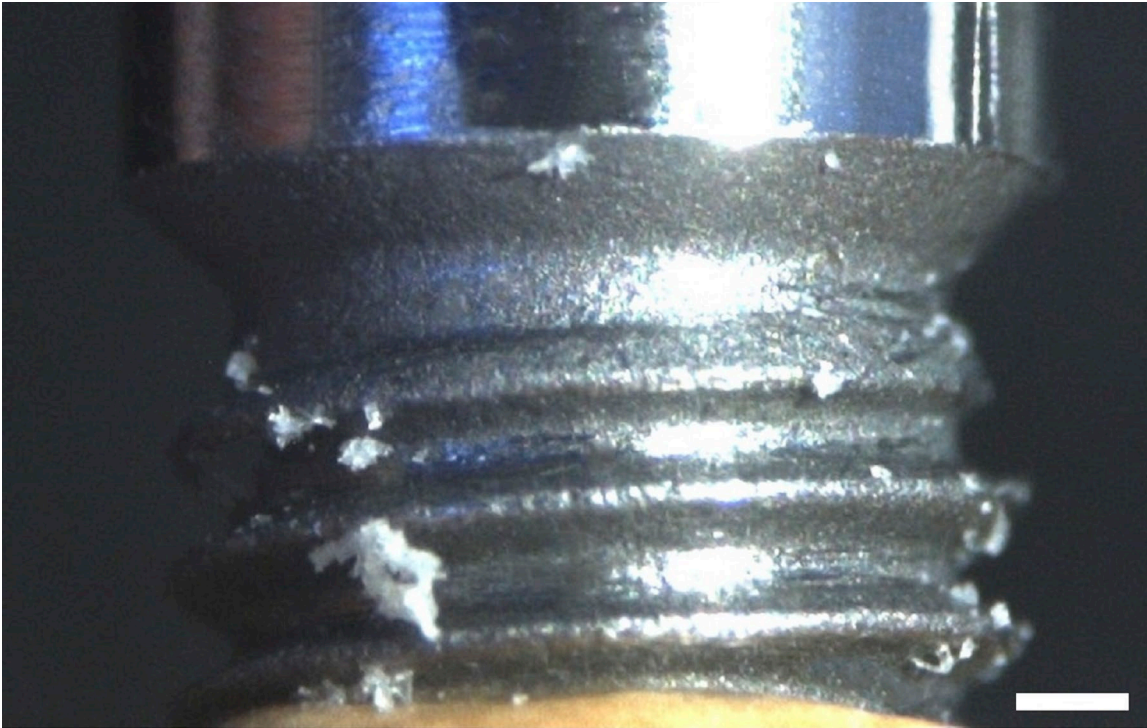
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284 Fig. 1 Image of the three implant conditions studied that reproduce A) control group; B) misfit  
285 group; C) threads group



286

287 Fig. 2 Microscopic image (10x) showing both microfilaments and amorphous particles at the misfit  
 288 level. White bar = 400  $\mu$ m



289

290 Fig. 3 Microscopic image (10x) showing amorphous particles on the exposed threads. White bar =  
 291 400  $\mu$ m

292 TABLE:

293 Table 1. Presence/absence percentage of spongy floss material in the three groups.

Group			Material		Total
			Presence	Absence	
Control	Count	0	7	7	
	% in group	0.0%	100.0%	100.0%	
Misfit	Count	6	1	7	
	% in group	85.7%	14.3%	100.0%	
Threads	Count	4	3	7	
	% in group	57.1%	42.9%	100.0%	

294