



HAL
open science

Long-term stability of surgical bone regenerative procedures of peri-implantitis lesions in a prospective case-control study over three years

Ann-Marie Roos-Jansåker, Christel Lindahl, Rutger G. Persson, Stefan Renvert

► To cite this version:

Ann-Marie Roos-Jansåker, Christel Lindahl, Rutger G. Persson, Stefan Renvert. Long-term stability of surgical bone regenerative procedures of peri-implantitis lesions in a prospective case-control study over three years. *Journal of Clinical Periodontology*, 2011, 38 (6), pp.590. 10.1111/j.1600-051X.2011.01729.x . hal-00631684

HAL Id: hal-00631684

<https://hal.science/hal-00631684>

Submitted on 13 Oct 2011

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Long-term stability of surgical bone regenerative procedures of peri-implantitis lesions in a prospective case-control study over three years

Journal:	<i>Journal of Clinical Periodontology</i>
Manuscript ID:	CPE-10-10-2899.R2
Manuscript Type:	Original Article Implant Dentistry
Date Submitted by the Author:	15-Feb-2011
Complete List of Authors:	Roos-Jansåker, Ann-Marie; Public dental health Services, Periodontology Lindahl, Christel; University of Kristianstad, Oral Sciences PERSSON, Rutger; University of Berne, Periodontology, Div Oral Micorbiology; University of Washington, Periodontics and Department of Oral Medicine Renvert, Stefan
Topic:	Implantology
Keywords:	Peri-implantitis, Surgery, Bone graft, Membrane, Defect fill
Main Methodology:	Other

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7 **Long-term stability of surgical bone regenerative procedures**
8 **of peri-implantitis lesions in a prospective case-control study over**
9 **three years**
10
11
12

13
14
15 **Ann-Marie Roos-Jansåker¹, Christel Lindahl², G. Rutger Pesson^{2,3,4}, Stefan**
16 **Renvert^{2,5,6}**
17
18

19
20 ¹Department of Periodontology, Public Dental Health Service, Kristianstad, Sweden
21

22 ²Department of Oral Sciences, Kristianstad University Kristianstad, Sweden
23

24 ³Departments of Periodontics and Oral Medicine, University of Washington, Seattle
25
26 WA. USA.
27

28
29 ⁴Department of Periodontology University of Bern, Bern, Switzerland
30

31 ⁵School of Dental Sciences, Trinity Collage, Dublin, Ireland
32

33 ⁶Blekinge Institute of Technology, Karlskrona, Sweden
34
35

36
37
38 Key words: Peri-implantitis, surgery, bone graft, membrane, defect fill, plaque index
39

40
41 Running title: Surgical treatment of peri-implantitis
42

43
44 Number of words in abstract: 199
45

46
47 Number of words in manuscript: 3264
48

49
50 Number of tables: 5
51

52
53 Number of figures: 8
54

55
56 Corresponding author:
57

58 Stefan Renvert
59 Kristianstad University, 291 88 Kristianstad, Sweden
60 Tel. +46+44-204090
E mail: stefan.renvert@hkr.se

Abstract

Objectives: To evaluate the extent of bone fill over three years following surgical treatment of peri-implantitis with bone grafting with or without a membrane.

Material & Methods: In a non-submerged wound healing mode, 15 subjects with 27 implants were treated with a bone substitute (Algipore®) alone, and 17 subjects with 29 implants were treated with the bone substitute and a resorbable membrane (Osseoquest®). Implants with radiographic bone loss ≥ 1.8 mm following the first year in function, and with bleeding and/or pus on probing were included. Following surgery subjects were given systemic antibiotics (10 days) and rinsed with chlorhexidine. After initial healing the subjects were enrolled in a strict maintenance program.

Results:

Statistical analysis failed to demonstrate changes in bone fill between one and three years both between, and within procedure groups. Mean defect fill at three years was $1.3 \pm (\text{S.D.})1.3$ mm if treated with bone substitute alone and $1.6 \pm (\text{S.D.})1.2$ mm if treated with an adjunct resorbable membrane, ($p=0.40$). Plaque index decreased from approximately 40% to 10% remaining stable during the following two years.

Conclusion: Defect fill using a bone substitute with or without a membrane technique in treatment of peri-implantitis can be maintained over three years.

Clinical Relevance

Scientific rationale: Limited information is available regarding the long term prognosis of regenerative treatment of intraosseous defects following surgical treatment of peri-implantitis lesions in humans.

Principal findings: Over a follow-up period of three years, a similar extent of radiographic evidence of bone fill following placement of a bone graft material with or without a concomitant use of a resorbable membrane in osseous defects adjacent to implants was identified. No changes were observed between year one and year three and both procedures appear to provide stable results in regards to radiographic evidence of bone fill.

Practical implications: Bone fill obtained following surgical treatment of peri-implantitis lesions can be obtained, and remain stable if subjects comply with supportive therapy visits and maintain good oral hygiene.

1
2
3
4
5
6 **Conflict of interest and sources of funding statement:**
7
8
9

10 None of the authors declare a conflict of interest. The present study was supported
11
12 by research foundations from the Public Dental Health Service, County of Skåne,
13
14 Sweden and Kristianstad University
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For Peer Review

Introduction

1
2
3
4
5
6 It is well established that peri-implantitis has an infectious etiology. A
7
8 complex biofilm around implants with peri-implantitis has been identified (Renvert et
9
10 al. 2007, 2008, Shibli et al. 2008). The infection results in a pathology that includes
11
12 soft tissue inflammation, and loss of implant surrounding alveolar bone. In the
13
14 progression of peri-implantitis, severe bone lesions with crater formed defect
15
16 characteristics can be found (Schwarz et al. 2007). Data suggest that the prevalence
17
18 of peri-implantitis is high (Roos-Jansåker et al. 2006a, Fransson et al. 2009,
19
20 Koldslund et al. 2010). Data also suggest that within the same subject with peri-
21
22 implantitis the characteristics of the bony lesions are similar and that the rate of
23
24 untreated lesions appear to increase over time (Fransson et al. 2010). There is no
25
26 evidence that the implant surface characteristics can have an influence on the
27
28 initiation of peri-implantitis (Renvert et al. 2011). Surgical treatment of peri-implantitis
29
30 lesions with an intra bony component has a favorable treatment outcome (Schwarz et
31
32 al. 2010).

33
34
35
36
37
38
39
40
41 Non-surgical therapy of peri-implantitis does not seem to be efficacious (Schwarz et
42
43 al. 2006b, Renvert et al. 2009, Persson et al. 2010). Surgical intervention and
44
45 cleaning of implants with hydrogen peroxide and adjunct systemic antibiotics have
46
47 demonstrated limited success over a five year period (Leonhardt et al. 2003).

48
49
50
51 Resective surgery and implantoplasty of cases with peri-implantitis seems to be
52
53 effective over a three year period (Romeo et al. 2005).

54
55
56
57
58 Different bone regenerative therapies have been used attempting to accomplish
59
60 healing of peri-implantitis defects in humans. A useful surgical treatment modality

1
2
3 including bone grafts covered by ePTFE membranes in animal with experimentally
4 induced peri-implantitis is effective in the management of peri-implantitis (Schou et al.
5
6 2003, Fiorellini et al. 2007). Surgical treatment of circumferential defects around
7
8 implants in humans using bone grafting and collagen membranes have been shown
9
10 to be useful (Schwarz et al. 2009, 2010). Available data also suggest that surgical
11
12 treatment of non-submerged implants with bony dehiscence can successfully be
13
14 treated with a stiff non-resorbable membrane combined with a xenograft (De Boever
15
16 & De Boever 2005).

17
18
19
20
21
22
23
24 Other studies in humans have shown that surgical treatment of implants with bone
25
26 lesions that were ≥ 4 mm, and with circumferential crater defects can effectively be
27
28 treated with a mixture of autogenous and xenogenous bone (Wiltfang et al. 2010).

29
30
31 Almost complete bone fill in subjects with peri-implantitis treated with surgical
32
33 intervention using laser debridement and application of bone grafts with collagen
34
35 membrane coverage has been demonstrated (Romanos & Nentwig 2008). These
36
37 findings are supported by other studies demonstrating that surgical treatment of peri-
38
39 implant defects with bone graft substitutes combined with resorbable membrane
40
41 methods and submerged healing or regenerative treatment with a bone substitute
42
43 alone or in combination with a resorbable membrane in a non-submerged model
44
45 results in defect fill (Roos-Jansåker et al. 2007a, b). The aim of the present study was
46
47 to evaluate three-year stability of defect fill after surgical regenerative therapy of peri-
48
49 implantitis including the use of a bone graft material with, or with a resorbable
50
51 membrane in an non-submerged mode of wound healing.
52
53
54
55
56
57
58
59
60

Material and Methods

Study design

The study design was a human prospective case-control, single blinded, longitudinal study comparing the radiographic outcome after three years.

Study population

The Institutional Review Board at the University of Lund, Sweden approved the study. All participating individuals signed an informed consent. The CONSORT guidelines for clinical trials were followed (Figure 1). Study subjects were recruited from (I) individuals examined in a survey evaluating the prevalence of peri-implantitis 9-14 years following placements of Brånemark implants (Brånemark system[®], Nobel Pharma, Göteborg, Sweden) and (II) subjects who had been referred for the treatment of peri-implantitis to the Clinic of Periodontology, Public Dental health Services and University of Kristianstad, Sweden. The present paper is a follow-up report based on the publication by Roos-Jansåker et al. 2007.

Thirty-eight consecutive consenting subjects scheduled by the surgeon for surgical treatment of peri-implantitis were enrolled. In order to be included the subject had a minimum of one osseo-integrated implant with peri-implantitis. In order to be included the subject must have an implant demonstrating a progressive bone loss of ≥ 3 threads (≥ 1.8 mm) following the first year of healing (Renvert et al. 2007). In addition, bleeding on probing with or without suppuration must be present at enrollment. This is in agreement with the consensus report of the 7th European Workshop on Periodontology (Lang & Berglundh 2011). Furthermore, efforts must first have been to treat the condition using a non-surgical protocol, and that such

1
2
3 treatments had failed. Subjects with radiographic evidence of horizontal bone loss
4
5 only and without evidence of a vertical crater-like defect were not included.
6
7
8
9

10 All subjects had surgical regenerative treatment using a bone graft substitute
11 (Algipore[®], Friadent, Malmö, Sweden). The first 19 subjects were treated with the
12 graft substitute that was covered with a resorbable membrane (Osseoquest[®], W.L.
13 Gore & Associates, Inc, Flagstaff, AZ). The next 19 subjects were treated with the
14 bone graft substitute alone.
15
16
17
18
19
20
21
22
23
24

25 *Clinical and Radiographic examination*

26
27 At baseline and year-three, the same examiner (A-M.R.J) performed the
28 radiographic examinations. At the time of assessment of the radiographs, the
29 examiner had only access to coded radiographs. Radiographs were obtained of
30 implants using individually made bite-blocks on an Eggen holder (Renvert et al.
31 1981). The bite-blocks were made of Provil[®] Novo, Putty Soft (Heraeus Kulzer,
32 GmbH I, Hanau, Germany). The X-ray films (Kodak Insight, EKC, Rochester, NY)
33 were supported by the bite-block to avoid displacement and curving of the films.
34 Attempts were made to place the film parallel to the long axis of the implant
35 examined. During the exposure the extension arm of the film holder was inserted into
36 an acrylic track mounted on the long cone of the X-ray apparatus. Threads not
37 supported by bone at the mesial and distal site of the implants were assessed.
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000

Surgical treatment

The study population and the surgical techniques have been described in detail previously (Roos-Jansåker et al. 2007a). All subjects received antibiotic coverage (amoxicillin 375 mg x 3 per day, and metronidazole 400 mg x 2 per day) during the first 10 days following surgery. Briefly, following removal of the supra-structure granulosomatous tissue was removed. The exposed implant threads were carefully debrided, treated with hydrogen peroxide (3%), and rinsed with copious amounts of a saline solution. The osseous defects were filled with a bone graft substitute (Algipore[®], Friadent, Malmö, Sweden). Before insertion of the Algipore[®] bone fill material, the bone graft material was mixed with blood from the subject. The first 19 consecutive subjects had a resorbable membrane (Osseoquest[®], W.L. Gore & Associates, INC, Flagstaff, AZ), placed over the filled defect. The following 19 consecutive subjects were treated with the bone graft substitute without a resorbable membrane. The abutments were then reconnected and the flaps were sutured with non-resorbable sutures (Gore 5-0, W.L. Gore & Associates, INC, Flagstaff, AZ) and the supra-structures were remounted. The wound healing was performed in a non-submerged mode.

During the first 5 weeks all subjects rinsed with 0.1 % chlorhexidine. During the first 3 days all subjects also received an anti-inflammatory and analgesic drug (Ibuprofen 400 mg x 3 days). Six weeks after surgery the first supportive therapy was given, and the subjects were enrolled in a maintenance program with visits every third month. At the visits, full mouth plaque scores were obtained. Plaque was disclosed using an erythrosine dye (Top Dent Lifco Dental AB, Enköping, Sweden). Re-instruction in oral hygiene procedures was performed as necessary. Teeth and implants were cleaned

1
2
3 using a rubber cup and a low-abrasive paste. During the follow-up period, none of the
4
5 subjects was prescribed antibiotics.
6
7

8 9 10 **Statistical methods**

11
12 Parametric tests (independent t-tests, equal variance not assumed), and non –
13
14 parametric tests (Mann-Whitney U test, Wilcoxon test, and Pearson χ^2 were
15
16 performed to assess differences over time and between groups. Statistical
17
18 significance was declared at $p < 0.05$. The Kolmogorov-Smirnov test was used to
19
20 define if the data presented with normal distribution or not. The SPSS PASW 18.0
21
22 statistical software (SPSS Inc. Chicago IL) for PC was used in the analysis.
23
24
25
26
27

28 29 30 **Results**

31
32 Subject characteristics at study baseline are presented (Table 1). At baseline, a total
33
34 of 38 subjects were enrolled. Two subjects died before the 1-year control, leaving 17
35
36 subjects, with 29 treated implants in the group receiving bone graft and membrane
37
38 treatment and 19 subjects with 36 treated implants in the group treated with bone
39
40 graft alone. Four subjects in the group treated with bone graft alone were lost to
41
42 follow-up during the 3-year period, leaving 15 subjects with 27 implants in this group
43
44 after three years. In the present analysis only the 32 subjects who returned to the
45
46 follow-up examination and had radiographs taken could be assessed. During the
47
48 present study period, no clinical complications as a result of the interventions were
49
50 found in any of the subjects.
51
52
53
54
55

56
57
58 One subject in each group had received Astra implants (Astra Tech system[®], Astra
59
60 Tech, Mölndal, Sweden). These implant had the same thread distance between

1
2
3 threads as for the Brånemark implants (0.6 mm) other subjects had received
4
5 machined surfaced implants (Brånemark system[®], Nobelpharma, Göteborg,
6
7 Sweden).. Subject characteristics are presented (Table 1). Analysis by Mann-
8
9 Whitney U test confirmed the lack of difference by study method.
10
11
12
13
14
15

16 The radiographic evidence of defect mean improvement with defect fill between
17
18 baseline and year three at implants treated with bone graft and membrane was a
19
20 mean gain of 1.6 mm (S.D. \pm 1.2 mm, range: -1 to +7). The corresponding
21
22 improvement with defect fill at implants treated with bone graft alone was a mean
23
24 gain of 1.3 mm (S.D. \pm 1.3, range -2 to + 6 threads) (NS). Statistical analysis failed to
25
26 demonstrate differences in the extent of defect fill (mean difference: 0.3 mm, S.E. diff:
27
28 0.3 mm, 95% CI: -1.0 to + 0.4 mm, P = 0.34). In the group treated with bone graft
29
30 material and membrane, a total of 15 implants (51.7 %) had a defect fill \geq 1.8 mm. In
31
32 the group treated with bone graft alone, a total of 12 implants (44.4 %) gained more
33
34 than 1.8 mm in defect fill.
35
36
37
38
39
40
41

42 When the data were dichotomized in regards to change in the number of exposed
43
44 threads as a gain if bone or bone fill could be identified at one or more previously
45
46 exposed threads, or if no change had occurred or if one or more additional threads
47
48 had been exposed three years after intervention statistical analysis (Pearson's χ^2)
49
50 failed to demonstrate differences in gain /loss of thread exposure by surgical
51
52 treatment modality (p = 0.89). The distribution of bone level changes in the two study
53
54 groups between baseline and year three after surgery are presented (Table 2).
55
56
57
58 Statistical analysis failed to demonstrate differences in the extent of defect fill both in
59
60 regards to number of threads filled and defect fill in mm by study group assignment.

1
2
3 The distribution of bone level changes in the two study groups between baseline and
4
5 year three after surgery are presented (Table 3).
6
7

8
9
10 Analysis by Mann-Whitney U test failed to demonstrate a difference in bone fill
11
12 between year one and year three between the two study groups ($P= 0.36$). Within
13
14 each study group related samples Wilcoxon signed rank test failed to demonstrate a
15
16 difference in bone fill between year one and year three in the group receiving bone
17
18 graft alone ($P=0.18$), or in the group treated with bone fill and membrane ($P= 0.42$).
19
20 Bone fill mean values, SD, and range of fill are presented (Table 4).
21
22
23
24
25
26

27 Non-parametric Wilcoxon test identified that plaque index continued to improve
28
29 between year one and year three after surgery ($p = 0.02$). Statistical analysis (Mann-
30
31 Whitney U test) failed to demonstrate differences in this change of plaque scores by
32
33 intervention ($p = 0.43$). The distributions of changes in the mean % plaque scores at
34
35 various time points up to year three are presented (Figure 4).
36
37
38
39
40

41 *Examples of treatment outcome at year three*

42

43
44 Background clinical information and radiographs from before treatment of peri-
45
46 implantitis and at year three are presented for one selected case defined as a non-
47
48 responding case, and from one case defined as successfully treated (Table 5). Intra-
49
50 oral radiographs taken immediately before and at three years after surgical treatment
51
52 of peri-implantitis representing a non responding treatment outcome (Figure 5A and
53
54 5B) and a successfully treated case (Figure 6A and 6B) are shown. In these cases,
55
56 the immediate postoperative wound healing was uneventful. The maintenance
57
58
59
60

1
2
3 protocol was highly effective as illustrated by the low plaque scores during the study
4
5 period.
6
7

8 9 **Discussion**

10
11 In a previous report, one-year data following surgical treatment of peri-implantitis
12
13 using a bone graft substitute demonstrated that the clinical conditions and
14
15 radiographic conditions had improved (Roos-Jansåker et al.2007a). These results
16
17 had occurred in spite of the fact that a majority of the subjects included were
18
19 smokers, and with a past history of periodontitis (Roos-Jansåker et al. 2007a). It has
20
21 previously been discussed that a smoking history and having a history of periodontitis
22
23 can negatively influence the outcome of surgical treatment and reconstruction of
24
25 defects around dental implants (Roos-Jansåker et al. 2006b, Karoussis et al. 2004,
26
27 Máximo et al. 2008). Smoking has also been considered as a risk factor during
28
29 wound healing following implant placement (Sadig & Almas 2004). The fact that
30
31 smoking may have a negative influence on regenerative procedures in the
32
33 management of periodontitis is well established (Mayfield et al. 1998, Trombelli et al.
34
35 1997, Rosén et al. 1996, Tonetti et al.1995, Kornman & Roberson 2000). It is
36
37 therefore of interest that also in smokers, the use of a bone graft material placed in
38
39 bone defects around implants can remain stable also at three years after intervention.
40
41 Our findings are consistent with results reported elsewhere using bone substitutes in
42
43 a non smoking study population (Schwarz et al.2008).
44
45
46
47
48
49
50

51
52 Subjects with a history of periodontitis and specifically in men with dental implants
53
54 appear to be at risk for peri-implantitis. A history of smoking may be of less
55
56 significance as a risk factor for peri-implantitis (Koldsland et al. in press). In spite of
57
58 the accrued risk factors in the present study population it should be emphasized that
59
60 both surgical study modalities resulted in a successful three year outcome of surgical

1
2
3 treatment reestablishing bone fill around implants with a previous history of peri-
4
5 implantitis (2006).
6
7
8
9

10 The importance of plaque control after periodontal therapy and supportive therapy
11 has been described extensively (i.e. Nyman et al. 1975, 1977, Rosling 1983, Rosling
12 et al. 2001). In the present study the post-surgical management was focused on a
13 strict oral hygiene program that continued during the study. Thus, the overall average
14 plaque score at year three was very low. This may explain the good results reported.
15
16 In a previous study using non-surgical management of peri-implantitis it was not
17 possible to reach a similar oral hygiene level which in part may explain the less
18 favorable clinical outcome (Renvert et al 2009, Persson et al. 2010). It is possible that
19 the surgical intervention in this study resulted in an improved soft tissue architecture
20 after wound healing facilitating oral hygiene measures. This may, in part, explain the
21 differences in plaque control efficacy in the present surgical intervention study
22 compared to the non-surgical intervention reported in previous papers. Nevertheless,
23 other studies employing surgical intervention in non-smokers with peri-implantitis
24 reported higher plaque scores. However, they also reported a gradual deterioration of
25 results primary obtained (Schwarz et al. 2006a). Higher plaque scores than reported
26 in the present study have also been reported in a long term retrospective study
27 (Matarasso et al. 2010). Thus, the surgical procedure and the wound healing may not
28 be effective without good plaque control during the follow up period.
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51

52 The present follow-up, three years after surgical intervention comparing a bone
53 substitute with or without the adjunct treatment with a resorbable membrane
54 demonstrated that the additional effort to obtain stability did no seem to result in
55 enhanced three year results as assessed by radiographs. Our results are consistent
56
57
58
59
60

1
2
3 with those reported from studies of experimental healing in dogs (Nociti et al. 2000),
4
5 or in a non-human primate model (Schou et al. 2003). It is possible that the use of a
6
7 bone graft with the additional placement of a membrane may be more efficient in
8
9 specific bone lesions around implants (Schwarz et al. 2010). Although somewhat
10
11 better results have been presented in a 10-year follow clinical trial using bone grafts
12
13 with the adjunct use of resorbable membranes in comparison to not using such
14
15 membranes, the clinical relevance appeared to be negligible (Nygaard-Østby et al.
16
17 2010). The study by Nygaard-Østby et al. (2010) also identified that the resolution of
18
19 deep intra-bony periodontal defects requires a structured maintenance program
20
21 emphasizing high oral hygiene standards.
22
23
24
25
26
27
28

29 In the present study, the extent of bone fill obtained at one year after surgical
30
31 treatment using either a bone graft alone or bone graft and a resorbable membrane
32
33 could be maintained up to three years after treatment. Thus, provided oral hygiene is
34
35 excellent both procedures resulted in a clinically relevant defect fill. A pre-requisite for
36
37 a successful treatment outcome might also be the anatomy of bone defect. A well
38
39 defined crater-like defect might be the most reliable factor for stable conditions.
40
41
42
43
44
45

46 The limitation of using the radiographic assessment method used in the present
47
48 study is obvious. The radiographic evaluation does not allow distinguishing between
49
50 osseointegration of the graft in direct contact to the implant, or if the bone graft
51
52 simply remains as a defect fill. However in comparison to the one year results (Roos-
53
54 Jansåker et al. 2007a) the present findings at three years demonstrated stable
55
56 results without progression of bone loss. Our results are consistent with histological
57
58 results obtained from animal studies demonstrating that hard tissue fill and osseo-
59
60

1
2
3 integration can occur in experimentally created defects around implants (Abushahba
4 et al. 2008). This would also be the result at implants previously exposed to an
5
6 infectious biofilm, and animal studies it has also been demonstrated that it is possible
7
8 to obtain re-osseointegration on previously infected implant surfaces (Alhag et al.
9
10
11
12
13 2008).

14
15
16
17 The two cases identified with the similar age and clinical conditions, albeit with
18
19 opposite gender represent examples of a successful and a non-successful treatment
20
21 outcome of circumferential advanced lesions at implants placed in the maxilla. Both
22
23 subjects had had a previous history of peri-implantitis at the same or other implants,
24
25 and both of them were former smokers. At the time of surgical intervention in the
26
27 study the clinical conditions were similar in both cases. The presences of
28
29 circumferential defects with a significant vertical component were in both cases
30
31 suitable for the assigned therapy. The study treatment was the same in both cases
32
33 using a bone graft material without membrane coverage. Both subjects complied with
34
35 the post-surgical instructions and maintained excellent oral hygiene. The differences
36
37 identified between the two cases were that the subject with a non-successful
38
39 outcome had a medical diagnosis of diabetes mellitus and clinical lack of keratinized
40
41 and attached mucosa at the buccal aspect of the implant in treatment. Furthermore,
42
43 the infection at the implant appeared to harbor pathogens that are commonly therapy
44
45 resistant. The present observations from these two cases and the observations made
46
47 should only be used to suggest further studies on the role of keratinized attached
48
49 tissues, systemic health, and local infection in relation to therapy in cases with peri-
50
51
52
53
54
55
56
57
58
59
60 implantitis.

1
2
3 In conclusion, defect fill obtained at one year after surgical treatment with a bone
4 graft and membrane or with bone graft alone remain stable between one and three
5
6 years in cases on maintenance care.
7
8
9

10 11 12 13 14 15 ***Acknowledgements***

16
17 This project was supported by research foundations from the Public Dental Health
18 Service, County of Skåne, Sweden and Kristianstad University, Sweden. We thank
19
20 Mr. Nuray Güner, (MA, Medical Statistics, MSc, Engineering Physics), for the help
21
22 with the statistics.
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

References

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abushahba, F., Renvert, S., Polyzois, I., & Claffey, N. (2008) Effect of grafting materials on osseointegration of dental implants surrounded by circumferential bone defects. An experimental study in the dog. *Clinical Oral Implants Research* **19**, 329-334.

Alhag M, Renvert S, Polyzois I, & Claffey N. (2008) Re-osseointegration on rough implant surfaces previously coated with bacterial biofilm: an experimental study in the dog. *Clinical Oral Implants Research* **19**, 182-187.

De Boever AL, De Boever JA. (2005) Guided bone regeneration around non-submerged implants in narrow alveolar ridges: a prospective long-term clinical study. *Clinical Oral Implants Research* **16**, 549-556.

Fiorellini, J.P., Kim, D.M., Nakajima, Y., & Weber, H.P.(2007) Osseointegration of titanium implants following guided bone regeneration using expanded polytetrafluoroethylene membrane and various bone fillers. *International Journal of Periodontics Restorative Dentistry* **27**, 287-294.

Fransson C, Wennström J, Tomasi C. & Berglundh T. (2009) Extent of peri-implantitis-associated bone loss. *Journal of Clinical Periodontology* **36**, 357-363.

Fransson, C., Tomasi, C., Pikner, S.S., Gröndahl, K., Wennström, J.L., Leyland, A.H & Berglundh, T. (2010) Severity and pattern of peri-implantitis-associated bone loss. *Journal of Clinical Periodontology* **37**, 442-448.

1
2
3 Karoussis, I.K, Müller, S, Salvi, G.E., Heitz-Mayfield, L.J.A., Brägger, U. & Lang, N.P.
4
5 (2004) Association between periodontal and peri-implant conditions: a 10-year
6
7 prospective study. *Clinical Oral Implants Research* **15**, 1-7.
8
9

10
11 Koldslund, O.C, Scheie, A.A & Aass, A.M. (2010) Prevalence of Peri-implantitis
12
13 related to severity of disease with different degrees of bone loss. *Journal of*
14
15 *Periodontology* **81**, 231-238.
16
17

18
19 Koldslund OC, Scheie AA, Aass AM. The association between selected risk
20
21 indicators and severity of peri-implantitis using mixed model analyses. *Journal of*
22
23 *Clinical Periodontology* 2010 Dec 15 (preprint)
24
25
26

27
28 Kornman, K. & Robertson, P. (2000) Fundamental principles affecting the outcomes
29
30 of therapy for osseous lesions. *Periodontology 2000* **22**, 22-43.
31
32
33

34
35 Lang N.P, & Berglundh T (2011), Peri-implant diseases. Consensus report 7th
36
37 European Workshop on Periodontology. *Journal of Clinical Periodontology*, (pre-
38
39 online access)
40
41
42

43
44 Leonhardt, Å., Dahlen, G. & Renvert, S. (2003) Five-year clinical, microbiological, and
45
46 radiographical outcome following treatment of peri-implantitis in man. *Journal of*
47
48 *Periodontology* **74**, 1415-1422.
49
50
51

52
53 Máximo, M.B., de Mendonça, A.C., Alves, J.F., Cortelli, S.C., Peruzzo, D.C., &
54
55 Duarte, P.M. (2008) Peri-implant diseases may be associated with increased time
56
57 loading and generalized periodontal bone loss: preliminary results. *Journal of Oral*
58
59 *Implantology* **34**, 268-273.
60

1
2
3 Matarasso, S., Rasperini, G., Iorio Siciliano, V., Salvi, G.E., Lang, N.P. & Aglietta, M.
4
5 A (2010) 10-year retrospective analysis of radiographic bone-level changes of
6
7 implants supporting single-unit crowns in periodontally compromised vs. periodontally
8
9 healthy patients. *Clinical Oral Implants Research* **21**, 898-903.
10
11

12
13 Mayfield, L., Söderholm, G., Hallström, H., Kullendorff, B., Edwardsson, S., Bratthall,
14
15 G., Brägger, U. & Attström, R. (1998) Guided tissue regeneration for treatment of
16
17 intraosseous defects using a bioabsorbable membrane. A controlled clinical study.
18
19 *Journal of Clinical Periodontology* **25**, 585-595.
20
21

22
23
24
25 Nociti, F.H. Jr., Caffesse, R.G., Sallum, E.A., Machado, M.A., Stefani, C.M., & Sallum,
26
27 A.W. (2000). Evaluation of guided bone regeneration and/or bone grafts in the
28
29 treatment of ligature-induced peri-implantitis defects: a morphometric study in dogs.
30
31 *Journal of Oral Implantology* **26**, 244-249.
32
33

34
35
36
37 Nygaard-Østby, P., Bakke, V., Nesdal, O., Susin, C., & Wikesjö, U.M. (2010)
38
39 Periodontal healing following reconstructive surgery: effect of guided tissue
40
41 regeneration using a bioresorbable barrier device when combined with autogenous
42
43 bone grafting. A randomized-controlled trial 10-year follow-up. *Journal of Clinical*
44
45 *Periodontology* **37**, 366-373.
46
47

48
49
50
51 Nyman, S., Rosling, B. & Lindhe, J. (1975) Effect of professional tooth cleaning on
52
53 healing after periodontal surgery. *Journal of Clinical Periodontology* **2**, 80-86.
54
55

56
57
58
59 Nyman, S., Lindhe, J. & Rosling, B. (1977) Periodontal surgery in plaque-infected
60
dentitions. *Journal of Clinical Periodontology* **4**, 240-249.

1
2
3 Persson, G.R., Samuelsson, E., Lindahl, C., & Renvert, S.(2010) Mechanical non-
4 surgical treatment of peri-implantitis: a single-blinded randomized longitudinal clinical
5 study. II. Microbiological results. *Journal of Clinical Periodontology* **37**, 563-573
6
7

8
9
10
11 Renvert, S., Roos-Jansåker, A.M., Lindahl, C., Renvert, H., & Persson, G.R (2007)
12 Infection at titanium implants with or without a clinical diagnosis of inflammation.
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Renvert, S., Roos-Jansåker, A-M. & Claffey, N. (2008) Non surgical treatment of peri
implant mucositis and peri-implantitis: a literature review. *Journal of Clinical
Periodontology* **35** (Suppl. 8), 305-315.

Renvert, S., Samuelsson, E., Lindahl, C. & Persson, G.R. (2009) Mechanical non-
surgical treatment of peri-implantitis: a double-blind randomized longitudinal clinical
study. I: clinical results. *Journal of Clinical Periodontology* **36**, 604-609.

Renvert S., Polyzois J., Claffey N. (2011) How do implant characteristics influence
peri-implant disease. *Journal of Clinical Periodontology* (pre-online access).

Romanos, G.E., & Nentwig, G.H.(2008) Regenerative therapy of deep peri-implant
infrabony defects after CO2 laser implant surface decontamination. *International
Journal of Periodontics Restorative Dentistry*. **28**, 245-255.

Romeo, E., Ghisolfi, M., Murgolo, N., Chiapasco, M., Lops, D., & Vogel, G. (2005)
Therapy of peri-implantitis with resective surgery. A 3-year clinical trial on rough

1
2
3 screw-shaped oral implants. Part I: clinical outcome. *Clinical Oral Implants Research*
4
5 **16**, 9-18.
6
7

8
9 Rosling, B. (1983) Periodontally treated dentitions: their maintenance and prognosis.
10
11 *International Dental Journal* **33**, 147-151.
12
13

14
15
16 Rosling, B., Serino, G., Hellström, M.K., Socransky, S.S. & Lindhe, J. (2001)
17
18 Longitudinal periodontal tissue alterations during supportive therapy. Findings from
19
20 subjects with normal and high susceptibility to periodontal disease. *Journal of Clinical*
21
22 *Periodontology* **28**, 241- 249.
23
24
25

26
27
28 Roos-Jansåker, A-M., Lindahl, C., Renvert, H. & Renvert, S. (2006a) Nine - to
29
30 fourteen- year follow-up of implant treatment. Part II. presence of peri-implant lesions.
31
32 *Journal of Clinical Periodontology* **33**, 290-295.
33
34

35
36
37 Roos-Jansåker, A-M., Lindahl, C., Renvert, H. & Renvert, S. (2006b) Nine - to
38
39 fourteen- year follow-up of implant treatment. Part III. factors associated with peri-
40
41 implant lesions. *Journal of Clinical Periodontology* **33**, 296-301.
42
43
44

45
46
47 Roos-Jansåker, A-M., Renvert, H., Lindahl, H. & Renvert, S. (2007a) Surgical
48
49 treatment of peri-implantitis using a bone substitute with or without a resorbable
50
51 membrane: a prospective cohort study. *Journal of Clinical Periodontology* **34**, 625-
52
53 632.
54
55
56
57
58
59
60

1
2
3 Roos-Jansåker, A-M., Renvert, H., Lindahl, H. & Renvert, S. (2007b) Submerged
4 healing following surgical treatment of peri-implantitis: a case series. *Journal of*
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Roos-Jansåker, A-M., Renvert, H., Lindahl, H. & Renvert, S. (2007b) Submerged healing following surgical treatment of peri-implantitis: a case series. *Journal of Clinical Periodontology* **34**, 723-727.

Rosen, P.S., Marks, M.H., & Reynolds, M.A. (1996) Influence of smoking on long-term clinical results of intrabony defects treated with regenerative therapy, *Journal of Periodontology* **67**, 1159-1163.

Sadig, W. & Almas, K. (2004) Risk factors and management of dehiscant wounds in implant dentistry. *Implant Dentistry* **13**, 140-147.

Schwarz, F., Bieling, K., Latz, T., Nuesry, E. & Becker, J. (2006a) Healing of intrabony peri-implantitis defects following application of a noncrystalline hydroxyapatite (Ostim™) or a bovine-derived xenograft (Bio-Oss™) in combination with a collagen membrane (Bio-Gide™). A case series. *Journal of Clinical Periodontology* **33**, 491-499.

Schwarz, F., Bieling, K., Nuesry, E., Sculean, A., Becker, J. (2006b) Clinical and histological healing pattern of peri-implantitis lesions following non-surgical treatment with an Er:YAG laser. *Lasers Surgery in Medicine* **38**, 663-671.

Schwarz, F., Herten, M., Sager, M., Bieling, K., Sculean, A., Becker, J (2007). Comparison of naturally occurring and ligature-induced peri-implantitis bone defects in humans and dogs. *Clinical Oral Implants Research* **18**, 161-170.

1
2
3 Schwarz, F., Sculean, A, Bieling, K., Ferrari, D., Rothamel, D. & Becker, J. (2008)
4
5 Two-year clinical results following treatment of peri-implantitis lesions using
6
7 nanocrystalline hydroxyapatite or natural bone mineral in combination with a collagen
8
9 membrane. *Journal of Clinical Periodontology* **35**, 80-87.
10
11

12
13
14
15 Schwarz, F., Sahm, N., Bieling, K. & Becker, J. (2009) Surgical regenerative
16
17 treatment of peri-implantitis lesions using a nanocrystalline hydroxyapatite or a
18
19 natural bone mineral in combination with a collagen membrane: a four-year clinical
20
21 follow-up report. *Journal of Clinical Periodontology* **36**, 807-814.
22
23

24
25
26
27 Schwarz, F., Sahm, N., Schwarz, K., & Becker, J. (2010) Impact of defect
28
29 configuration on the clinical outcome following surgical regenerative therapy of peri-
30
31 implantitis. *Journal of Clinical Periodontology* **37**, 449-455.
32
33

34
35
36 Schou, S., Holmstrup, P., Skovgaard, L.T., Stoltze, K., Hjørting-Hansen, E., &
37
38 Gundersen, HJ.(2003) Autogenous bone graft and ePTFE membrane in the
39
40 treatment of peri-implantitis. II. Stereologic and histologic observations in cynomolgus
41
42 monkeys. *Clinical Oral Implants Research* **14**, 404-411.
43
44

45
46
47 Shibli, J.A., Melo, L., Ferrari, D.S., Figueiredo, L.C., Faveri, M. & Feres, M. (2008)
48
49 Composition of supra- and subgingival biofilm of subjects with healthy and diseased
50
51 implants. *Clinical Oral Implants Reserach*.**19**, 975-982.
52
53

54
55 Tonetti, M.S., Pini-Prato, G., & Cortellini, P. (1995) Effect of cigarette smoking on
56
57 periodontal healing following GTR in infrabony defects. A preliminary retrospective
58
59 study. *Journal of Clinical Periodontology* **22**, 229-234.
60

1
2
3 Trombelli, L., Kim, C.K., Zimmerman, G.J., & Wikesjö, U.M.E. (1998) Retrospective
4
5 analysis of factors related to clinical outcome of guided tissue regeneration
6
7 procedures in intrabony defects. *Journal of Clinical Periodontology* **24**, 366-371.
8
9

10
11
12 Wiltfang, J., Zernial, O., Behrens, E., Schlegel, A., Warnke, P.H., & Becker, .S.T
13
14 (2010). Regenerative Treatment of Peri-Implantitis Bone Defects with a Combination
15
16 of Autologous Bone and a Demineralized Xenogenic Bone Graft: A Series of 36
17
18 Defects. *Clinical Implant Dentistry Related Research*.**21**, (in press).
19
20
21
22
23
24
25

26 Zitzmann, N.U., & Berglundh, T.(2008). Definition and prevalence of peri-implant
27
28 diseases. *Journal of Clinical Periodontology* **35** (8 Suppl), 286-291.
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1

Subject characteristics at study baseline (IDDM: diabetes mellitus)

	Bone graft only including 15 subjects	Bone graft and membrane including 17 subjects
Age	Mean: 65.6 S.D.: 7.4 Range: 54-76	Mean: 66.3 S.D.: 6.7 Range: 55-79
Gender	Female: 57.9 %	Female: 58.8 %
Years of education	Mean: 9.3 S.D.: 3.6 Range: 6-17	Mean: 9.1 S.D.: 2.7 Range: 6-15
Systemic conditions	Health: 64.7 % IDDM: 5.9 % Heart disease: 17.6 % Other: 11.8 %	Health: 52.6 % IDDM: 10.5 % Heart Disease: 15.8 % Other: 21.1 %
Current smokers	68.4 %	70.6 %
Never smoked	10.5 %	5.9 %
Number of smoke years	Mean: 40.5 S.D.: 12.0 Range: 0 - 57	Mean: 38.6 S.D.: 15.9 Range: 0 - 62
Tooth loss	Unknown: 43.8 % Periodontitis: 56.3 %	Unknown: 50.0 % Periodontitis: 50.0 %
Teeth	Edentulous maxilla: 94.1 % Edentulous mandible: 41.4 % Total edentulous: 52.9 %	Edentulous maxilla: 78.9 % Edentulous mandible: 26.3 % Total edentulous: 36.8 %
% bone loss at teeth if present	Mean: 69.5 % S.D.: 27.8 % Range: 33-88 %	Mean: 69.3 % S.D.: 35.5 % Range: 21- 88 %

Table 2.

Defect changes between baseline and year three after surgery (implant level).

Bone level change (mm)	Bone graft and membrane including 29 implants		Bone graft alone including 27 implants	
	Number	%	Number	%
-1.2	0	0	1	4
-0.6	2	7	2	7
0.0	3	10	4	15
0.6	2	7	3	11
1.2	4	14	5	18
1.8	6	21	4	15
2.4	5	17	2	7
3.0	5	17	4	15
3.6	0	0	2	7
4.2	2	7	0	0

Table 3.

Defect changes between year one and year three of follow-up after surgery (implant level).

Bone level change (mm)	Bone graft and membrane including 29 implants		Bone graft alone including 27 implants	
	Number	%	Number	%
-1.8	1	3	0	0
-1.2	0	0	0	0
-0.6	1	3	1	4
0.0	21	73	24	89
0.6	3	10	0	0
1.2	2	7	1	4
1.8	1	3	0	0
2.4	0	0	1	4

Table 4

Results of treatment at the implant level observed after three years compared to one year for implants treated with bone graft and membrane, or bone graft alone.

Variable	Bone graft and membrane			Bone graft alone		
	Mean	S.D.	Range	Mean	S.D.	Range
Defect fill (number of threads)	0.2	± 0.9	2.5:-3.0	0.2	± 0.8	3.5:-1.0
Defect fill (mm)	0.1	± 0.5	1.5:-1.8	0.1	± 0.5	2.1:-0.6

Table 5.

Characteristic findings for two cases illustrating either a non-responding or a responding outcome of surgical treatment of peri-implantitis, and with an observation period of three years.

Variables	Non responding case	Responding case
Gender and age	Male, 68 years	Female, 69 years
Medical /smoking	Diabetes mellitus (type II), former smoker	No systemic diseases reported former smoker
Periodontal therapy	No case history	Periodontal therapy in the past
Peri-implantitis	Previous treatment at other implants	Previous treatment for peri-implantitis at this location
Implant(location and years in function)	14, 10 years	24; 5 years
Probing pocket depth	mes: 4 mm, buc: 4mm dist:4 mm, pal:4 mm	mes: 6 mm, buc: 5mm dist:5 mm, pal:6 mm
Bone sounding	mes: 7 mm, buc: 8 mm dist: 8 mm, pal: 6 mm	mes: 10 mm, buc: 12 mm dist: 10 mm, pal: 11 mm
Surgical procedure	Open flap debridement with Algipore ® treatment without membrane technique, antibiotic coverage	Open flap debridement with Algipore ® treatment without membrane technique, antibiotic coverage
Baseline thread exposure (xray)	mes: 6 threads and dist: 6 threads	mes: 4 threads and dist: 5 threads
Threads exposed at surgery	mes:6, buc:7 dist:7, pal:7	mes: 3, buc:6, dist:6, pal:7
Horizontal destruction at surgery	mes 3 mm, buc: 5 mm dist:2 mm, pal:5 mm	mes:0 mm, buc:5 mm, dist: 0 mm, pal: 3mm
Vertical destruction assessed at surgery (depth)	mes:2 mm, buc: 0 mm dist:3 mm, pal: 0 mm circumferential	mes: 3 mm buc:0 mm, dist: 1 mm, pal: 2 mm circumferential
Year 3 mesial thread exposure (xray)	6	0
Year 3 distal thread exposure (xray)	6	0
Buccal mucosa baseline	non keratinized, no change to year 3	keratinized 3 mm, no change to year 3
Mucosal recession baseline	Buccal: 4 mm, Pal:2 mm	
Bacterial findings at the time of surgery	Enterococci positive Antibiotic resistance consistent with Pseudomonas infection	<i>S.epidermis</i> , <i>F.nucleatum</i> , <i>S.sanguinis</i>
Bacterial findings at year 3	negative	negative
Oral hygiene	Excellent, plaque scores on average < 10%	Excellent plaque scores on average < 10 %

1
2
3
4
5
6
7
8
9
10
11 **Legends**

12 **Figure 1.**

13
14
15 CONSORT flowchart
16
17
18

19
20
21 **Figure 2**

22
23 Examples of radiographs taken from one subject at baseline, year one, and year 3
24 after follow-up.
25
26
27

28
29
30 **Figure 3**

31
32 Example of radiographs taken from another subject at baseline, year one, and year 3
33 after follow-up.
34
35
36

37
38
39 **Figure 4**

40
41 Mean plaque index from baseline to 3 years in Group 1 (bone graft substitute +
42 membrane) and Group 2 (bone graft substitute).
43
44
45
46

47
48
49 **Figure 5A**

50
51 Baseline radiograph illustrating the alveolar bone conditions at the implant (replacing
52 tooth 24) at a non-responding defect. Notice the number of implant threads not
53 supported by bone and the crater defect. Clinical details are presented in table 5.
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14 **Figure 5B**

15
16 Radiograph from year three after surgical intervention and placement of bone graft
17 material illustrating the alveolar conditions at the implant (replacing tooth 24) at a
18 non-responding defect, and similar extent of bone defect and implant threads
19 exposed as at baseline. Notice the number of implant threads not supported by bone
20 and the crater defect. Clinical details are presented in table 5.
21
22
23
24
25
26
27
28
29

30 **Figure 6 A**

31
32 Intra-oral radiograph from baseline illustrating the alveolar bone conditions at the
33 implant (replacing tooth 14). Notice the number of implant threads not supported by
34 bone and the crater defect. Clinical details are presented in table 4. The opaque area
35 visible on the radiograph is part of the stent used to standardize the positioning
36 before image exposure.
37
38
39
40
41
42
43
44
45
46
47

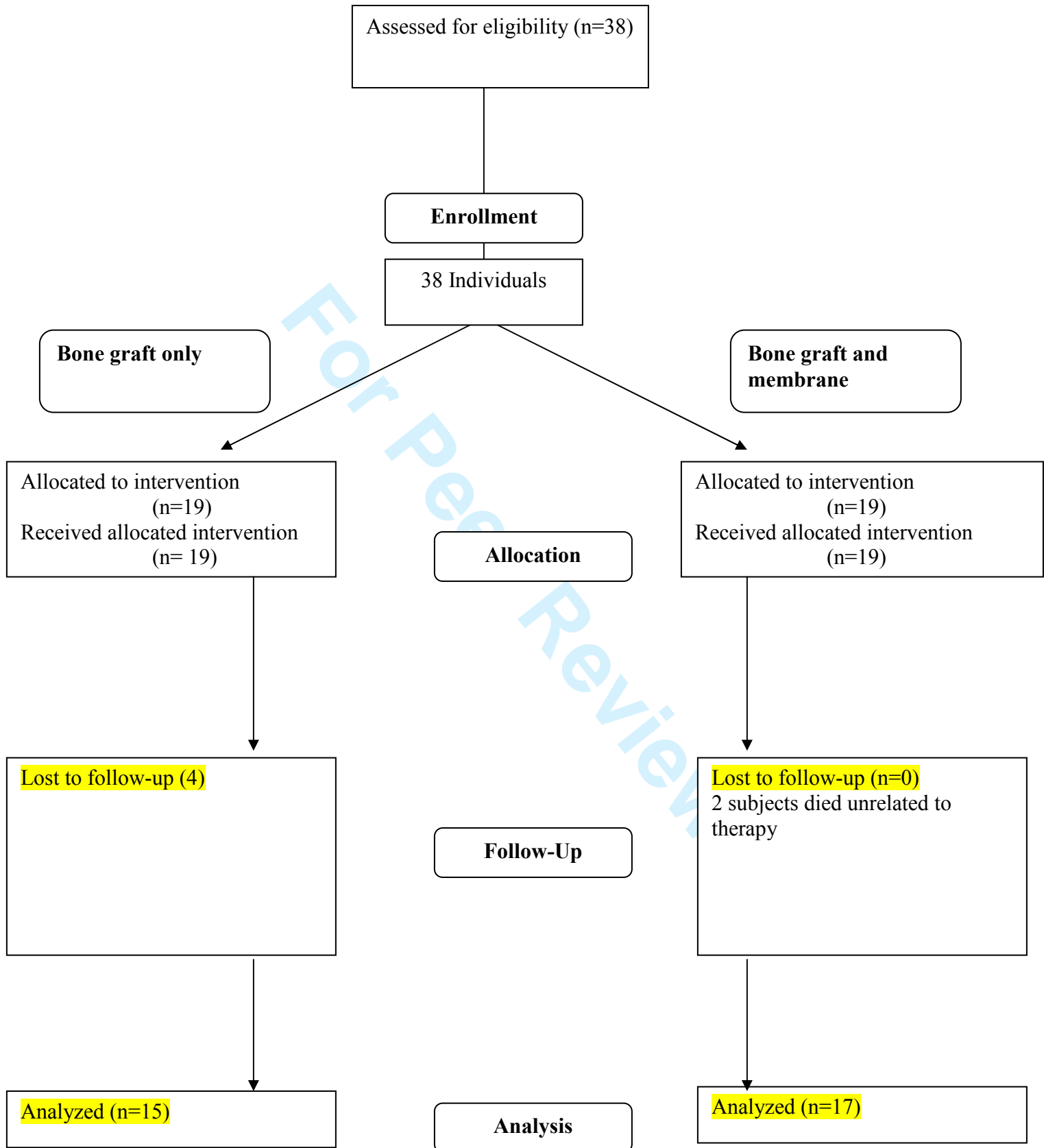
48 **Figure 6B**

49
50 Radiograph from year three after surgical intervention and placement of bone graft
51 material illustrating the alveolar conditions at the implant (replacing tooth 14), and in
52 principle complete fill of crater defect with bone fill material used. Notice that no
53 threads are exposed. Clinical details are presented in table 5. The image suggests
54
55
56
57
58
59
60

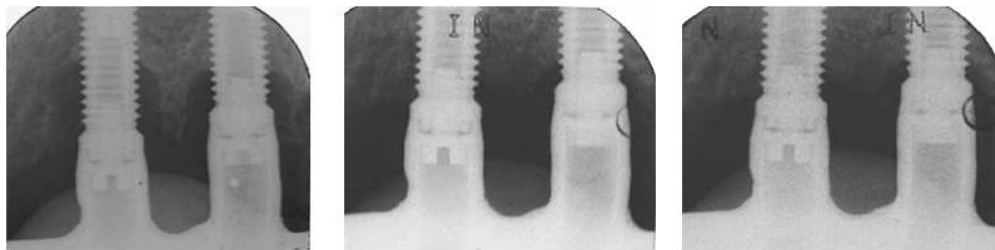
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

that the lesion has been filled with radiopaque material and this should not be interpreted as bone regeneration or “osseo-integration”.

For Peer Review

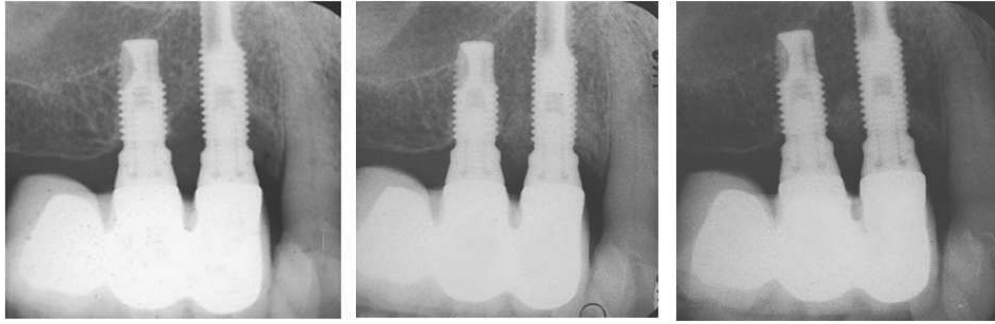


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Examples of radiographs taken from one subject at baseline, year one, and year 3 after follow-up.

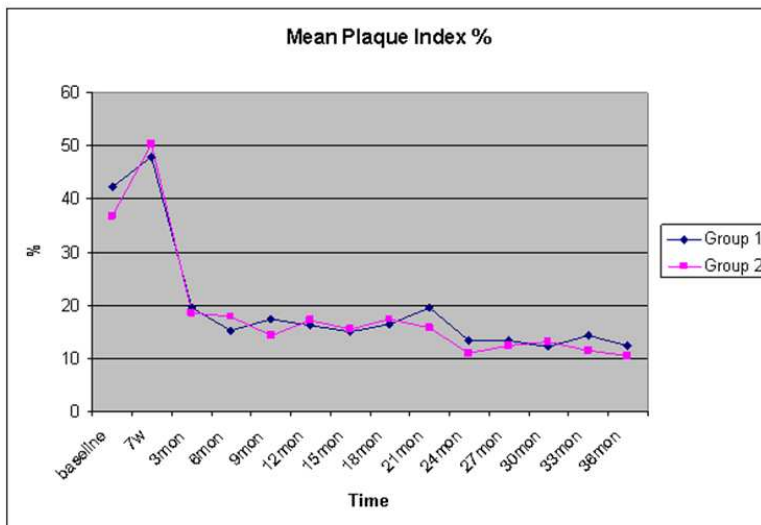
For Peer Review



Example of radiographs taken from another subject at baseline, year one, and year 3 after follow-up.

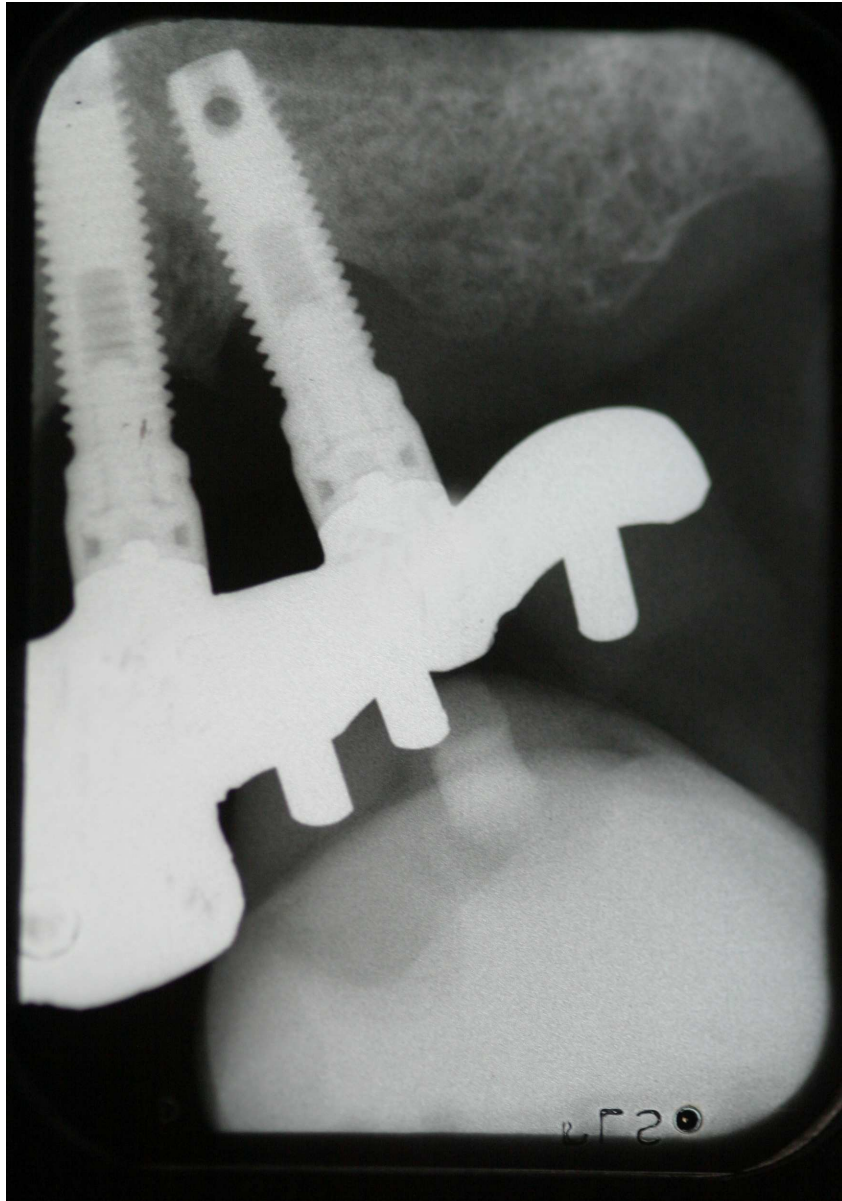
Or Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



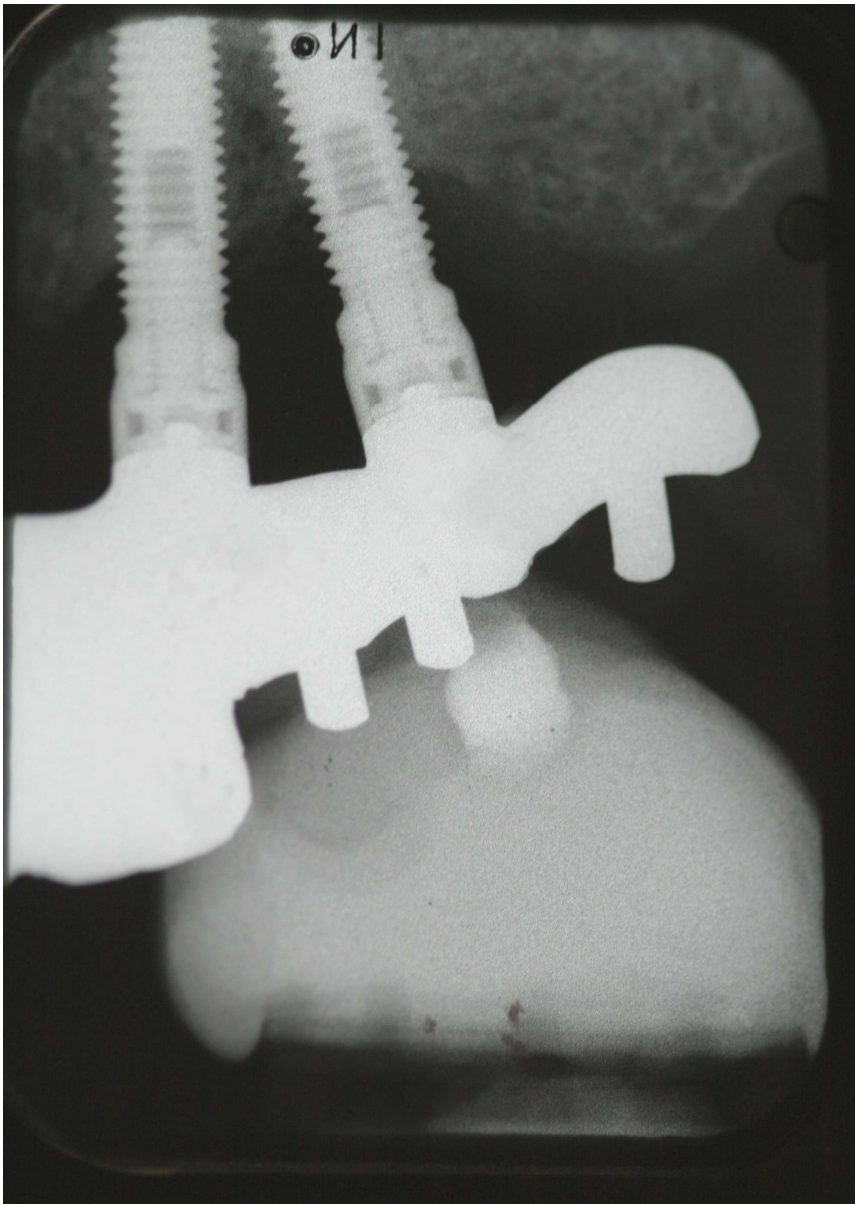
Mean plaque index from baseline to 3 years in Group 1 (bone graft substitute + membrane) and Group 2 (bone graft substitute).

Review

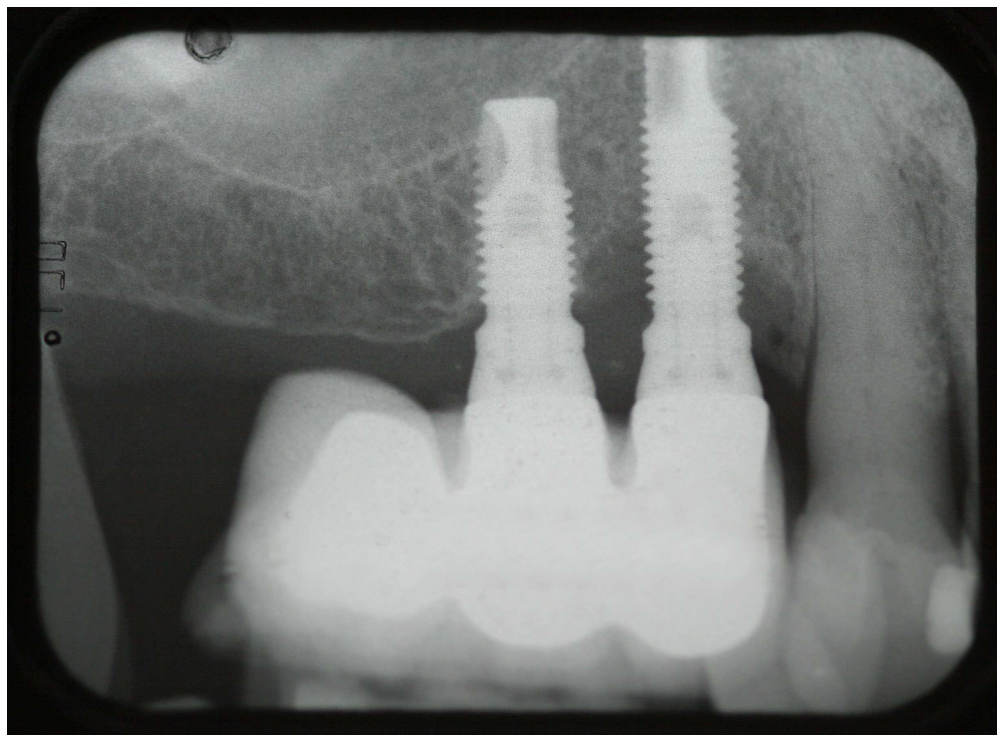


Baseline radiograph illustrating the alveolar bone conditions at the implant (replacing tooth 24) at a non-responding defect. Notice the number of implant threads not supported by bone and the crater defect. Clinical details are presented in table 5.

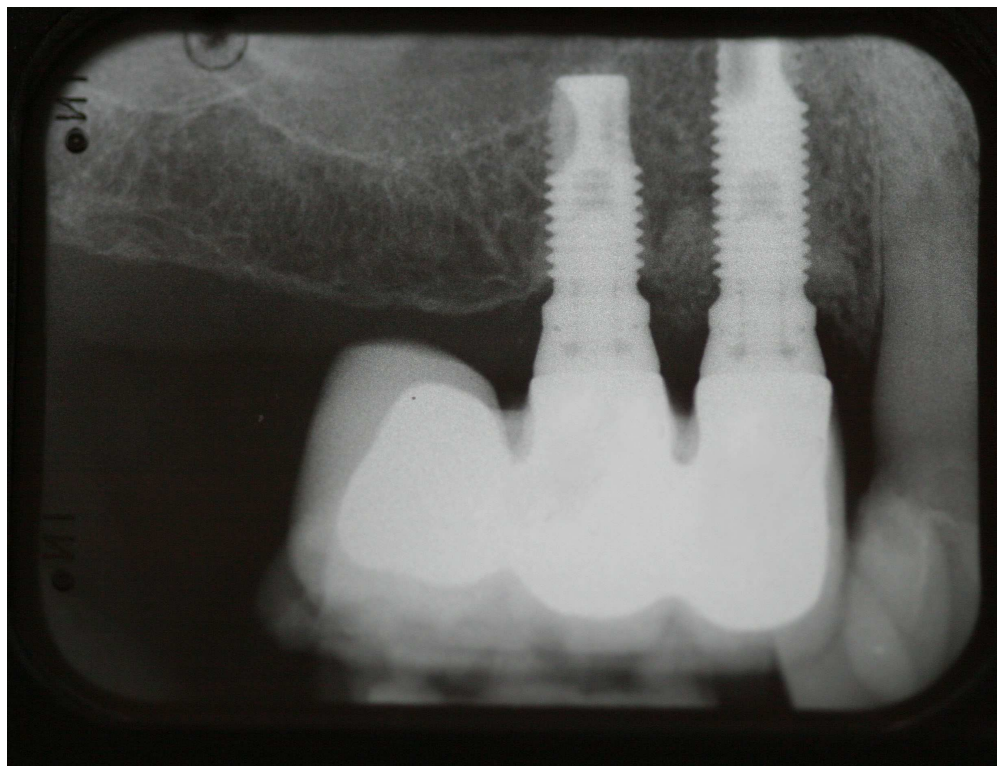
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Radiograph from year three after surgical intervention and placement of bone graft material illustrating the alveolar conditions at the implant (replacing tooth 24) at a non-responding defect, and similar extent of bone defect and implant threads exposed as at baseline. Notice the number of implant threads not supported by bone and the crater defect. Clinical details are presented in table 5.



Intra-oral radiograph from baseline illustrating the alveolar bone conditions at the implant (replacing tooth 14). Notice the number of implant threads not supported by bone and the crater defect. Clinical details are presented in table 4. The opaque area visible on the radiograph is part of the stent used to standardize the positioning before image exposure.



Radiograph from year three after surgical intervention and placement of bone graft material illustrating the alveolar conditions at the implant (replacing tooth 14), and in principle complete fill of crater defect with bone fill material used. Notice that no threads are exposed. Clinical details are presented in table 5. The image suggests that the lesion has been filled with radiopaque material and this should not be interpreted as bone regeneration or "osseo-integration".