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Therapeutic Outcomes using the Sandwich's Technique in Treating Severe Advanced Periodontitis with Secondary Occlusal Trauma: A long-term Study for 5.1-39 years

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Abstract

The purpose of the study was to investigate the treatment outcomes on the abutments with severely advanced periodontitis (SAP) and secondary occlusal trauma (SOT), using the Sandwich's technique of combined provisional prosthesis (PP), non-surgical periodontal therapy (NSPT) and crown and sleeve- coping telescopic denture (CSCTD). A total of 272 teeth were used as the abutments of 45 CSCTDs, which included PP, NSPT, and CSCTDs. Clinical records revealed that teeth that received PP, NSPT, and CSCTDs had follow-up periods ranging from 5.1to 39 years in maxillary and mandibular teeth, respectively. The periodontal parameters of the abutments included gingival index, plaque index, probing depth, and clinical attachment levels at the baseline and the end of study. Supportive periodontal treatment was made at 2- to 3-month intervals. The average cumulative survival rate of abutments was 93.0%. The distal free end abutment (DFEA) survival rate was 89.1%. Twelve DFEAs that were lost, accounting for a failure rate of 63.2% among a total 19 DFEAs for CSCTD therapy throughout the end of the study. We concluded that the use of Sandwich's technique in treating SAP with SOT appeared to be an alternative and valuable option.

Key words: Sandwich's technique, SAP, SOT, RABL

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Introduction

Data in some literature had indicated that non-surgical periodontal therapy (NSPT) might not only improve clinical and microbiological parameters, but could also resolve inflammation and arrests adult periodontitis.[1-4] Some problematic areas, such as the entrance dimension of furcation concavity and patterns of osseous defects, may adversely respond to non-surgical periodontal therapy given limited access to these sites. In addition, the results of clinical studies, [5-8] indicated that deep probing pocket depth (PD) within the molar furcation involvements (FIs) are prone to more clinical attachment loss (CAL), and an increased mortality rate when observed over years. Conflicting data were reported regarding the bone fills of angular defects following surgical and non-surgical periodontal therapy. Renvert et al. [9] illustrated that limited repair often occurred in the treatment of intra-osseous defects with flap operation, and there was virtually no bone fill after root planning. In contrast, the findings of minimal bone fills after scaling and root planning were different from the findings reported by both Rosling et al. [10] and Polson & Heijl [11] that an abundant bone repair occurred post-surgically.

It could be argued that the loss of periodontal attachment was influenced by some deteriorative factors, such as the type of plaque infection, host susceptibility, systemic conditions, smoking, the presence of ill-fitting restorations, teeth crowding, morphology of alveolar bone destruction, and secondary occlusal trauma (SOT) etc.

Lindhe & Nyman[12] and Rosling e al. [10] observed that following proper periodontal therapy did not diminish the increased tooth mobility.

Teeth that displayed severely reduced but healthy periodontium might still exhibit a progressively increased mobility, and splinting of these teeth might be necessary. However, during the recall phases or even at the pre-surgical period, it becomes obvious that the reduced periodontal support associated with SAP around the teeth, either for the entire dentition or in some parts of the arch, may be insufficient to withstand force resulting from torque and occlusal stress. Such teeth may be subject to large stress, become mechanically deteriorated, and ultimately result in tooth loss. The clinical data, reported by Nyman et al.[13] and Lundgren et al.[14] showed that permanent periodontal prosthesis can result in hyper-mobility of isolated abutment teeth, especially for the prosthesis with a cross-arch design. A recent case series study[15] used simple intentional replantation for periodontally compromised or hopeless teeth accompanied by extensive bone loss even beyond the root apex, and promising bone gain (without bone grafting) was observed. An 88.2% overall cumulative survival rate of those affected teeth (5.1-13 years follow-up) was noted.[15] The present study involves one of our long-term follow-up case series regarding the preservation of similarly compromised teeth using the strategies of NSPT, provisional prosthesis (PP), and crown and sleeve-coping telescopic denture (CSCTD) prosthetic procedures.

The purpose of this retrospective report was to longitudinally investigate the treatment outcomes of tooth abutments affected with SAP with SOT using the Sandwich's technique.

Representative Case 1

A 24-year-old Chinese female sought management of her periodontal disease at the Department of Periodontics, School of Dentistry, Kaohsiung Medical University in 1976. The chief complaints included gum bleeding, swelling with purulent exudation, severe gingival recession, pathological migration, and generalized tooth mobility over the maxillary anterior teeth and both maxillary and mandibular premolars and molars. Deep caries were also found on teeth # 14 and # 15. Initial probing depths of the maxillary teeth were generally 7 mm except tooth # 13, # 23, and # 27(Fig. 1). Probing depth of 5-7 mm was also found around teeth # 35, # 37, # 41- #43 and #47. Grade III tooth mobility was noted for on maxillary teeth #15, #17- # 25, whereas Grade II mobility was noted for teeth # 41, # 42, and # 47. Class II furcation molar involvement was noted on tooth # 17.

Periapical radiographs revealed moderate and severe radiographic alveolar bone loss (RABL) around both maxillary and mandibular teeth (Fig. 1) initially. A diagnosis of generalized aggressive periodontitis with Class II FI and SOT was established (Fig. 1).

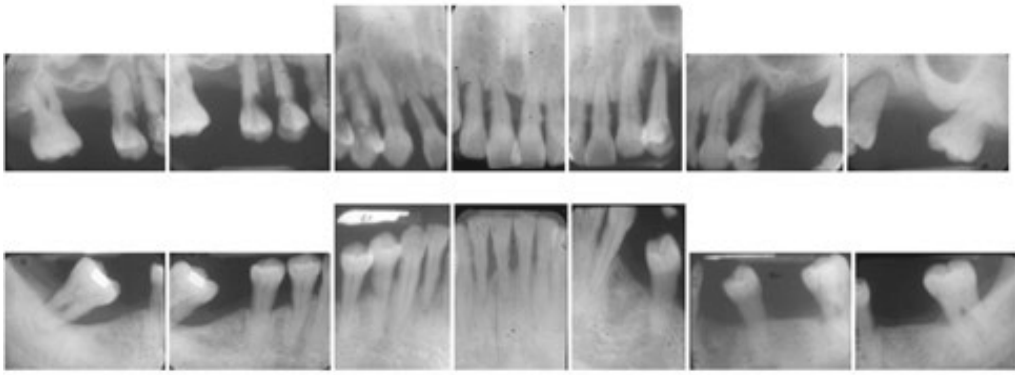

Figure 1: Full mouth periapical radiographs at baseline (1976) reveal severe and generalized alveolar bone loss, SOT, angular bony defects, and Grade II to III furcation involvement at the right posterior teeth # 14, #15, and #17. In addition, deep caries are noted for teeth #14 and #15. Radiographies also illustrated that many maxillary and mabdibular teeth are affected with moderate to severe bone loss, pathological migration and Grade II and III mobility.

The patient was instructed on plaque control and received, scaling, and root planning once every two weeks, followed by pocket irrigation with chlorhexidine gluconate (0.12%)*(Scodyl, Mederson Co., Kaohsiung City, Taiwan.) for the initial 3-6 months. Subsequent recalls for monitoring and reinforcement of plaque control were conducted throughout the end of the study. The Sandwich's technique of provisional prosthesis (PP), NSPT, and/or CSCTDs over-dentures were made to resolve her SOT and stabilized the mobile abutments after intentional extirpation of all remaining teeth for preserving the abutments with compromised conditions. These therapies were tried to hopefully achieve, bone fills of intra-bony osseous defects of the candidate tooth sites.

Supportive periodontal maintenance therapy was performed once every 2-3 months throughout the period of study. Clinical parameters including GI, PLI, PD, and CAL were generally reduced to normal ranges (< 3 mms). In addition, radiographic follow-up examinations of affected maxillary and mandibular teeth showed excellent repair at sites affected with severely advanced alveolar bone defects using the Sandwich technique. Tooth #27 was lost 39.0 years later due to further bone loss after periodontal prosthetic therapy (Fig. 2).

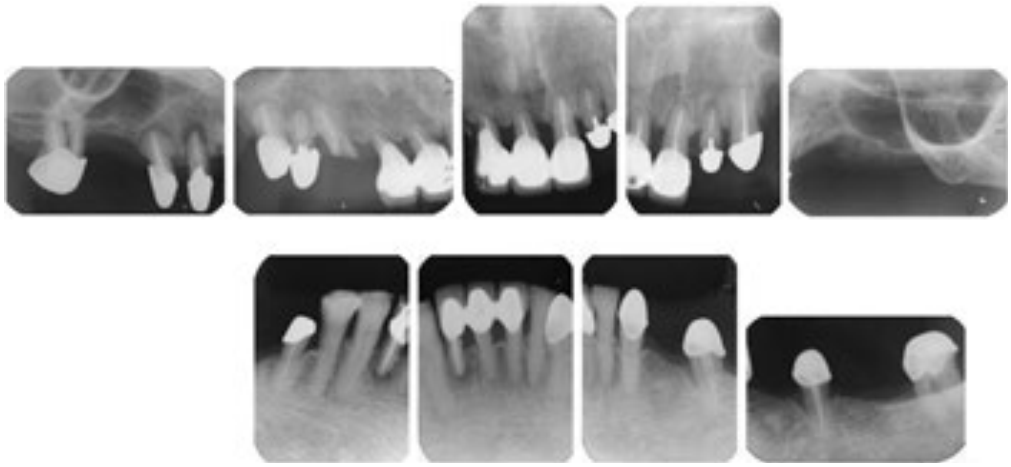

Figure 2: Periapical radiographs in representative case 1 after using the Sandwich's technique therapy 39 years later. Excellent bone fill is noted at sites of the advanced alveolar bone defects and abutments of inner crowns (2015) compared with those at the baseline (1976)

Case 2

The patient, a 45-year-old female in good health, presented with chief complaints of toothache, gum bleeding, and swelling, gingival recession with pus discharge, severe food impaction, poor aesthetics and tooth mobility at the upper right posterior and lower right anterior and posterior areas. In addition, pain and discomfort when chewing were noted for those teeth. Pathological tooth migration, uneven occlusal plane, Grade II and III tooth mobility, ill-fitting fixed prosthesis, and tooth decay were also noted. These symptoms persisted since she was 36-years-old. She visited many local dental clinic and was told that all mobile teeth should be extracted.

Clinical examination showed that heavy calculus and dental plaque deposits existed around all remaining teeth. Periapical radiographs revealed a severe and generalized radiographic alveolar bone loss (RABL), SOT, angular bony defects at #12, #14, #15, #17, # 22, #25, #27, # 41, and #42- #47 at the baseline (Fig. 3). Clinical probing and radiographs also revealed that Grade II to III furcation involvements on at teeth #-14 and #-17. A diagnosis of severe generalized chronic periodontitis accompanied by SOT, severe furcation involvement and ill-fitting fixed prosthesis was made (Figs.3, 4).

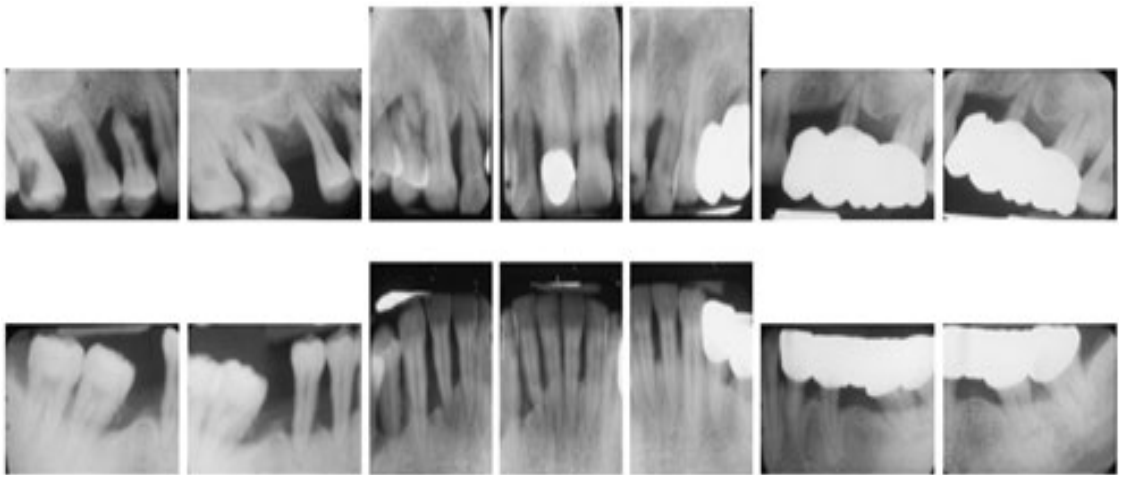

Figure 3: Periapical radiographies in representative case 2 disclosed generalized severe alveolar bone loss, SOT, angular bony defects, ill-fitting prosthesis, Grade II to III furcation involvement and deep caries for #17 and #23 at baseline (1987).

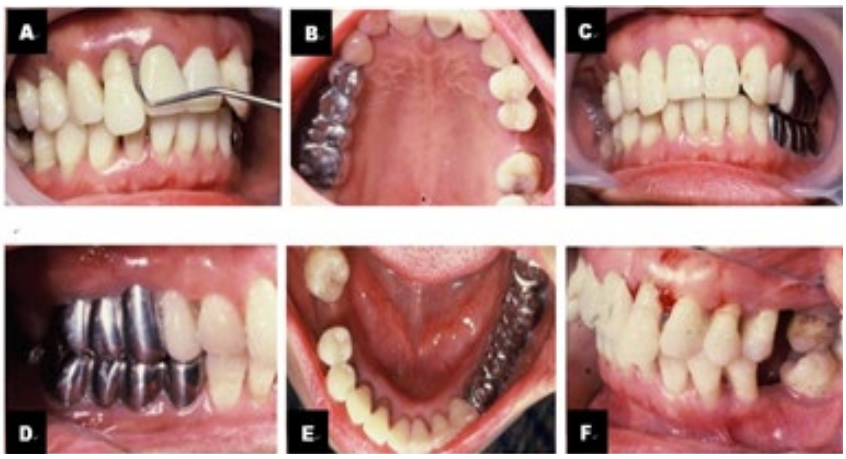

Figure 4 : Clinical images of the intraoral mouth revealed ill-fitting fixed prosthesis, deep pockets, heavy deposits of calculus and plaque, localized teeth missing and pathological migration at the baseline.

Periodontal parameters, including GI, PLI, PD, CAL, and the alveolar bone score were measured at baseline (1987, Figs. 3, 4) and every 6 months. Similarly, the Sandwich's technique of periodontal and prosthetic therapies using PP, NSPT, CSCTD and/or fixed prosthesis was applied. Good improvement in clinical conditions was noted after periodontal supportive and prosthetic treatment and at follow-up for clinical and radiographic examination 30 years later (2017; Figs.5, 6).

Basic periodontal therapy included oral hygiene education, and scaling/root planning once every 2-4 weeks for the first 6 to 12 months followed by infra-bony pocket irrigation with chlorhexidine gluconate (0.12%)*. An upper immediate removable over-denture was constructed after removal of the upper left ill-fitting prosthesis. Intentional root canal therapy was performed on teeth with severe loss of bony support (#11, #15, # 17, # 21- 25, and #27). Fixed prostheses were made for the left teeth #34- #37 and right posterior teeth #44- #47. Subsequent visits for maintenance care were established every 2-3 months throughout the study period. A Sandwich's technique of PP, NSPT, and CSCTD (Fig. 6) was performed later. Radiographic images obtained 30 years later demonstrated remarkable alveolar bone filling at teeth abutments supporting both the CSC telescopic dentures of the upper arch and fixed prosthetic restoration of the lower arch compare with baseline radiographs (Fig. 3 vs. Fig. 5 and Fig.4 vs. Fig.6).

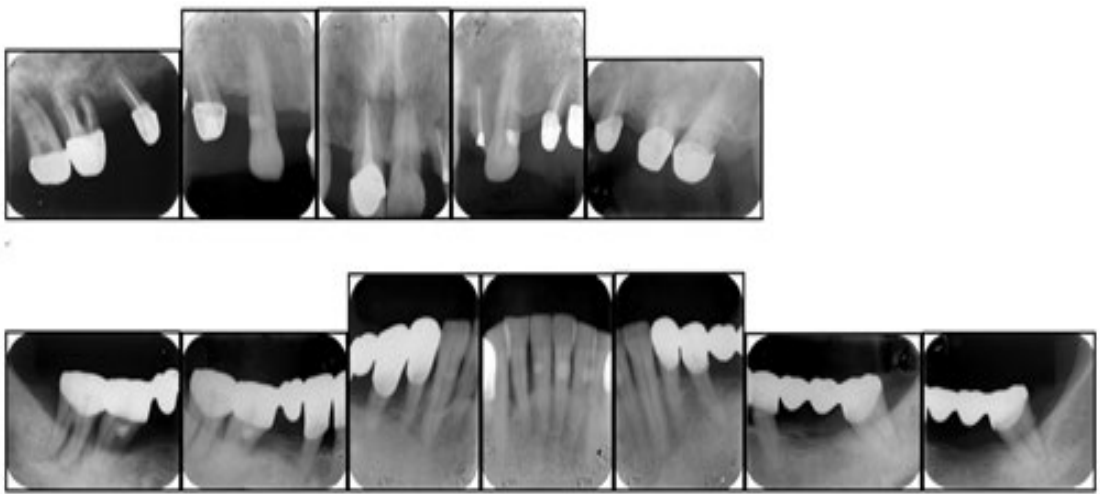

Figure 5: Radiographic periapical views of the Sandwich's technique of PP, NSPT, and CSCTD treatment results 21 years later (2008). Although more teeth affected with severe bone loss, were previously characterized by hopeless periodontal prognosis; only the mesio-buccal root of teeth #17 and # 18 showed a continue reduction in bone height. However, no symptoms or signs were observed and most teeth (#22, #23, #25, #27, #28, and #42-#45) disclosed remarkable bone fills during 21years of follow-up using professional and personal maintenance therapies every 2-3 months.

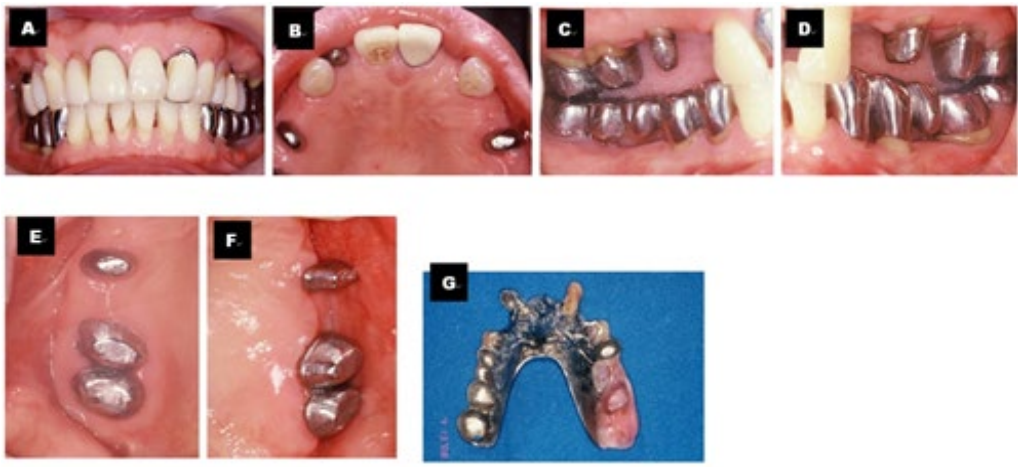

Figure 6: Clinical images illustrated excellent improvement in periodontal conditions after using the Sandwich's technique of PP, NSPT, and CSCTD treatment 21 years later (2008). (A) Frontal view of CSCTD application; (B) Palatal view of inner crowns; (C and D) Right and left buccal view of inner crowns without wear of the CSCTD; (E and F) Palatal view of inner crowns at right and left posterior abutments; (G) Occlusal view of upper CSCTD prosthesis (pure titarium framework).

Materials and Methods

The present subjects are an extension of our cases series study on the outcome of a periodontal prosthetic strategy for the treatment of individuals affected with SAP, and alveolar bone loss > 60%. These subjects were selected from the Dental Out-patient Clinic of Kaohsiung Medical University Hospital (1976 and 2017). The present study was based on a retrospective analysis of 28 patients affected with SAP and STFO. Proper informed consent was obtained from the patients. A total 272 treated teeth were used as the abutments of CSCTDs. Teeth consisted of both maxillary (139 abutments) and mandibular group (133 abutments). All patients were in good health without contraindications for dental treatment. The teeth, which were selected from cases with SAP and SOT, were treated using the Sandwich's techque of PP, NSPT, and CSCTDs. The present study focused on the survival rates of CSC telescopic abutments after periodontal therapy. The mean age of the study subjects was 54.4 ± 9.1 years old. Clinical records illustrated that all subjects received the Sandwich's technique included PP, NSPT, and, CSCTDs procedures, and follow-up periods ranged from 5.1 to 39 years with a mean of 11.8±7.6 years and 10.1±7.3 years for maxillary and mandibular teeth, respectively.

Clinical examinations conducted on the teeth included the gingival index(GI),[16] plaque index (PII),[17] probing depth, horizontal and vertical clinical attachment levels (recorded for six sites on each tooth surface) and teeth mobility at the baseline, 6 months, 1 year, and regular follow-up until the end of the study. The removable PP was fabricated for the purpose of splinting the mobile teeth and stabilizing the teeth affected with SOT. This removable PP design was used as a precursor of the permanent periodontal prosthesis for the CSC retainer, [18] or CSCTDs. [19, 20] other additional advantages of CSCTDs included easy cleaning of abutments by patient at home. The same clinicians performed all treatment. Supportive periodontal maintenance was scheduled at two to three months.

RABL percentages at the alveolar bone crest for each abutment were determined by measuring the medial and distal alveolar crest of the most apical defect to the root apex on standardized parallel periapical and/or vertical bite-wing radiographs at baseline, margin of TPP, and margin of the inner crown.[21]

Results

Twenty-eight subjects with 139 maxillary and 133 mandibular treated teeth were polled in this study. The age of study subjects ranged from 29 to 78 years (mean age, 54.4±9.1). Demographic data of this study were as follows: 1) the mean of the treatment periods was 11.8 ± 7.6 years (range. 5.1 to 39.0 years) and 10.1±7.3 years (range. 5.2 to 39.0 years) for maxilla and mandible arches, respectively; 2) mean of initial RABL (RABLi) ranged from 36.2±12.5% to 66.0±15.5% (18.0% to 100 %) and from 34.4±6.4 % to 64.3±3.8 % (18.0 % to 72.9 %) for maxilla and mandible arches, respectively. (Tables 1 and 2)

Case	CSCTD	RABLi (%)	Abutment(s)		Sandwich's	FU Periods
No.	Abutments Sites	Ranges	Loss (n)	Sites	Technique	(years)
1	17,15,14,13,22,23,24,27	33.3 - 100	2	24,27	PP/NSPT/CSCTD	39
2	18,17,15,14,22,25,26,27	38.3 - 90.2	2	18,15	PP/NSPT/CSCTD	21
3	x	x	x	x	x	x
4	17,16, 15,13,12,22,23,24,27,28	18.0 - 42.2	3	17,27,28	PP/NSPT/CSCTD	12
5	16,14,23,24,25	40.1 - 52.4	0	0	PP/NSPT/CSCTD	8.6
6	18,15,14,24,25,28	28.4 - 56.8	0	0	PP/NSPT/CSCTD	7.2
7	x	x	x	x	x	x
8	16,15,24,26,27,28	35.6 - 64.1	0	0	PP/NSPT/CSCTD	6.4
9	17,15,14,23,24,27	30.2 - 61.8	0	0	PP/NSPT/CSCTD	7.1
10	16,14,12, 21,25,27	30.3-73.4	1	27	PP/NSPT/CSCTD	7.0
11	17,15,14,12,11, 24,25,27	46.4-73.6	1	12	PP/NSPT/CSCTD	5.8
12	13,12,11,21,23,24,26,27	26.3-50.9	0	0	PP/NSPT/CSCTD	5.2
13	13,12,22,23,24	21.9-66.3	0	0	PP/NSPT/CSCTD	7.5
14	17,15,13, 26	43.8-76.2	0	0	PP/NSPT/CSCTD	9.3
15	13,12,11, 21,23,26	38.0-54.9	0	0	PP/NSPT/CSCTD	18.3
16	15,14, 21,22,24,26	22.4-45.5	0	0	PP/NSPT/CSCTD	10.4
17	16,13,12,11, 22.24	41.0-76.7	0	0	PP/NSPT/CSCTD	13.5
18	13,12,23,25	34.5-76.2	2	13,23	PP/NSPT/CSCTD	10.8
19	x	x	x	x	x	x
20	x	x	x	x	x	x
21	17,15,14,12,11, 21,22,27	32.1-79.6	0	0	PP/NSPT/CSCTD	12.6
22	16,14, 24	61.6-79.2	0	0	PP/NSPT/CSCTD	11.9
23	x	x	x	x	x	x
24	17,16, 26,27	70.5-90.4	0	0	PP/NSPT/CSCTD	12.0
25	17,15, 21,25,27	28.1-54.6	0	0	PP/NSPT/CSCTD	10.2
26	17, 24,26,28	49.7-78.6	0	0	PP/NSPT/CSCTD	5.1
27	18,17,15, 22,25,27,28	30.8-50.5	0	0	PP/NSPT/CSCTD	13.0
28	13,11,21,23,25,26	32.9-46.9	0	0	PP/NSPT/CSCTD	17.1
Total	**SR : 92.1% (128/139)**	**18.0 - 100**	**11**	**Lnma=5; Lma=6**		**5.1- 39.0**
no	Mean (SD)	34.4(6.4)-64.3(3.8)				11.8 (7.6)
	Median	**33.1 - 65.2**				

Table 1: Therapeutic outcomes o of maxillary abutments of the Sandwich's technique initially and during follow-up periods based on the RABLi (%). (5.1- 39 years; mean = 11.8 (7.6) years; median= 10.3 years)

Loss of non-molar abutments (Lnma), A= 5/139 (2.2%); Loss of molar abutments (Lma), P= 6/139 (5.8%); Loss of A+P = 11/139 (7.9%)
SR: survival rate % (n): 92.1% (128/139); X: teeth missing at baseline; RABLi: radiographic alveolar bone loss at baseline; PP: provisional prosthesis; NSPT: non-surgical periodontal therapy; CSCTD: crown and sleeve-coping telescopic denture (C) Red color: Loss of distal end terminal abutments (DETA) loss = 6 abutments (total DETAs=46; total abutments= 139).

Clinical data regarding the survival and loss rates of teeth that served as the abutments of prosthesis (PP, and CSCTDs), follow-up periods, location of abutments, and number of abutments , maximal and minimal RABL before and after treatment are shown in Tables 1, 2 , 3, 4 and 5. Among 139 maxillary abutments treated by the Sandwich's technique of PP, NSPT, and CSCTDs, 11 abutments (red color marks) were lost during the follow-up period yielding a survival rate of 92.1% and a loss rate of 7.9% until the end of the study (mean elapsed time of 11.8±7.6 years). Of the 139 abutments, 5 non-molar abutments were lost, for a loss rate of 3.6% for maxillary non-molar (Mn-m) abutments, and 6 molar abutments (Ma) (red color marks) were lost, for a total loss rate of 4.3% (Table 1). Out of 133 abutments of the mandibular arch treated by the combined therapy of NSPT, PP, and CSCTDs, 8 abutments (3 in non-molar tooth and 5 in molar teeth) were lost, yielding a survival rate of 94.0% and a total loss rate of 6.0%, until the end of the study (mean elapsed time of 10.1±7.3 years). Loss of 3 non-molar and 5 molar abutments resulted in loss rates of 2.3% and 3.8%, respectively. Table 3 presents the maximal and minimal RABL levels, ranges and fol-

low-up periods at baseline, and the end of the study follow-up from 5.1 - 39 years and 5.2 - 39 years for maxillary and mandibular abutments, respectively. The mean and ranges of RABL (%), during the follow-up periods, were 11.8±7.6 years for maxillary abutments and 10.1±7.3 years for mandibular abutments.

Table 4 indicated that survival rates of 92.1% and 94.0% were observed in abutments of both the maxillary and mandibular arches, respectively. For a total of 272 abutments the survival rate was 93.0% (253/272). The survival rates of the distal free end abutment (DFEA) were 87.0% in both maxillary (40/46) and in mandibular (40/46) teeth, respectively. Twelve abutments lost (6/139 in maxilla and 6/133 in mandible) were allocated at the distal free end abutment (DFEA) among a total of 19 abutments lost, which accounted for a 63.2% (12/19) loss rate for CSCTD therapy throughout the entire of study.

Table 5 presents the data of initial (RABLi) and final RABL (RABLf) level changes, before and at the end of the study, treated by the Sandwich technique of PP, NSPT and CSCTD procedures. Bone gains were found in the most upper non-molar and molar abutments with a mean differences of 8.4% (±11.0) and 13.8 % (±14.1) whereas a means bone gains of 7.8 % (±11.0) and 10.7% (±9.9) were noted for lower non-molar and molar abutments, respectively (Table 5).

Case	CSCTD	RABLi (%)	Abutment(s) Loss	Site(s)	Sandwich's	Periods
No.	Abutments Sites	Ranges		(n)	Technique	(years)
1	47,45,33,35,37	34.6 - 63.2	1	47	PP/NSPT/CSCTD	39
2	x	x	x	x	X	x
3	47,43, 34,35	37.2 - 72.8	1	35	PP/NSPT/CSCTD	6.5
4	47,45,44,43,42, 33,35,36,38	29.5 - 59.5	1	43	PP/NSPT/CSCCTD	12.6
5	44,43,42,41, 31,32,33,37	31.7 - 62.5	0	0	PP/NSPT/CSCTD	8.6
6	45,44,43,33,34,38	35.4 - 62.4	0	0	PP/NSPT/CSCTD	7.2
7	44,43, 35,36	42.8 - 61.7	1	36	PP/NSPT/CSCTD	10.0
8	48,47,45, 33,34	38.9 - 63.4	0	0	PP/NSPT/CSCTD	6.4
9	47,45, 33,35,37	33.1 - 66.3	0	0	PP/NSPT/CSCTD	7.1
10	48,45,44,34,38	39.4 - 65.3	0	0	PP/NSPT/CSCTD	7.0
11	x	x	x	x	X	x
12	43,42,41,31,32,33,36	31.6 - 60.4	0	0	PP/NSPT/CSCTD	5.2
13	43,42,33,36	39.1 - 63.7	0	0	PP/NSPT/CSCTD	7.5
14	x	x	x	x	X	x
15	46,43,42, 31,32,33,34,37	18.6 - 69.2	0	0	PP/NSPT/CSCTD	18.3
16	47,43, 34,36	37.2 - 72.9	1	36	PP/NSPT/CSCTD	6.7
17	47,45,44,43,42, 33,35,36	29.5 - 59.6	1	43	PP/NSPT/CSCTD	6.4
18	44,43,42,41, 31,32,33,38	31.7 - 62.6	0	0	PP/NSPT/CSCTD	6.0
19	45,44,43, 33,34	35.3 - 62.5	0	0	PP/NSPT/CSCTD	5.7
20	44,43, 35,37	42.8 - 61.8	1	37	PP/NSPT/CSCTD	5.4
21	48,47,45, 33,35	38.9 - 63.5	0	0	PP/NSPT/CSCTD	12.6
22	47,45, 33,35,38	33.1 -66.4	0	0	PP/NSPT/CSCTD	6.7
23	48,45,44,34	39.4 - 65.4	0	0	PP/NSPT/CSCTD	6.4
24	x	x	x	x	X	x
25	43,42,41, 31,32,33,37	31.6 - 60.5	0	0	PP/NSPT/CSCTD	9.8
26	43,42, 33,37	39.1 - 63.8	0	0	PP/NSPT/CSCTD	12.1
27	x	x	x	x	X	x
28	46,43,42,31,32,33,34,38	18.0 - 69.3	0	38	PP/NSPT/CSCTD	19.3
Total	**SR: 94.0 % (124/132)**	**18.0 - 72.9**	**8 : Lnma=3; Lma=5**			**5.2- 39**
10.1(7.3)	**Mean (SD)**	34.4(6.4)-64.3(3.8)				
	Median	**35.0 - 63.4**				**7.5**

Table 2: Therapeutic outcomes of mandibular abutments of the Sandwich's technique initially and at follow-up periods based on the RABLi (%) (5.2 - 39 years; mean (SD) = 10.1(7.3) years; median = 7.5 years).

Loss of non-molar abutment (Lnma) =3/133(2.3%); Loss of molar abutment (Lma)= 5/133 (3.8%); loss of Lnma+Lma = 8/133(6.0%)x: teeth loss at baseline; RABLi: initial radiographic alveolar bone loss ; PP: provisional prosthesis; N: non-surgical periodontal Therapy (NSPT); CSC: crown and sleeve-coping telescopic denture; SR: survival rate; Red color: Loss of distal end terminal abutments (DETA) loss = 6 abutments. (total DETAs=46; total abutments= 132).

RABL (M ±SD)(%)	Maxilla (M± SD)	Mandible (M± SD)
Maxi. RABL at baseline	66.0±15.5 (%)	64.3±3.8 (%)
Mini. RABL at baseline	36.2±12.5 (%)	34.4±6.4 (%)
RABL ranges	18.0 - 100 (%)	18.0-72.9 (%)
Mean FU periods(yrs)	11.8±7.6 (years)	10.1±7.3 (years)
FU periods ranges	5.1- 39 (years)	5.2- 39 (years)
Maxi. RABLi (%): Maximal RABLi at baseline; Mini. RABLi (%) Minimal RABLi at baseline SAP: severely advanced periodontitis; SOT: secondary occlusal trauma; SD: standard deviation FU: follow-up period (mean ±SD)(years)		

Table 3: Marginal radiographic alveolar bone loss (RABL; mean±SD) levels at baseline among 28 individuals affected with SAP and STFO with 5.1 to 39 years.

Table 4: The survival and loss rates of 272 abutment teeth and ranges of radiographic alveolar bone loss (RABL) after the Sandwich's technique treatments in 28 individuals affected with SAP and SOT (from 5.1 to 39 years).

Tooth type	Survival and loss rates of abutments		
	Maxilla n (%)	Mandible n (%)	Total (A+P) n (%)
SRs of N-Ma. SRs of Ma SR of N-MA & MA. SRs of DETAs LRs in DETAs loss	134/139 (96.4%) 133/139 (95.7%) 128/139 (92.1%) 40/46(87.0%) 6/11 (54.6%)	129/132 (97.7%) 127/132 (96.2) 124/132 (94.0%) 40/46 (87.0%) 6/ 8(75.0%)	263/272(96.7%) 260/272(95.6%) 253/272 (93.0%) 80/92 (87.0%) 12/19 (63.2%)

SAP: severely advanced periodontitis;
STFO: secondary trauma from occlusion;
Abuts. : abutments:
n : number;
SRs: survival rates;
LRs: loss rates;
DETAs: distal end terminal abutments ;
Total DETAs of maxilla = 46;
Total loss of maxillary DETAs = 6;
Total DETAs of mandible = 46;
Total loss of mandibular DETAs = 6 (SeeTables 1, and 2, " Abutment Site");

RABL	Upper Non-molar Abuts.	Upper molar Abuts.	Lower Non-molar Abuts.	Lower Molar Abuts.
RABLi Mean(SD) Range (%) N	 58.4 ±14.4 18.0 - 84.1 92	47.4±13.6 23.2 -100 47	63.9 ±13.7 18.6 - 7.9 99	50.2±10.3 30.2 - 69.2 34
RABLf Mean(SD) Range (%) N	66.8 ±15.0 29.6 - 89.2 87	64.4±15.0 38.4 - 86.6 41	68.9 ±10.0 42.2 - 82.1 96	61.0 ±13.6 32.8 - 83.6 29
Difference (%) Mean (SD)	8.4 ±12.5	13.8±14.1	7.8 ±11.0	10.7 ±9.9
Difference (mm) Mean (SD)	1.3 ±2.2	1.5 ±1.5	0.9 ±1.31	1.1 ±1.0
P-value	P<0.0001	P<0.01	P<0.001	P<0.01
Total FU (years)	5.1 - 39	5.1 - 39	5.2 - 39	5.2 - 39
Median (years)	10.3	10.3	7.5	7.5
FU period Mean(SD) (years)	11.8 (±7.6)	11.8 (±7.6)	10.1 (±7.3)	10.1 (±7.3)

Table 5: Initial and final radiographic alveolar bone loss changes, before and after the Sandwich's technique
RABLi: initial RABL; **RABLf:** final RABL; **Abuts:** abutments; **SD:** standard deviation; **FU:** follow up

Discussion

Limited longitudinal data are reported in the literatures regarding the combined use of NSPT, PP, and CSCTD prosthetic treatment (the Sandwich's technique) in severe periodontal cases with SAP and SOT. [4, 18-20, 22] Additionally, these studies were often based on limited case reports and short-term observations. The present study retrospectively and longitudinally investigated survival rates of abutment teeth affected by SAP with SOT. Conservative approaches of the Sandwich's technique using PP, NSPT, and CSCTD prosthetic strategies were applied to evaluate the long-term (5.1-39 years) effect of this therapy. Among 272 abutments with 46 CSCTDs in 28 subjects, 128 out of 139 abutments of CSCTDs in maxilla were lost, yielding a survival rate of 92.1%, whereas 8 out of 133 abutments were lost at the end of the study, yielding a survival rate of 94.0% (Table 5). The survival rate of abutments seemed to be higher in mandibular arches compared with maxillary arches. In addition, the survival rate of abutments with CSCTDs design was also higher for anterior teeth (96.4% and 97.7%) compared with posterior teeth (95.7% and 96.2%) for mandibular and maxillary arches (Table 5), respectively.

The present study also indicated the mean maximal and minimal RABLs in both the maxillary (66.0±15.5%) and mandibular (64.3±3.8%) arches, respectively. Mean ranges of RABLs were 18.0-100% and 18.0-72.9% for mandibular and maxillary arches, respectively. Clinical follow-up periods were 11.8±7.6 years and 10.1±7.3 years in abutment of maxillary and mandibular arches, respectively, in this longitudinal clinical study (Table 3). In addition, the present study also showed that both non-molar and molar abutments had bone gains from 7.8% (±11.0) to 13.8% (±14.1) using the Sandwich's technique, including PP, NSPT and CSCTD, from 5.1 to 39.0 years for these periodontal compromised teeth in maxillary and mandibular arches (Table 4). The current study demonstrated remarkable healing of bony defects and the reappearance of the lamina dura using the Sandwich's technique after follow-up of 5.1 to 39.0 years for these periodontally compromised teeth.

Limited or no clinical reports presented the abutment survival rate of DETAs using periodontal (NSPT) and prosthetic (CSCTD) therapies. An interesting finding is that 12 DETA abutments were lost (63.2%) among the total abutment loss (19 abutments) of CSCTD prosthesis, revealing reduced periodontal bony support and SOT during and at the end of the study. Therefore, this information appears to be the first report to longitudinally evaluate the outcome of the Sandwich's technique included PP, NSPT, and CSCTD treatments (≥10 years). These data suggested that (DETA) abutments even accompanied by severe bone loss and SOT might not act as a risk factor for terminal abutments of CSCTD prosthesis. Regarding possible reasons for DETA loss, we propose that most abutments affected often exhibit less bony support initially (bone loss>60%), SOT, and uneven and heavy loads after long-term use of the CSCTDs. Provisional crown and CSC telescopic retainers have been suggested as a valuable prosthetic approach (periodontal prosthesis) in the treatment of SAP.[18, 20] This prosthetic design provides some advantages such as stabilizing hyper-mobile abutments via CSCTD design, offering easy plaque control and reducing leveling force on the weak abutments affected by SAP and SOT. [15,18, 20]

The major discrepancy regarding molar prognosis was focused on the high prevalence of complications, such as root morphology, root fracture, recurrence of furcation lesion, poor plaque control over the internal root concavity and inconclusive treatment modalities. Other risk factors, such as the furcation anatomy, bony defect topography, and the dimension of residual periodontal supporting tissues close to the defect, are also important. [1,15,19,20] Our earlier report indicated a remarkable clinical improvement in advanced furcation invasion cases after root separation and/or resection therapy compared to those exclusively using CSCTD.[20] The results of the present study further showed, by clinical and radiographic assay, that following the Sandwich's technique included PP, NSPT, and CSCTD therapies, good periodontal healing in both anterior and posterior abutments occurred. Periapical radiographs indicated a complete fill of bony defects, and reappearance of the lamina dura around the abutment teeth compared with baseline data from the initial visit (Figs. 1 and 2). Clinical episodes that occurred before therapy disappeared within 3-6 months after therapy. These findings seem to indicate that basic periodontal treatment, proper periodontal and prosthetic reconstruction of compromised abutments and regular supportive maintenance may offer a better choice for maintaining the dentition longitudinally. This simple, conservative approach may also improve patient's masticator function, eliminate SOT on abutment teeth, and improve aesthetic appearance.

Recent promising results using regenerative therapy for periodontal compromised teeth (extensive bone loss at or beyond the root apex) have been reported, achieving 92% retention of these teeth with comfortable function for 5 years.[23] More recently, our data revealed that another strategy using intentional replantation and CSCTDs for similar periodontal compromised teeth yielded prominent bone gain without bone grafting.[15] These findings are inconsistent with those of Andereasen and Kristerson. [24] The current study demonstrated remarkable healing of bony defects and the reappearance of the lamina dura via the Sandwich's technique after follow-up of 5.1 to 39.0 years for these periodontally compromised teeth. The effect of immobilization on teeth with hyper-mobile and poor bony support using the Sandwich's technique of PP, NSPT, and CSCTD may promote periodontal repair and bone regeneration. [15] This finding was supported by the results of earlier investigators.[18, 22, 20] Therefore, the current periodontal prosthetic concept could not only achieve an effective method for preserving teeth with compromised prognosis, but also provided a conservative option (NSPT) (without flap operation, GTR, and GBR) for patients.

The decision we are confronted with clinically is whether to retain a periodontally compromised tooth or place a dental implant. Clinicians should make an evidence-based decision, rather than one based on treatment convenience.[25] Although, an implant may act as a good treatment modality for tooth extraction at any point, tooth extraction is an irreversible treatment. Minimal or no solid evidence-based documents have been reported regarding the absolute benefit and success of implant versus treatment outcomes. [26] Regarding long-term implant survival, the percentage of implant loss reported by Levin and Halperin-Sternfeld [25] varied between 0% and 33.6% during the follow-up period of 15 to 20 years. The cumulative survival rate ranged from 69.6% to 100%. Some longer follow-up studies (up to 23 years) indicated that further bone loss might occur, which would lead to a greater implant loss rate over longer follow-up periods. The effectiveness of supportive periodontal therapy in SAP cases was unequivocally documented in the literature.[6,7,27-29] The current study proposed combined periodontal and prosthetic therapies in this disease category, with a survival rate of 93.7% of teeth subjected to critical evaluation and special treatment (follow-up of 5.1 to 39.0 years). We thus concluded that the sequential use of the Sandwich's technique included PP, NSPT, and CSCTD (periodontal prosthetic remedy) appeared to be a valuable alternative for preserving the compromised teeth that served as an abutment necessary for restoring occlusal function via over-denture removal.

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