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Letter from the Editor

The recent years have seen a fast-growing demand for dental implant supported prostheses in Singapore. The Academy of Medicine Singapore and Ministry of Health have published clinical practice guidelines to provide local dental practitioners and patients with evidence-based guidance on dental implants in edentulism. Readers can find the recommendation from these guidelines in this issue of the SDJ.

The case report on the prosthetic rehabilitation of a partially edentulous patient after an ablative maxillary surgery is an interesting read. An implant supported high strength full ceramic fixed dental prosthesis and an obturator prosthesis were used.

Read the review of Brillat-Savarin's *The physiology of Taste*, published in 1825. The book is a famous gastronomical literature containing passages which described the functions of the tongue and teeth as well as the acts of mastication and deglutition. They are surprisingly accurate by modern standards.

The front cover of SDJ 2012 featured the work of Singaporean water colourist, Choo Meng Foo. Mr. Choo, who is an

artist with notable talents, works with acrylic, watercolour, ink and photography.

Time has wings. My term as Editor-in-Chief ends with this issue. I would like to thank our editors and reviewers for their time and hard work. They have helped authors clarify their thoughts and enriched our journal. I am also grateful to the authors of published articles and those that could not be accommodated due to SDJ's tight publication space. They have made SDJ possible. I would look back at the last four years with nostalgia and wish SDJ and the new Editor-in-Chief, Dr Sum Chee Peng every success.

We hope you will enjoy this issue of SDJ.

Editor-in-Chief
Tan Peng Hui

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Available online at www.sciencedirect.com**SciVerse ScienceDirect**journal homepage: www.elsevier.com/locate/sdj**Review Article****Incidental maxillary sinus findings in patients referred for head and neck CT angiography[☆]****Christopher G.T. Lim^{a,*}, Manfred Spanger^{a,b}**^aBox Hill Hospital, Eastern Health, Victoria 3128, Australia^bMonash University, Australia

ARTICLE INFO

Keywords:

Maxillary sinus

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ABSTRACT

Background: Maxillary sinus pathology is a common finding on routine CT scans of the head and neck. The purpose of this study was to assess the incidental findings in the maxillary sinus on CT scans in patients who presented for head and neck CT angiography.

Study design: Images of patients referred for head and neck CT angiography were reviewed over a 5-month period. All maxillary sinus incidental findings were recorded and categorised into mucosal thickening, polypoid mucosal thickening, partial and total opacification. The age and gender of the patients and the side of mucosal pathology was also recorded.

Results: A total of 262 CT scans were reviewed (524 maxillary sinuses). Seventy-two patients had pathological changes (27.5%), 44 (16.8%) had mucosal thickening, 20 (8.0%) had polypoid thickening, 6 (2.3%) had partial and another 7 (2.7%) had complete opacification.

Conclusions: There is a high rate of undiagnosed maxillary sinus pathology incidentally found on CT scans. Clinicians reviewing head and neck CT scans such as dentists, general medical practitioners, maxillofacial and ENT surgeons should be vigilant and aware of maxillary sinus disease when interpreting CT scans of the maxilla and patients should be followed up appropriately.

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1. Introduction

Since its introduction in the 1970s, computer tomography has become an important medical imaging tool used in the detection, prevention and screening of disease. It is a widely and readily available investigative tool in most medical centres in developed countries. Furthermore, smaller machines such as cone-beam CT scanners are becoming more popular in private facilities. Due to this, more incidental findings are found on routine imaging. CT findings in the maxilla such as mucosal thickening and polypoid lesions are common in the general population. Pathological findings in the maxilla are important to clinicians such as dentists, maxillofacial and ENT surgeons as it may impact on the patient's medical status or treatment planning in surgical procedures. Dental and maxillofacial implants are potentially placed close to the mucosal layer and often this layer is augmented or manipulated during such procedures. Maxillary pathology may impact on the patients airway function and can also be malignant. This study aims to evaluate the prevalence of incidental findings in the maxillary sinus in a group of patients who were referred for head and neck CT angiography.

2. Material and methods

The images reviewed were acquired through the hospital image database and was searched for patients who had CT angiography of the head and neck at Box Hill Hospital, Eastern Health, Victoria, Australia. These referrals were for radiological investigation for arterial and cerebrovascular disease unrelated to their maxillary sinuses. The CT scans examined the carina to the vertex and were viewed in 2 mm axial and coronal slices with all scans reviewed by the same individual with experience in reading facial CTs and an experienced radiologist. The period examined was between June 2011 and October 2011. Only head and neck angiography with contrast CTs were reviewed and cases which had incomplete viewing of the maxillary sinuses were not included.

The age and sex of patients were recorded and patients were arbitrarily grouped according to the following age brackets: 18–29, 30–49, 50–69 and 70 and above.

The incidental findings were classified as mucosal thickening, polypoid mucosal thickening and partial and total opacification. Mucosal thickening was any thickening of more

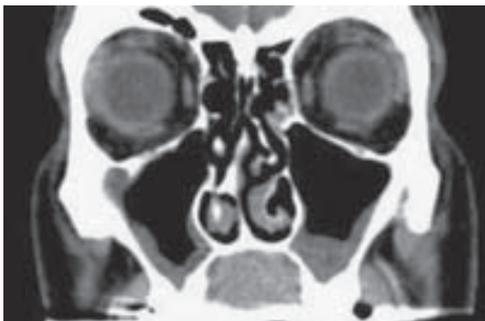


Fig. 1 – Mucosal thickening more than 1 mm thick and on more than one wall in both maxillary sinuses.

than 1 mm in at least one wall of the maxilla (Fig. 1). Polypoid lesions were defined as homogenous round opacities with distinct demarcating boundaries at the base (Fig. 2) while partial opacification was defined as at least one-third of the maxillary sinus being opacified without clear distinct boundaries (Fig. 3). Complete opacification was a completely opacified maxilla in all axial and coronal slices (Fig. 4).

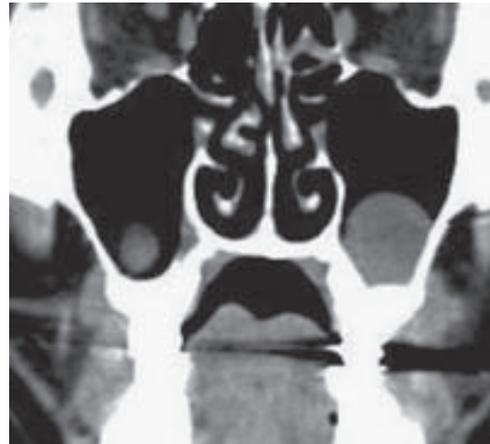


Fig. 2 – Bilateral round, polypoid and distinctly demarcated lesions in both maxillary sinuses, more evident on the left.



Fig. 3 – Partial opacification in both maxillary sinuses.

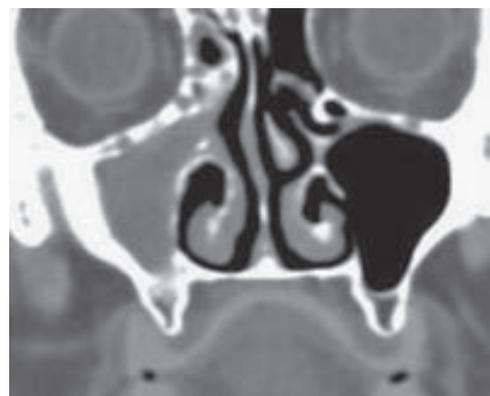


Fig. 4 – Complete opacification in the right maxillary sinus.

Any conflicting views were resolved with discussion and consensus.

3. Results

A total of 262 CTs were reviewed. The age range of patients was between 23 and 100 and the average being 67 years. The largest age group was over 70 and consisted of 121(46.2%) patients.

Maxillary sinus pathology was found in 72 patients (27.5%). Forty-four patients (16.8%) had mucosal thickening of which 19 (7.3%) had this occurring bilaterally. Nasal polyps were seen in 20 patients (7.6%). Bilateral polyps existed in 5 (1.9%) of these patients. Six patients (2.3%) had partial and 7 (2.7%) had complete opacification of the sinuses. Several patients had more than one finding (Table 2).

No correlation was found between age groups and sinus pathology. There were similar findings throughout age categories for all pathology except for the 18-29 group as this cohort had limited numbers (Table 1).

4. Discussion

Seventy-two patients (27.5%) had maxillary sinus pathology on CT which was within the range of previous reports [1-3]. The most frequent finding was unilateral or bilateral mucosal thickening which was present in 16.8% of patients. In previous studies the prevalence of this cited on CT scans has been between 24.9% and 83.2% [1-3]. Irritation of the maxillary sinus mucosa is presumed to cause this phenomenon and is most likely due to acute or chronic mucosal infections. Odontogenic factors have been implicated and reported to be the main factor in 10-12% of cases of maxillary sinusitis [4]. The slightly lower incidence in our study may be due to demographic and age factors. Furthermore, the definition used for mucosal thickening may not be consistent with

previous studies as we defined this as more than 1 mm thick on at least one sinus wall.

Polyps or were found in 20 patients (7.6%). Previous studies have defined these on CT scans as mucous retention cysts and report an incidence of 12.4-22% [5,6]. They are assumed to be an extension of mucosal thickening and are also caused by irritation of the sinus mucosa from chronic infection. Kanagalingam et al. found no statistical significance of dental disease and polypoid mucosal thickening [8]. In several reports these were not shown to be symptomatic and treatment with surgery was largely unnecessary [7,8].

Opacification was an infrequent finding consistent with previous reports [2,9]. In the current study, 5.0% of patients had either complete or partial opacification in one or both sinuses. Although inflammatory disease is assumed to be the likely diagnosis, other differentials should be ruled out such as fungal sinusitis and neoplastic disease. Chen et al. found a 5.1% incidence of malignancy, 10.4% benign tumours and a 29.3% fungal disease in his series of unilateral opacification [10]. Kaplan et al. found a high incidence of mucoceles and nasal polyposis in complete unilateral opacification in patients who underwent endoscopic sinus surgery [11]. In a series of 1118 CT scans reviewed of the maxillary sinus, Ahsan et al. [9] found 28 with complete opacification with 12 of these patients being further diagnosed with neoplastic disease. In a similar study by Rudralingam et al. [12] 6 out of 20 cases of opacified sinuses on CT were malignant. These CT findings should prompt further follow up and investigation to rule out malignancy.

5. Conclusion

The maxillary sinus should be evaluated carefully in all CT scans as incidental findings are prevalent. Clinicians such as dentists, general medical practitioners, maxillofacial and ENT surgeons should be aware of sinus pathology. They should be

Table 1

Age group	18-29	30-49	50-69	70+
Male	0	9	63	81
Female	3	16	49	50
Total	3 (1.1%)	26 (9.9%)	112 (42.7%)	121 (46.2%)

Table 2

	Total ^a	Unilateral		Bilateral	18-29	30-49	50-69	70+
		L	R					
No finding	190							
Mucosal thickening	44	11	14	19	1 (33.0%)	5 (19.2%)	18 (16.1%)	20(16.5%)
Polypoid mucosal thickening	20	9	6	5	0	4 (15.4%)	10 (8.0%)	6(5.0%)
Partial Opacification	6	1	1	4	0	0	4 (3.6%)	2(1.7%)
Total Opacification	7	2	4	1	0	0	4 (3.6%)	3(2.5%)

^a Total number of patients who could each have either unilateral or bilateral sinus pathology.

particularly aware of CT scans which show complete opacification of the maxillary sinuses which may represent malignancy. A comprehensive radiological examination will allow the clinician to make appropriate referrals if significant sinus pathology is seen.

Acknowledgements

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Available online at www.sciencedirect.com**SciVerse ScienceDirect**journal homepage: www.elsevier.com/locate/sdj**Scientific Article**

Clinical effectiveness of autologous platelet rich fibrin in the management of infrabony periodontal defects

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ARTICLE INFO**Keywords:**

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Growth factors
Osseous defects
Bone regeneration

ABSTRACT

Background: This interventional controlled clinical trial with split mouth design compares the clinical effectiveness of autologous platelet rich fibrin with open flap debridement in the management of infrabony periodontal defects.

Methods: Fifteen patients with paired contralateral infrabony defects were treated with open flap debridement and autologous platelet rich fibrin (experimental group) or open flap debridement alone (control group). The changes in probing pocket depth, clinical attachment level, and radiographic defect depth were evaluated. Patient perception regarding pain and discomfort following the procedures and early soft tissue healing responses were assessed by visual analog scales, scored 7 days after the surgical procedures. Final reevaluation was done 1 year after surgery.

Results: Baseline clinical and radiographic measurements were comparable between the groups. Reevaluation at 1 year revealed that both treatment modalities resulted in a significant decrease in probing pocket depth, gain in clinical attachment and radiographic bone fill of the defects compared to baseline. Postoperative differences observed between the two groups were 2.27 ± 0.29 mm ($P < 0.001$) for probing pocket depth, 3.33 ± 0.35 mm ($P < 0.001$) for clinical attachment level and 1.29 ± 0.32 mm ($P < 0.001$) for radiographic infrabony defect depth reduction, all in favor of the experimental group. Patient preference was greater and early healing response better for the experimental group as assessed by the visual analog scores.

Conclusion: Within the limitations of this study it can be concluded that use of platelet rich fibrin is more effective than open flap debridement alone in the management of infrabony periodontal defects.

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1. Introduction

The ultimate goal of periodontal therapy is the regeneration of lost tissues. Periodontal regeneration involves the formation of alveolar bone, cementum, and a new functional periodontal ligament [1]. For periodontal regeneration to occur, a number of biologic events; including cell migration, adherence, multiplication, and differentiation, need to occur in a well-orchestrated sequence [2].

For many years, research has attempted to use biologically active molecules to achieve periodontal regeneration. Polypeptide growth factors (PGFs) are biologic mediators that have the ability to regulate cell multiplication, migration, and differentiation. Several PGFs have been identified in human periodontal tissues [3]. Of all known PGFs, platelet-derived growth factor (PDGF) was shown to exert a favorable effect on periodontal regeneration as measured by gain in clinical attachment and radiographic defect fill in humans [3,4].

Though the use of growth factors has shown tremendous promise in periodontal regenerative approaches, the routine use of these growth factors in everyday clinical practice has not been achieved so far. One of the major challenges pertaining to the use of growth factors was the non-availability of an ideal carrier [5].

Platelet-rich plasma (PRP) was first introduced as a delivery system for growth factors in 1998 by Marx et al. [6]. Though diverse clinical reports are available with regard to advantages of adjunctive use of platelet concentrates to periodontal surgical procedures [7,8], the most recent systematic review and metaanalysis has concluded that platelet concentrates may exert a positive adjunctive effect when used for the treatment of infrabony defects [9].

A recent innovation in the field of dentistry is the development of autologous platelet rich fibrin matrix (PRFm) as a growth factor delivery system. Platelet rich fibrin is a second generation platelet concentrate developed by Choukroun et al. [10] in 2005. It is nothing but centrifuged blood without any addition and avoids any kind of biochemical handling of blood. The combined properties of fibrin, platelets, leukocytes, growth factors and cytokines makes platelet rich fibrin a healing biomaterial [11] with tremendous potential for bone and soft tissue regeneration. The available data are limited, and further investigation is required to assess the regenerative potential of platelet rich fibrin, which led us to examine the hypothesis of an enhanced regenerative outcome of PRFm in infrabony periodontal defects.

The aim of this interventional controlled clinical trial was to assess the clinical effectiveness of PRFm to bring about periodontal regeneration by comparing it with conventional open flap debridement in periodontal infrabony defects. This study also aimed to assess the patient perception and preference for these two surgical techniques considering pain and discomfort during the first week of surgery and the differences in early healing response by means of visual analog scales.

2. Materials and methods

This controlled clinical trial with a split mouth design was conducted in the department of Periodontics, Government Dental College, Kozhikode, Kerala, India from September 2009 to October 2010. The study consisted of an experimental group which was treated by placement of platelet rich fibrin following open flap debridement (OFD+PRFm) and a control group treated by open flap debridement (OFD) alone. Clinical and radiographic parameters were reevaluated after 1 year.

2.1. Sample size

The ideal sample size to assure adequate power for this clinical trial was calculated as described by Chan [12]. It was determined that 11 defects per group would be necessary to provide 80% power with α of 0.05.

Fifteen systemically healthy, non-smoking subjects were selected for the study. Prior to initiating this study, the patients were informed of the purpose and design of this clinical trial and were required to sign an informed consent. The study design and consent form were approved by the Institutional ethics committee, Government Dental College, Kozhikode in accordance with the Helsinki Declaration of 1975 as revised in 2000.

The criteria for inclusion of subjects in this study were individuals who:

1. had paired, contralateral interproximal infrabony defect with a probing pocket depth (PD) ≥ 6 mm, clinical attachment level (CAL) loss ≥ 5 mm, and an osseous defect depth estimated from radiographic evaluation (IBD) as ≥ 4 mm;
2. were systemically healthy without a history of allergies; and
3. had at least 2 mm of keratinized gingiva on the facial aspect of the selected tooth.

The following patients were excluded from the study:

1. Hematological or immunological disorders.
2. Pregnancy or lactation.
3. Smoking or the use of other tobacco products.
4. Those taking drugs known to interfere with wound healing.
5. Had used antibiotics within the previous 1 year;
6. Had been treated for periodontitis during the previous 2 years.
7. Those with unacceptable oral hygiene (plaque index $(PI > 2)$) after the reevaluation of phase I therapy.
8. Were not willing to sign an informed consent.

2.1.1. Presurgical therapy

Prior to the surgery, after careful instructions on proper oral hygiene measures full mouth scaling and root planing procedures were performed under local anesthesia. Six to eight weeks following phase I therapy, periodontal evaluation was performed to confirm the suitability of the sites for this study and baseline data was recorded. The sites were divided into experimental and control groups at the time of periodontal surgery. Either right sided or maxillary defects were operated first and whether the site belonged to experimental or control group was determined by a simple lottery method by the toss of a coin.

2.1.2. Pro forma

A detailed questionnaire was used to record demographic data, clinical and radiographic parameters.

2.1.3. Clinical parameters

A clinical examination was performed by a single examiner (NS) who was masked to the treatment group to which a patient was assigned, at baseline and 1 year after the surgical procedure. The clinical parameters assessed included probing depth (PD), recession/enlargement (REC), and clinical attachment level (CAL). Patient oral hygiene status and gingival inflammation were evaluated using plaque index (PI) [13] and Modified Gingival Index [14] (MGI) respectively.

2.1.4. Radiographic examination

Standardized reproducible radiographs using paralleling cone technique with positioning aids were taken at each experimental and control site at baseline and 1 year after surgery. All radiographs were evaluated by a single examiner (RJ) who was masked to the treatment group to which a patient was assigned and also to whether the radiograph was taken at baseline or reevaluation. All radiographs were superimposed on a standardized transparent calibration sheet and measurements were made. Radiographic infrabony defect depth (IBD) was assessed using the method described by Cardaropoli and Leonhard [15]. The vertical dimension between the projection of the bone crest on the root surface (BCP) and the most coronal level along the root surface where the periodontal ligament space was considered to have a normal width (BoBD—base of bone defect) was measured and designated as infrabony defect depth ($IBD = BCP - BoBD$). The distance from the crest of remaining alveolar bone to the cemento-enamel junction (CEJ) was also recorded (CEJ-BC) (Fig. 1).

2.1.5. Treatment procedures

All periodontal surgical procedures were performed by a single operator (AR). Standard surgical procedures for experimental and control sites were performed as follows. After local anesthesia, crevicular incisions were made and full-thickness mucoperiosteal flaps were elevated. Vertical releasing incisions were performed only if necessary for better access or to achieve more favorable closure of the surgical site. Meticulous defect debridement and root planing were carried out to remove sub gingival plaque, calculus, inflammatory granulation tissue, and pocket epithelium.

2.1.6. Preparation of platelet rich fibrin matrix (PRFm)

10 ml blood was drawn by venipuncture of the right ante-cubital vein. Blood was collected in sterile glass test tubes without any anticoagulants and immediately centrifuged on a table top centrifuge (KW-70, Almicro™ Instruments, Ambala Cantt., Haryana, India) at 3000 rpm for 10 min. This resulted in the separation of three basic fractions because of differential densities: the bottom red blood cells (RBCs), middle platelet rich fibrin (PRFm), and the top layer of platelet-poor plasma (PPP). PPP was aspirated and discarded and the PRFm was separated from underlying RBCs by the



Fig. 1 – Illustration showing radiographic measurements performed. BC—bone crest level. BCP—projection of the bone crest on the root surface, BoBD—base of bone defect, IBD—distance from BCP to BoBD.

use of sterile stainless steel scissors. The PRFm was immediately placed into the infrabony osseous defects in the experimental group. Surgical flaps were repositioned to their presurgical level and sutured with 4-0 silk sutures achieving primary closure. Periodontal packs were placed to cover the surgical areas. Control sites were treated in every way similar to experimental sites except for the preparation and placement of PRFm.

2.1.7. Postsurgical care

Postoperative care included systemic administration of amoxicillin, 500 mg, every 8 h for 5 days, paracetamol 500 mg every 8 h for 3 days and 0.2% chlorhexidine digluconate rinse three times daily for 6 weeks. Sutures were removed 1 week post-surgery.

A visual analog scale (VAS1) was used to assess the patient experience with the two treatment modalities. At 1 week after the procedure the patient was asked to assign scores for the surgical procedure with a minimum score of 0 and a maximum score of 10 taking into consideration: (1) pain during the first week after surgery and duration for which the pain lasted; (2) redness and discomfort during the first week after surgery; and (3) overall perception of the surgical procedure and patient opinion regarding the procedure. Study subjects assigned maximum scores to the surgical procedure of their preference. Thus higher scores indicated higher patient acceptance and minimum immediate post-operative discomforts.

Another visual analog scale (VAS2) was designed and used to assess the initial soft tissue healing which was done by an examiner who was unaware of the group to which the patient belonged. Scoring was done based on the early changes

healing of the surgical site. The scoring criteria were:

- 1- Mild inflammation (slight change in color/texture) of any unit of gingiva.
- 2- Mild inflammation of the entire gingival unit.
- 3- Moderate inflammation (moderate glazing, redness, edema, and/or enlargement) of the gingival unit.
- 4- Severe inflammations (redness, edema, enlargement, spontaneous bleeding or ulceration) of the gingival unit.

2.1.8. Maintenance phase

After suture removal, mechanical plaque control using the roll tooth brushing technique was resumed at the surgically treated sites. The patients were recalled once a month up to 1 year post-surgery for oral hygiene reinforcement and prophylaxis. All clinical and radiographic measurements were rerecorded at the end of 1 year.

2.2. Statistical analysis

All data were analyzed using statistical software (SPSS 17.0 for Windows, SPSS South Asia (P) Limited, Bangalore, India). Results were averaged (mean \pm SD) for probing pocket depth, clinical attachment level, gingival recession, Infrabony defect depth, and alveolar crest resorption. The net difference between each pair of measurements (pre- and postoperative) was calculated, followed by computation of the difference between treatment groups. Wilcoxon Signed Ranks Test was used to compare means between baseline and 1 year in each of the groups. Mann-Whitney test was used for intergroup comparisons at baseline and after 1 year.

For the visual analog scores, the frequency with which each score occurred was recorded for the experimental and control groups. Intra- and intergroup comparisons were made using the χ^2 test.

Table 1 – Comparison of baseline clinical and radiographic parameters (Mann-Whitney test).

Parameter	Experimental group (mean \pm SD)	Control group (mean \pm SD)	P value
PD (mm)	7.53 \pm 1.06	7.07 \pm 1.03	0.23
CAL (mm)	8.20 \pm 1.21	7.53 \pm 1.30	0.16
REC (mm)	0.67 \pm 0.98	0.33 \pm 0.62	0.27
CEJ-BC (mm)	1.50 \pm 1.16	1.21 \pm 1.05	0.50
IBD (mm)	5.07 \pm 1.08	4.57 \pm 0.65	0.15

3. Observations and results

The study group consisted of 15 patients with a mean age of 29.47 \pm 7.65 years (range 17–44 years). There were 9 female and 6 male patients in the study group. The mean plaque index scores at baseline was 1.24 \pm 0.25 and the mean modified gingival index scores were 1.27 \pm 0.34. Proper oral hygiene maintenance was ensured throughout the maintenance phase. All 15 patients completed the study. Defects in the

Table 2 – Changes in clinical and radiographic parameters from baseline to reevaluation (Wilcoxon signed ranks test).

Parameter	Experimental group			Control group		
	Baseline	Reevaluation (1 year)	P Value	Baseline	Reevaluation (1 year)	P Value
	(mean \pm SD)			(mean \pm SD)		
PD (mm)	7.53 \pm 1.06	2.87 \pm 0.99	0.001	7.07 \pm 1.03	4.67 \pm 0.82	0.000
CAL (mm)	8.20 \pm 1.21	3.47 \pm 1.45	0.001	7.53 \pm 1.30	6.13 \pm 1.46	0.002
REC (mm)	0.67 \pm 0.98	0.60 \pm 0.83	0.317	0.33 \pm 0.62	1.47 \pm 1.13	0.002
CEJ-BC (mm)	1.50 \pm 1.16	1.43 \pm 1.22	0.655	1.21 \pm 1.05	1.36 \pm 1.22	0.317
IBD (mm)	5.07 \pm 1.08	3.14 \pm 1.35	0.001	4.57 \pm 0.646	3.93 \pm 0.83	0.003

Table 3 – Comparison of Mean changes obtained for clinical and radiographic parameters between the two groups at reevaluation (Mann-Whitney test).

Parameter	Experimental (Mean ± SD)	Control (Mean ± SD)	change between groups (Mean ± SE)	P value
PD change (mm)	4.67 ± 0.90	2.40 ± 0.63	2.27 ± 0.29	0.000
CAL change (mm)	4.73 ± 0.88	1.40 ± 1.06	3.33 ± 0.35	0.000
REC change (mm)	-0.07 ± 0.26	1.13 ± 0.74	1.20 ± 0.20	0.000
CEJ-BC change (mm)	0.07 ± 0.62	0.14 ± 0.54	0.21 ± 0.21	0.541
IBD change (mm)	1.93 ± 1.07	0.64 ± 0.50	1.29 ± 0.32	0.001

Table 4 – Patient perception and acceptance between the two groups (VAS1).

Count	Group		P value
	Experimental	Control	
4	0	3	0.024
5	1	4	
6	4	6	
7	6	2	
8	4	0	
Total	15	15	

Table 5 – Assessment of early healing response (VAS2).

Count	Group		P-value
	Experimental	Control	
1	5	0	0.036
2	7	8	
3	3	7	
Total	15	15	

experimental and control groups healed uneventfully. No cases of flap dehiscence or infection were detected.

Both groups were comparable at baseline with respect to probing depth (PD), clinical attachment level (CAL), gingival recession (REC) depth of the infrabony defects (IBD) and distance from the cemento-enamel junction to bone crest (CEJ-BC) (Table 1).

Both the experimental group and the control group showed a significant gain in clinical attachment levels and probing depth reduction and reduction in infrabony defect depth at 1 year (Table 2). There was no significant gingival recession in the experimental group during the 1 year after the surgery. However there was a statistically significant gingival recession with a mean value of 1.13 ± 0.74 mm in the control group during the same time interval (Table 2).

Though both groups achieved statistically significant improvements in the clinical and radiographic parameters assessed it was found that the magnitude of improvements in these parameters were significantly higher for the experimental group (Table 3).

Experimental sites presented with greater mean clinical attachment gain with a mean difference of 3.36 ± 0.38 mm

between the groups ($P < 0.000$). The postoperative differences in probing depth between the two groups were found to be 2.29 ± 0.3 mm ($P < 0.000$) in favor of the experimental sites (Table 3). There was a statistically significant difference of 1.2 ± 0.2 mm in levels of gingival recession between the two groups indicating a lesser mean gingival recession in the experimental group (Table 3).

Experimental sites presented with a greater amount of reduction in infrabony defect depth with a mean difference in reduction of 1.29 ± 0.32 mm ($P < 0.000$) (Table 4). There was no significant crestal bone resorption (CEJ-BC) in either of the groups ($P = 0.541$) (Table 3).

For VAS1, in the experimental group the most commonly recorded scores were 7 and 8 (55%). In the control group scores 6 and 5 (67%) were most common. This difference in frequency of scores was found to be statistically significant between the groups (Table 4).

In VAS2 assessing the early healing soft tissue changes; in the experimental group the score 1 (33%) and score 2 (47%) were most common. In the control group there was no site with a score of 1. Scores 2 (53%) and 3 (47%) were most often recorded. There was a statistically significant difference in the frequency of scores between these two groups (Table 5).

4. Discussion

For the study, 30 infrabony sites in 15 patients were selected using a split-mouth design. Though recent evidences suggest both parallel and split mouth designs to be equally effective [9], the split mouth design was chosen as this permits better assessment of how the same host responds to two different treatment modalities.

The sample size was enough to ensure 80% power for the study. The sample size selected for this study was comparable to other interventional clinical trials in periodontal literature. Randomization was not attempted in this clinical trial because in split mouth design when one site was randomly assigned as either experimental or control the other site automatically selected itself to the remaining group. True randomization was hence possible for only for half the sites.

Patient blinding regarding the type of therapy was not possible in this trial because of the procedures of blood collection and preparation of platelet rich fibrin associated with the experimental sites. However the investigators

performing clinical and radiographic evaluations were masked of the treatment group as to which the study site belongs.

Platelet rich fibrin alone was used in the experimental group and not as an adjunct to other regenerative approaches like bone replacement grafts or guided tissue regeneration in the present study. There has been conflicting reports regarding the use of platelet concentrates along with bone replacement grafts. Even though some studies claim a superior clinical effectiveness for the combination [16], reports claiming no added advantages for the combination are also available [17]. The recent metaanalysis [9] states that combination of platelet concentrate with guided tissue regeneration (GTR) masks the true effectiveness of platelet concentrates.

In the present study platelet rich fibrin was used rather than the more extensively studied platelet rich plasma as it offers several advantages like ease of preparation, no biochemical handling of blood or use of any gelling agent like calcium chloride and no risks associated with the use of bovine thrombin. As it is a completely autologous material it is highly cost effective.

The success of this technique entirely depends on the speed of blood collection and immediate centrifugation [10]. In order to obtain a clinically usable platelet rich fibrin clot, in the present study a chair side centrifuge was used and it was ensured that the freshly drawn blood was immediately transferred to the centrifuge without any delay to prevent dehydration.

The results of this clinical trial indicate a positive effect for the use of platelet rich fibrin in the management of infrabony periodontal defects in terms of improvement in clinical and radiographic parameters.

At reevaluation one interesting finding in the present study was the absence of post-operative increase in gingival recession in the experimental group as compared to controls. Moreover the experimental group shows a mild decrease in preoperative recession levels (0.07 ± 0.62 mm). Even though this value is of no clinical significance; this calls for more clinical studies using platelet rich fibrin in the management of gingival recession.

The improvement in clinical parameters and better bone fill in the experimental group are suggestive of the effectiveness of platelet rich fibrin in regenerative periodontal therapy. These results may be attributed to the contents of the platelet rich fibrin clot namely fibrin, platelets, leukocytes, growth factors and cytokines.

The fibrin matrix supporting the PRFm clot constitutes the determining element responsible for the therapeutic potential of platelet rich fibrin [11]. The fibrin matrix plays important role in four highly specific aspects of healing: angiogenesis, immune control, harnessing the circulating stem cells, and wound protection by epithelial cover [11].

The angiogenesis property of fibrin matrix is explained by the 3-dimensional structure of the fibrin gel and by the simultaneous action of cytokines trapped in the meshes. During hemostasis and healing, the fibrin clot traps the circulating stem cells and allows the vascular and tissue restoration. An important phase of angiogenesis is $\alpha\beta 3$ integrin expression by endothelial cells, allowing the cells to bind to fibrin, fibronectin, and vitronectin. Regulation

of this integrin expression could be brought on by fibrin itself [18].

Among the growth factors contained in the platelet rich fibrin clot, platelet-derived growth factors (PDGF), Insulin-like growth factors (IGF) and transforming growth factor β (TGF- β) play the most important roles. PDGF- α and - β receptors are expressed in regenerating periodontal soft and hard tissues. PDGF initiates periodontal ligament cell chemotaxis, mitogenesis and matrix synthesis. Application of PDGF alone or in combination with IGF-1 results in partial repair of periodontal tissues [19].

In the present study we observed a significant bone fill in the experimental group. Direct interactions between fibrin and osseous cells during healing are insufficiently documented [11]. On the other hand, numerous animal studies deal with the fibrin effect on osseous healing. The results are contradictory; osseous healing is either improved or remains unchanged [20]. Growth factors contained in the platelet rich fibrin clot could have contributed to the radiographic bone fill observed in the present study. PDGF has been shown to have a significant regenerative impact on PDL cells and osteoblasts [21]. It has also been reported that PRFm induces a significant and continuous stimulation of proliferation in all cell types of the periodontium except epithelial cells [22]. PRFm stimulates human bone mesenchymal cell proliferation and differentiation [23].

Our results in the experimental group were compared to those studies using platelet rich plasma alone as periodontal regenerative approach [16,17]. Our results are in accordance with these studies in terms of changes in clinical attachment levels, probing depths, and radiographic bone fill. However the magnitude of change in CAL and PD at reevaluation is much higher in the present study as compared to studies using PRP alone.

It has been reported that the CAL gain after conventional or regenerative periodontal treatment was dependent on the initial PD; that is, deeper the initial PD, the greater the PD reduction and the CAL gain [24]. This is significant considering that the baseline levels of probing pocket depth and Clinical attachment levels in the present study were comparable to studies that used PRP [16,17]. Markou et al. [17] reported a mean improvement in PD of 3.92 ± 1.1 mm, CAL of 3.08 ± 0.95 mm 1 year after periodontal surgery. Tunc Ilgenli et al. [16] reported a mean improvement in PD of 2.1 ± 0.5 mm, CAL of 1.5 ± 0.7 mm and a radiographic reduction of infrabony defect depth of 0.6 ± 1.2 mm 18 months after surgery. In contrast, the present study reports a mean change in PD of 4.67 ± 0.90 mm, CAL of 4.73 ± 0.88 mm and a radiographic reduction in infrabony defect depth of 1.93 ± 1.07 mm at 1 year after surgery.

The reason for the improved results with platelet rich fibrin may be attributed to the difference in structure between PRP and PRFm [10] and their growth factor content. PRP uses a bovine thrombin and calcium chloride resulting in sudden fibrin polymerization. PRFm has the characteristic of polymerizing naturally and slowly under physiologic concentrations of autologous thrombin. This difference in polymerization results in two different biochemical architectures for the resulting product: Condensed tetra molecular or bilateral junctions in PRP and connected trimolecular or equilateral junctions in PRFm [25].

Bilateral junctions are constituted with strong thrombin concentrations and allow the thickening of fibrin polymers; this leads to the constitution of a rigid network, not very favorable to cytokine enmeshment and cellular migration. In contrast equilateral junctions allow the establishment of a fine and flexible fibrin network able to support cytokines enmeshment and cellular migration. Moreover, this 3-dimensional organization will give great elasticity to the fibrin matrix.

There are wide variations in quantity of growth factor released from platelet concentrates prepared using different preparation protocols. A study by Gassling [26] assessed Growth factor release from PRP and platelet rich fibrin (PRF) and found that after 10 days the amount of growth factors released from PRP is higher than that from PRF. However in a comparative study He et al. [27] concluded that PRF released autologous growth factors gradually and expressed stronger and more durable effect on proliferation and differentiation of rat osteoblasts than PRP in vitro.

Our study also evaluated the patient perception with respect to the two surgical procedures using a visual analog scale. Majority of patients reported a preference for regenerative surgery with PRFm. It has been proposed that PRFm is a healing biomaterial that accelerates wound closure and mucosal healing, with a significant diminution of pain and discomfort, due to fibrin bandage and growth factor release [11]. However a Hawthorne effect could have also played a part in these results as the patient could not be blinded to the procedures.

A second visual analog scale was used to assess the early wound healing. The experimental group had significantly lower scores indicating that PRFm indeed accelerates early wound healing. Degranulation of leukocytes in the PRFm could release cytokines into the fibrin clot. The major cytokines reported to be present in PRFm are proinflammatory cytokines like interleukin 1 β (IL1 β), interleukin 6 (IL 6), tumor necrosis factor α (TNF α) and anti-inflammatory cytokines interleukin 4 (IL 4). So PRFm clot could be considered as an immune organizing node and its defense capacities against infections would be quite significant [28]. This could have contributed to the better healing responses and enhanced patient comfort.

Whether the damaged tissues heal by regeneration or repair following any periodontal regenerative approach depends upon two crucial factors: the availability of cell type(s) needed; and the presence or absence of cues and signals necessary to recruit and stimulate these cells [29]. The use of platelet rich fibrin provides a convenient approach by which the presence of both these factors can be expected at the surgical sites. Thus the added advantages of fibrin and the sustained release of growth factors present in the platelet rich fibrin matrix could be responsible for the superior results observed in the experimental group of our study. Future researches focusing on clinical trials and histological evaluations are necessary to further assess the periodontal regenerative potential of platelet rich fibrin.

The limitations associated with this controlled interventional clinical trial are the inability to do true randomization and assessment of periodontal regeneration through assessment of clinical and radiographic parameters alone.

5. Conclusions

Within the limitations of this study it can be concluded:

1. Use of platelet rich fibrin significantly improved the clinical and radiographic parameters that were assessed in this study.
2. Platelet rich fibrin significantly reduced the postoperative pain and discomfort after periodontal surgery and significantly accelerated periodontal wound healing.

It remains to be seen whether the adjunctive use of other regenerative approaches along with platelet rich fibrin increases its clinical effectiveness or masks its true regenerative potential. Multicenter trials with large sample size and longer follow up time are required to further assess the regenerative potential of platelet rich fibrin.

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Maxillofacial prosthodontic management of an ablative maxillary surgical defect using a combination of conventional obturator prosthesis and an early loading implant supported high-strength full ceramic fixed dental prosthesis

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ABSTRACT

Prosthodontic rehabilitation of maxillary defects and early loading of endosseous implants has been widely published. The combination of the aforementioned treatment modalities are seldom reported in peer reviewed journals. This article describes the clinical presentation, management and prosthodontic rehabilitation of the maxillary defect of a patient. Clinical and scientific concerns are discussed.

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1. Introduction

Prosthodontic rehabilitation of maxillary defects always involves the usage of immediate surgical, interim and

definitive obturator [1]. When there are multiple missing teeth, the choices of strategic abutment teeth are limited. In addition, the increase in weight and size of the prosthesis is approximately inversely proportional to the number of

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remaining teeth [1]. In general, a more intact maxillary dentition, curvilinear abutment alignment, and the presence of teeth over the defect side are beneficial in the obturator prosthesis design, retention, function and prognosis [2].

Under most circumstances, the retention of an obturator prosthesis is derived from the tissue undercuts over the defect. In cases where there is insufficient soft tissue undercuts, it is generally considered to be an unfavorable defect and prosthesis retention will be relying mainly on the residual dentition [3,4].

Application of endosseous implants in maxillofacial cases has been long documented [3,4].

The original endosseous implant protocol required a period of a few months for osseointegration before the connection of a definitive dental prosthesis [5-7]. Recently, early loading of endosseous implants has been accepted as a viable treatment protocol to the conventional 2-stage delayed loading protocol.

New developments in implant surface treatments have resulted in the reduction of healing time and the clinical concept of immediate loading [8-13]. In selected clinical situations, immediate implant loading is a predictable protocol [14-16]. Flapless surgical implant placement has also been shown to produce predictable treatment outcomes, and postsurgical discomfort is seldom encountered [17,18].

Overdenture studies have suggested that newly placed endosseous implants should be splinted together within a short period of time to prevent implant axial rotation and micromotion [19-21].

It has been shown that longer implants [22-25], higher primary implant stability [26-28], and flapless surgical implant [17,18] placement may enhance the prognosis of early loading of endosseous implants.

The usage of high strength full ceramic base fixed prosthodontic materials has gained more popularity in recent years. However its usage in combined fixed and removable prosthodontics situation has been rarely reported [29].

This clinical report describes the prosthetic management of a patient who received a partial maxillectomy using a combination of early loading endosseous implant supported fixed prosthesis and conventional obturator prosthesis.



Fig. 1 - Intra-oral frontal view showing a recent biopsied area on the maxillary right buccal sulcus.



Fig. 2 - Intra-oral occlusal view showed a swelling on the right maxillary area. Noted that only 5 maxillary teeth in an unfavorable linear configuration could be used as potential abutments.



Fig. 3 - Panoramic radiograph clearly showing the lesion. The estimated resection would remove all the maxillary right teeth, the supporting dentoalveolus, hard palate and only 5 maxillary teeth would be left on the left maxillary area.

2. Case report

A 37-year-old gentleman was referred to the Specialist Dental Group, Mount Elizabeth Hospital, Singapore. He is a professional speaker in a religious organization. His main concern was that he has an asymptomatic swelling over the right side of his face for more than 3 years.

Panoramic radiography and cone-beam computer tomography (CT) scan examination revealed a large bony lesion over his right maxillary sinus (Fig. 1). There were multiple missing teeth on his maxilla (Fig. 2). A biopsy confirmed that the lesion was an ameloblastoma. The cone-beam CT scan confirmed the lesion was eroding all his remaining teeth in the right maxilla. Sufficient bone volume was identified for the placement of endosseous implants in the anterior maxilla. Approximately 25 mm superoinferior and 8 mm buccolingual bone volume was measured on his maxillary incisal area (Fig. 3). The patient was seen by the Otorhinolaryngologist (ENT surgeon) on the same day.



Fig. 4 – Mounted maxillary and mandibular casts with the immediate surgical obturator wax up.



Fig. 5 – One day before the ablative surgery, endosseous implants were placed in the anterior maxilla under a flapless procedure.



Fig. 6 – Post-implantation panoramic radiograph showing maximum bone height engagement. The ENT surgeon was informed of the location of the implants and its relative position with respect to the anterior resection margin.

3. Treatment sequence

A pair of maxillary and mandibular casts was made on the day of the consultation using irreversible hydrocolloid (Orthoprint,

Zhermack, Italy). The diagnostic casts were poured in Type V dental stone (Noritake Dental Stone, Kyoto, Japan).

An interocclusal record was made using an interocclusal registration material (Regisil; Dentsply International). The casts were mounted on a semi-adjustable articulator with a facebow record (Hanau Wide-vue; Teledyne Waterpik, Fort Collins, CO).

After a clinical discussion with the ENT surgeon, the surgical margins were outlined on the dental cast. It was confirmed that the anterior maxilla area will be spared from the surgical excision. An immediate surgical obturator was planned.

In the laboratory, the maxillary teeth on the right side were removed from the cast according to the surgical margin. Artificial teeth (Dentacryl SA; Dentsply International) were arranged in wax (NeoWax; Dentsply International) to replace his maxillary incisors and posterior teeth on his right maxilla in the anticipated resection area. After the denture teeth were set up, the immediate surgical obturator was processed using heat-polymerized acrylic resin (Lucitone 199; Dentsply International) (Fig. 4).

1 day before the planned surgical resection of the ameloblastoma, 3 endosseous implants (4.0 mm × 18 mm, 3i Certain, Biomet 3i) were placed in the maxillary right lateral, central and left lateral incisor areas using a flapless procedure under the guidance of a prosthodontist (Fig. 5). No surgical template was used (Fig. 6).

A definitive impression of the implants was made in polyvinyl siloxane impression material (Imprint 3 regular Body, 3M Espe AG, Germany) immediately after the implant placement. Maxillary definitive cast was made of type IV dental stone (GP Fujirock EP, GC America Inc., USA). The cast was mounted on a semi-adjustable articulator (Hanau Wide-vue; Teledyne Waterpik, Fort Collins, CO).

A 4 units splinted cement-retained fixed dental prosthesis was made of zirconia base material (Zeno Zr bridge, Wieland Dental+Technik GmbH & Co. KG, Pforzheim, Germany) to restore the missing maxillary incisors using a double scan technique [29].

Surgical resection of the ameloblastoma was performed on the second day. Under general anesthesia, the maxillary right canine was extracted prior to the surgical resection and the anterior bone cut was made through the center of the canine extraction socket. The rest of the maxillary resection was carried out as per usual technique. The immediate surgical



Fig. 7 – Frontal view of the oral cavity at one week post-operative. The patient was functionally rehabilitated immediately with a surgical obturator after the resection. Extra-oral soft tissue healing was satisfactory.



Fig. 8 - Completed implant supported fixed dental prosthesis.



Fig. 11 - Radiographic verification of the fit of the prostheses.



Fig. 9 - The immediate surgical obturator was relined and the anterior denture teeth removed to fit to the new fixed dental prosthesis.



Fig. 12 - Occlusal view of the defect at 3-month post-operative. Note the excellent soft tissue health around the implant and inside the defect.



Fig. 10 - Frontal view of the new implant supported anterior fixed dental prosthesis and the relined maxillary immediate surgical obturator.

obturator was inserted right after the completion of the surgical procedure (Fig. 7).

1 week after the surgical resection, the obturator was removed and the surgical site was debrided. Definitive custom titanium implant abutments were placed on the maxillary



Fig. 13 - Altered cast of the maxillary defect. Unlike other radical maxillary resection, minimum soft tissue undercut was noted on the lateral aspect in this case; little retention could be derived from the defect.

implants and torque down to 30 N cm (Fig. 8). The definitive maxillary anterior fixed partial denture was inserted in resin-modified cement (Rely-X Unicem, ESPE, St. Paul, MN).



Fig. 14 – Completed maxillary prosthesis. The superior extension of the prosthesis contributes to the retention, stability and support of the obturator prosthesis; however, the restored dentition provided crucial prosthodontics retention.



Fig. 15 – Obturator in-situ. Note that the maxillary arch is approximately 2/3 intact and the dentition is in a curvilinear fashion. Prosthodontic prognosis is enhanced.

The maxillary incisor denture teeth in the immediate surgical obturator prosthesis were removed and the lingual contour of the baseplate was adapt to the new maxillary anterior teeth. The surgical obturator was relined in tissue-conditioning material (Coe-soft, GC America Inc., USA) to adapt to the surgical defect (Figs. 9–11).

Definitive impression of the maxillary removable prosthesis framework was made on the same day using irreversible hydrocolloid (Orthoprint, Zhermack, Italy). The definitive maxillary cast was poured in Type V dental stone (Noritake Dental Stone, Kyoto, Japan). A maxillary obturator framework was fabricated in cobalt-chromium alloy.

After a healing period of 3 months, the stability of the endosseous implant support prosthesis was confirmed (Fig. 12). An altered cast impression was made on the healed surgical defect (Fig. 13). A definitive obturator prosthesis was made in the conventional manner (Fig. 14). At the insertion appointment, the prosthesis intaglio surface adjustments were performed with a pressure indicating paste (Pressure Indicating Paste; Mizzy Inc., Cherry Hill, NJ) (Fig. 15).

The patient was instructed on the insertion and removal of the prostheses. Adequate speech and no leakage of fluid from the nostril during swallowing were confirmed.

4. Discussion

Resection of head and neck structures without proper rehabilitation could have adverse effects on the patient, both physically and psychologically. Resection of head and neck lesions is ideally managed in a multi-disciplinary manner. In this case, an ENT surgeon, an oral surgeon and a prosthodontist were involved. It is crucial for all the team members to understand the intended treatment outcome at the planning stage. A clear understanding between group members in the treatment team forms a crucial base for the execution of the treatment and resulting successful rehabilitation.

Maximum bone preservation and strategic placement of endosseous implants ensured optimum rehabilitation outcomes. In this report, the anterior maxillary incision line was made at the center of the extraction socket of the right maxillary canine. The dental team ensured that a clear resection margin was defined for the ENT surgeon and sufficient bone volume was secured at the posterior area of the endosseous implant at the right maxillary lateral incisor area. Alternatively, if the prosthodontics rehabilitation effort was initiated only after the resection was completed, the functional outcome would be the sequel of the surgical treatment and the predictability of the treatment would be uncertain.

Implants are ideally placed with the aid of a surgical template. In this case, the implants were placed by an experienced oral surgeon under direct clinical supervision of an experienced prosthodontist without a surgical template. A total of 3 implants were used. 2 implants were placed on the side that is closer to the anticipated surgical defect to ensure sufficient prosthesis support while the remaining implant was placed over the distal end of the edentulous space to eliminate cantilevering [30].

The patient was rehabilitated in a timely manner. Based on the original clinical presentation, if the patient was rehabilitated following a conventional obturator prosthesis, the prosthesis would be only supported by less than 5 natural teeth abutments while there would be 10 pontics. The masticatory function may be compromised.

The usage of high strength full ceramic restoration in combination with removable prosthodontics is rarely reported in the literature. As far as the authors are aware of, the usage of these newer fixed prosthodontics materials in combination with maxillofacial prosthodontics has never been documented prior to this report.

In the manner in which this patient was rehabilitated, by using an implant supported fixed dental prosthesis in combination with his natural teeth over the maxillary left side, the curvilinear alignment of the maxillary arch was mostly restored [2]. This indirectly reduced the weight of the prosthesis [31,32] and only 5 pontics were needed to be placed in the defect side over the obturator prosthesis.

With proper fluid seal in defect obturation, the patient's speech and swallowing were not compromised. Functional and esthetic elements were also enhanced using the

combination of endosseous implant supported fixed prosthesis and a conventional obturator prosthesis.

5. Summary

This report described the prosthetic rehabilitation of a partially edentulous patient after an ablative maxillary surgery. The usage of implant supported high strength full ceramic fixed dental prosthesis and an obturator prosthesis was discussed.

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Cytotoxicity of accelerated white MTA and Malaysian white Portland cement on stem cells from human exfoliated deciduous teeth (SHED): An *in vitro* study

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ABSTRACT

The aim of this study was to compare the cytotoxicity of accelerated-set white MTA (AWMTA) and accelerated-set Malaysian white PC (AMWPC) on stem cells from human exfoliated deciduous teeth (SHED). The test materials were introduced into paraffin wax moulds after mixing with calcium chloride dihydrate and sterile distilled water. Subsequently, the set cement specimens were sterilized, incubated in a prepared Dulbecco's modified Eagle medium (DMEM) for seven days. The biomarker CD166 was used for characterization of SHED using flow cytometry. The material extracts were diluted at five different concentrations and incubated for 72 h with SHED. The cell viability was evaluated using Dimethylthiazol diphenyltetrazolium bromide (MTT) assay, and the data was analysed using Mann-Whitney test ($P < 0.05$). The results showed that AWMTA revealed significantly greater cell viability at 25 and 12.5 mg/ml concentrations ($P < 0.05$). Concomitantly, AMWPC exhibited greater cell viability at concentrations < 12.5 mg/ml and the results were significant at 1.563 mg/ml ($P < 0.05$). Both materials demonstrated moderate cytotoxicity at 25 mg/ml and slight cytotoxicity at 6.25 and 3.125 mg/ml. At 1.563 mg/ml, no cytotoxic activity was merely observed with AMWPC. In conclusion, AMWPC exhibited favourable and comparable cell viability to that of AWMTA, and has the potential to be used as an alternative and less costly material in dental applications.

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Introduction

Mineral trioxide aggregate (MTA) is one of the most biocompatible endodontic materials that exhibits many advantageous properties including good sealing ability and favourable induction of dentin bridge formation [1,2]. Owing to these desirable properties, MTA is indicated for a wide range of clinical applications such as vital pulp therapy, root end fillings, repair of perforations and resorption defects [3,4]. Despite this favourable biological profile, MTA has some shortcomings, including long setting time (≈ 3 h), poor handling properties and high cost [3,5-7].

Portland cement (PC) has many common chemical and physical properties with MTA, and has been suggested as a viable substitute for MTA due to its lower cost [8]. However, PC also has similar disadvantages including long setting time and poor handling properties [3] that would favour its solubility, disintegration and dislodgement, especially when applied as a root end filling material [5].

In an attempt to decrease the setting time, some setting accelerators such as calcium chloride, calcium formate and NaOCl gel have been suggested as additives [5,9]. Some studies found that CaCl_2 has not only the ability to reduce the setting time of MTA and PC from 3 h to 20-30 min, but it also enhances the sealing ability and increases the release of calcium ions while maintaining a high pH [1,10]. The addition of CaCl_2 to MTA and PC did not alter their biocompatibility [1,10].

The regenerative techniques via stem cell therapy are considered currently as promising areas for research and therapeutic applications in dentistry. Stem cells of human exfoliated deciduous teeth (SHED) are a population of postnatal mesenchymal stem cells capable of extensive

proliferation and multi-potential differentiation. SHED were first isolated by Miura and co-workers in 2003 [11]. They have high plasticity, easy to be expanded *in vitro* and are readily accessible from exfoliating deciduous teeth of young patients [11]. SHED can be characterized by a few methods, among which are immunocytochemistry, Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) and flow cytometry [11-13]. Flow cytometry is a powerful technique that identifies the presence of antigens either on the surface of or within the cells [12]. In this instance, Cluster of Differentiation (CD) 166 is one of the most commonly used mesenchymal stem-cell surface markers that are positively expressed by SHED [12,13].

MTA and PC have shown favourable biocompatibility with various cell lines, including osteosarcoma cells, mouse lymphoma cells and human endothelial cells [1,14-16]. Nevertheless, within the limits of our knowledge, no study has been carried out to investigate the cytotoxicity of accelerated setting white MTA (AWMTA) and accelerated setting Malaysian white PC (AMWPC), using calcium chloride dihydrate as the accelerator, on SHED.

Materials and methods

The cryopreserved SHED were obtained from a previous work [13] (the Craniofacial Laboratory, School of Dental Sciences Universiti Sains Malaysia). SHED were thawed, cultured and incubated at 37°C in 5% CO_2 . Confluent cells (Fig. 1a) were detached using 0.25% trypsin, and then sub-cultured. The experiment was performed at passage 3 after characterization using a stem cell surface marker (CD166, PE stain, BioLegend, San Diego, USA) examined by a flow cytometry (BD FACS Canto II, Canada).

A pilot study which used different liquid to powder ratios for mixing MTA and Portland cement has been attempted in order to obtain an ideal consistency for both materials. Table 1 shows the values with regards to the amount of water that demonstrated ideal consistency and handling properties for AWMTA and AMWPC.

The mixed materials were applied into paraffin wax moulds supported by stainless steel (SS) (diameter 1.5 cm and 2 mm depth) [17] (Fig. 1b). After 24 h, the set materials were sterilized under ultraviolet (UV) radiation (Purifier Class II Biosafety Cabinet, Labconco, USA) (Fig. 1c) for 30 min (15 min on each side). The materials were then incubated in a prepared DMEM solution at 37°C for 7 days. Subsequently, the mixed materials were filtered (0.45 μm).

Table 1 - Composition of both test materials (AWMTA and AMWPC).

Test materials	Composition
AWMTA	1 g of ProRoot tooth-coloured (white) Mineral Trioxide Aggregate (WMTA, Dentsply, USA)+10% calcium chloride dihydrate (Merck, Germany)+200 μl sterile distilled water.
AMWPC	1 g of 63 μm sieved Malaysian white Portland cement (MWPC, Aalborg, Malaysia)+10% calcium chloride dihydrate (Merck, Germany)+250 μl sterile distilled water.

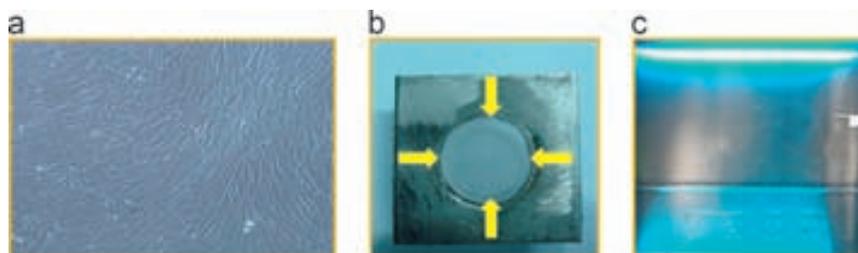


Fig. 1 - (a) Confluent SHED (P3), (b) paraffin wax supported by stainless steel mould and (c) UV sterilization of the set materials.

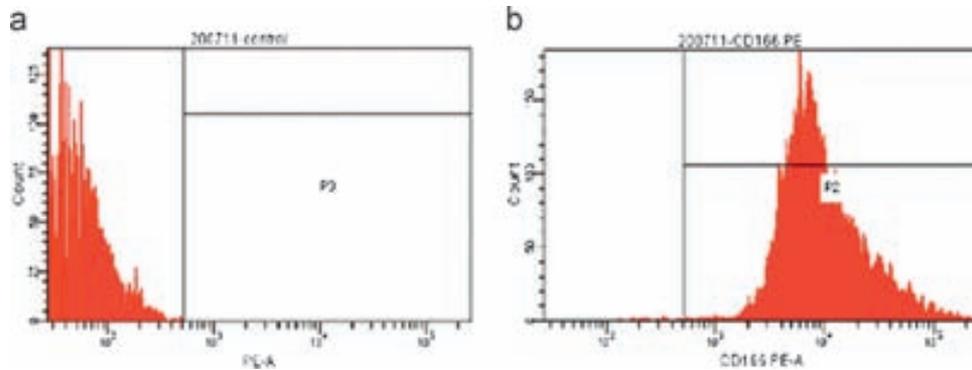


Fig. 2 – (a) Flow cytometry of the control group and (b) flow cytometry showing the positive expression of CD166 by SHED (98.5%).

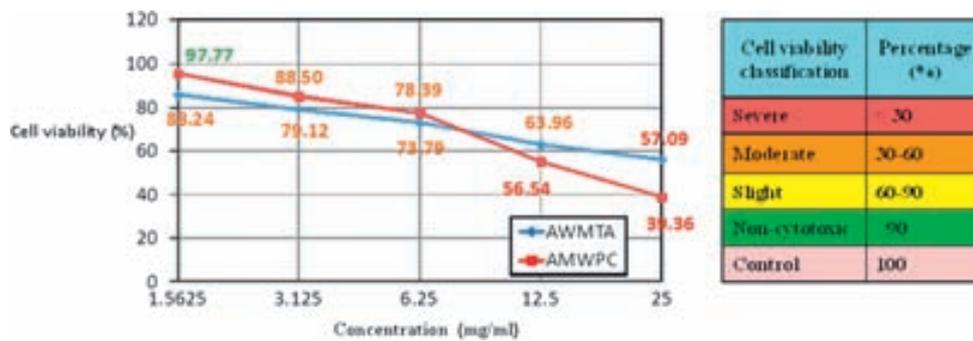


Fig. 3 – Cell viability values of AWMTA and AMWPC on SHED after 72 h. The cell viability is classified into severe, moderate, slight and non-cytotoxic [18], as shown in the table beside.

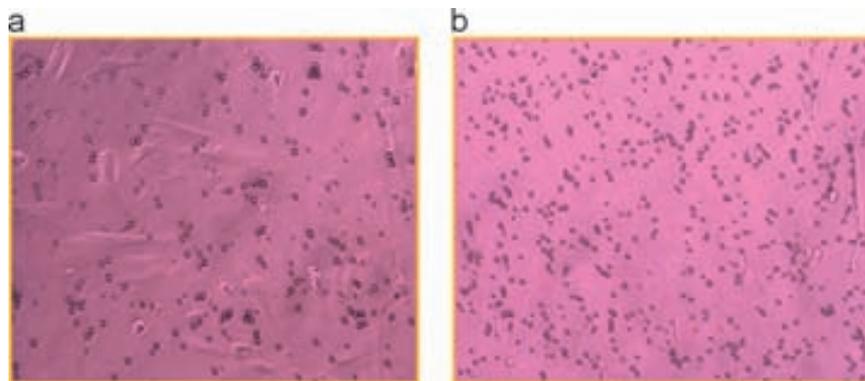


Fig. 4 – Microscopic images after an immediate application of the material extracts at 25 mg/ml on SHED. (a) AWMTA and (b) AMWPC. AMWPC shows more leachable particles than AWMTA.

Table 2 – Statistical analysis, using Mann-Whitney test, between the cytotoxicity of AWMTA and AMWPC.

Concentration (mg/ml)	n	AWMTA Median (IQR)	AMWPC Median (IQR)	z-statistics	P-value
25	12	56.14 (3.90)	38.77 (5.15)	-4.16	<0.001*
12.5	12	62.64 (8.26)	55.18 (6.43)	-2.77	0.006*
6.25	12	73.29 (7.99)	77.54 (9.08)	-1.73	0.083
3.125	12	79.27 (12.67)	85.09 (15.93)	-1.96	0.050**
1.5625	12	85.90 (13.78)	95.55 (11.66)	-2.28	0.023*

* Statistically significant (P < 0.05).
 ** Marginally significant (P < 0.05).

After seeding SHED into the 96-well plates for 24 h, the media were replaced by 200 μ l of the extracts (12 replicates for each concentration), and the last row served as the control group. The plates were then incubated at 37 °C and 5% CO₂ for a further 72 h.

At the end of that 72-h period, 30 μ l of Dimethylthiazol diphenyltetrazolium bromide (MTT) (5 mg/ml) was added into the 200 μ l extract, and incubated at 37 °C and 5% CO₂ for 4 h. Then, the medium was replaced by 200 μ l of dimethyl sulphoxide (DMSO). The optical density was measured using ELISA reader (Sunrise, Tecan) at the reference wavelength of 630 nm and the test wavelength of 570 nm.

The data collected were analysed using Predictive Analytics Software (PASW) Statistics version 18.0 (SPSS Inc., Chicago IL) using Mann-Whitney test with the level of significance set at $P < 0.05$.

Results

Flow cytometry analysis demonstrated that the CD marker (CD166) used to define the cryopreserved SHED was positively expressed by over 95% (Fig. 2). For cytotoxicity evaluation, the results show that at higher concentrations, AWMTA allowed greater cell viability values at 25 and 12.5 mg/ml concentrations than AMWPC, that released more particles than AWMTA (Figs. 3 and 4), and the difference was statistically significant ($P < 0.05$) (Table 2). AMWPC exhibited greater cell viability at concentrations < 12.5 mg/ml, and the results were significant at 1.563 mg/ml ($P < 0.05$) (Table 2). Both materials demonstrated moderate cytotoxicity at 25 mg/ml and slight cytotoxicity at 6.25 and 3.125 mg/ml. At 1.563 mg/ml, no cytotoxic activity was merely observed with AMWPC (Fig. 3).

Discussion

MTA generally refers to the original formulation, which was grey in colour, (GMTA) and was first introduced by Torabinejad and White in 1993 [19]. It is basically a refined mixture of Portland cement and bismuth oxide [20]. Due to the discolouration potential of this grey formulation to teeth and the supporting gingival [21], tooth-coloured (white) MTA (WMTA) was then introduced as a more suitable material for use in applications where discolouration of dental tissues became an aesthetic concern.

Despite the significant improvement in aesthetics, the long setting time of MTA still remained as its main drawback. The setting time has been reduced significantly by the addition of CaCl₂ [5,9,22]. Apart from the reported favourable biological profile of this accelerated formulation, its clinical application into areas where the moisture control is difficult to achieve would reduce the risk of contamination, especially during commencing highly complicated technique sensitive procedures such as pulp tissue regeneration via stem cell therapy.

Calcium chloride is a hygroscopic chemical compound that can be presented in different formulations. The dihydrate formula (CaCl₂·2H₂O) was chosen in this study due to its lesser hygroscopic nature than its anhydrous formulation.

This provides easier manipulation, and permit adequate time for proportioning before its addition to WMTA and MWPC.

In our investigation, a pilot study has been performed to determine the most suitable liquid to powder ratio that would exhibit the best handling properties of both materials in view of their application in critical clinical conditions such as during treatment of root perforations and retrograde fillings. Obtaining an ideal consistency of both materials is essential because the use of higher liquid to powder ratio during mixing would result in a more porous and soluble material that may leach more particles during the incubation time, thus masking the actual viability of the cultured cells and invalidating the results. In the meantime, Fridland and Rosado [23] found that the difference in liquid to powder ratios of Portland cement based materials, such as MTA, may affect the physical properties of the material including porosity and solubility. Nevertheless, when the material is incorporated into a biological system, such as the dental pulp, it seems that the difference in liquid to powder ratios of MTA do not have a significant influence on the histological outcomes [24].

In an attempt to obtain an accurate cytotoxicity evaluation via MTT assay, the maximum concentration of the material extracts was set at 25 mg/ml. This probably would correspond to the small amount of endodontic bio-materials usually indicated for vital pulp therapy, retro-grade filling and repair of perforation defects, in which, only one surface of the material is in direct contact with the pulp or periodontal tissues.

Our results demonstrated that both AWMTA and AMWPC at 25 mg/ml were cytotoxic to SHED. This is in agreement with a study by Hakki et al. [25], who found that 20 mg/ml of white MTA decreased the cell survival of OCCM-30 cementoblasts. AMWPC is significantly more cytotoxic than AWMTA at concentrations 25 and 12.5 mg/ml. Nevertheless, at 3.25 and 1.5625 mg/ml, the cell viability is significantly higher when compared to that of AWMTA. In addition, AMWPC is defined as non-cytotoxic at 1.5625 mg/ml, which is not represented with AWMTA. These fluctuating results at different concentrations might be attributed to the inherent biological effects of the leachable particles released from both materials, being more benign in AMWPC, when the extracts become diluted.

Conclusion

AMWPC exhibited favourable and comparable cell viability to that of AWMTA, and may have the potential to be used as an alternative material in dental applications.

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Available online at www.sciencedirect.com**SciVerse ScienceDirect**journal homepage: www.elsevier.com/locate/sdj**Clinical Practice Guidelines****Evidence-based guidelines for dental implants in edentulism**

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URL: <http://www.aestheticjawsurgery.com>

Dr Chan Siew Luen on behalf of the Workgroup for the AMS-MOH Clinical Practice Guidelines on Dental Implants in Edentulism

Traditionally, much of clinical practice is based on expert opinion or the collective opinion of a group of experts, such as a consensus conference. However, such guidelines are often biased. Guidelines that are evidence-based will be of greater value to practitioners as results will tend to be more reproducible given the same set of circumstances.

Clinical practice guidelines are systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances.¹ They are not meant to be clinical protocols that dictate a management plan for a specific patient. The final decision as to what treatment is best for a particular patient still rests on the judgment of the practitioner, based on the clinical data presented by the patient and availability of various treatment options.

There are different approaches to developing clinical practice guidelines. This set of guidelines on dental implants was developed by methods based on the protocols of the Scottish Intercollegiate Guidelines Network.²

In the past few years, we noted a significant increase in interest by patients and dentists in the use of dental implants to replace missing teeth. There has also been much variation of the original protocol of dental implantology that had been advocated by Per Ingvar Branemark.³ As such, a need arose for a set of clinical practice guidelines to help dentists evaluate the various types of dental implant treatment available for optimal management of their patients. The recommendation from these guidelines are published in this issue of the SDJ.

This set of guidelines is not meant to be comprehensive in scope. The workgroup identified several clinical questions that we deemed pertinent and reviewed the literature on them. The evidence was collated and critically appraised and recommendations were made accordingly. These recommendations were then graded based on the level of the evidence evaluated. A draft was then circulated to the respective specialist societies for feedback before it was published.

While the dentists in the workgroup did the literature review and drafted the initial recommendations, it was the Health Technology Assessment Branch of the Ministry of Health that rigorously checked the appropriateness of the recommendations and their grading against the publications reviewed. With this approach, we are confident that these guidelines are scientifically rigorous.

As more research is done, more information may arise that may impact the relevance of some recommendations. As such, these guidelines should be used with a consideration of new evidence after its publication.

Workgroup members

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Academy of Medicine—Ministry of Health Clinical Practice Guidelines: Dental Implants in Edentulism

The Academy of Medicine Singapore (AMS) and Ministry of Health (MOH) have published clinical practice guidelines on Dental Implants in Edentulism to provide dental practitioners and patients in Singapore with evidence-based guidance on dental implants in edentulism. This article reproduces the introduction and executive summary (with recommendations from the guidelines) from the AMS-MOH clinical practice guidelines on Dental Implants in Edentulism, for the information of SDJ readers.

Chapters and page numbers mentioned in the reproduced extract refer to the full text of the guidelines, which are available from the Ministry of Health website: http://www.moh.gov.sg/content/moh_web/healthprofessionalsportal/dentists/guidelines/cpg_dental/2012/cpgden_dental_implants_in_edentulism.html. For the levels of evidence (1⁺⁺ to 4) and the grades of recommendation (A-D and Good Practice Points or GPP), refer to the Dental Implant CPG Booklet, which can be downloaded from the website mentioned previously.

The recommendations should be used with reference to the full text of the guidelines.

Introduction

Objectives and scope of guideline

Dental implants are fast becoming an integral part of dental practice in Singapore. Until recently, implant dentistry was not taught in the proper milieu of most dental schools. On the academic front there has been much research and publications on this subject with varying levels of rigour. As such, a set of evidence-based guidelines covering some areas of controversies was deemed beneficial to practicing dentists in Singapore. The guidelines are not to be viewed as a protocol, but provide a framework to:

- guide dental healthcare professionals in their quest to give evidence-based care to their patients;
- appraise the various implant treatment options available today based on published evidence in the literature.

Target group

These guidelines are intended for use by general dental practitioners, oral and maxillofacial surgeons, prosthodontists, periodontists and endodontists.

Guideline development

These guidelines have been produced by a committee comprising general dental practitioners, endodontists, oral and maxillofacial surgeons, orthodontists, periodontists and prosthodontists appointed by the Academy of Medicine Singapore and Ministry of Health. They were developed using the best available current evidence and expert opinion. The

workgroup formulated this clinical practice guideline by reviewing published international guidelines and current evidence available in the research and clinical practice literature. The grading system used in the guidelines is described in the Dental Implant CPG Booklet, which is available on the MOH website.

Assessing the evidence

In assessing the evidence, different study designs were considered including randomised controlled trials, cohort studies, case control studies, uncontrolled clinical trials and expert opinions. Best practice guidelines important in implant dentistry were also included.

Scope of guideline

The workgroup identified certain areas in the practice of implant dentistry in Singapore where variation exists among dentists. This guideline covers these identified areas. This guideline is not meant to be exhaustive in coverage of other aspects of implant dentistry or the management of edentulism with other treatment modalities. This guideline provides recommendations for the use of dental implants for management of edentulism in patients with compromised healing abilities and patients with deficient bone stock. It also provides recommendations for the choice of loading and placement protocols as well implant geometry and dimensions. It is hoped that this guideline will help dentists in making evidence based clinical decisions in their management of edentulism with dental implants.

Review of guidelines

Evidence-based clinical practice guidelines are only as current as the evidence that supports them. Users must keep in mind that new evidence could supersede recommendations in these guidelines. The workgroup advises that these guidelines be scheduled for review 5 years after publication, or if new evidence appears that requires substantive changes to the recommendations.

Executive summary of recommendations

Details of recommendations can be found in the main text at the pages indicated.

Dental implants in irradiated bone

C The implant team must work closely with the cancer team members such as the radiation oncologist, oral and maxillofacial surgeon, prosthodontist, otolaryngologists/head and neck surgeons, plastic surgeon, speech therapists, dietician and physiotherapist. Such a combined consultation will lead to optimal planning as addressing questions such as:

- (a) Can bone from tumour resection be saved and reused in the same surgery?
- (b) Can implants be placed prior or during the resection surgery?

(c) Expected healing outcome from multidisciplinary treatment plan (p. 11).

Grade C, Level 2+

D Patients who receive implants and who were treated with radiation more than 5 years ago should be treated with utmost care (p. 12).

Grade D, Level 2+

D The use of hyperbaric oxygen though controversial may be considered as an adjunct to promote healing in these patients (p. 12).

Grade D, Level 2+

C Placement of endosseous implants in patients with a history of head and neck radiation therapy may be performed by clinicians with experience and training in head and neck radiation therapy (p. 12).

Grade C, Level 2+

Dental implants in patients receiving oral bisphosphonates

C Patients who have received or are receiving oral bisphosphonates may undergo dental implant therapy with caution (p. 13).

Grade C, Level 2+

C Patients on oral bisphosphonate therapy have to be counselled about the potential risks and complications before proceeding with dental implant treatment (p. 13).

Grade C, Level 2+

C A minimum pre-surgical serum CTX (beta-crosslaps) value of 150 pg/ml is recommended before extractions and/or implant surgery in patients on oral bisphosphonate therapy (p. 14).

Grade C, Level 2+

C Other non-invasive treatment alternatives must also be discussed with patients (pg 14).

Grade C, Level 2+

Dental implants in patients with controlled periodontal disease

C In patients who have been successfully treated for periodontal diseases and have lost teeth, dental implants can be used for tooth/teeth replacements. However, even well-maintained periodontal patients need to be informed of the higher than normal risks and potential for complications in dental implant therapy in the long-term (p. 16).

Grade C, Level 2+

GPP Patients with periodontal diseases should have their condition treated and well maintained before dental implants can be considered. Annual follow-up visits to their dentist are necessary to better maintain implants in patients with a history of treated periodontitis (p. 16).

GPP

Dental implants in smokers

C Smokers who undergo dental implant therapy are at higher risk of early implant failures and should be closely followed-up during the early healing phase of osseous integration (p. 17).

Grade C, Level 2+

C For smokers who undergo dental implant therapy, particular attention should be paid to complications such as peri-implantitis, marginal bone loss and bone graft healing as part of post-surgical implant care. Where possible, alternative prosthodontic treatment methods should be explored with such patients (p. 17).

Grade C, Level 2+

GPP Patients who are smokers can proceed with dental implant therapy provided they are warned about the higher risks of failures, especially early failures (p. 18).

GPP

GPP Smokers should be advised to stop smoking during the healing period and where possible prior to dental implant therapy and they should seek counselling help to stop the habit altogether (p. 18).

GPP

Narrow diameter implants

B Implants of diameters between 2.5 mm and 3.3 mm can be used predictably for mandibular overdenture retention (p. 19).

Grade B, Level 2++

GPP Due to lack of clinical data regarding implants of less than 2.5 mm in diameter (micro-implants), these implants are not recommended for routine treatment of edentulism (p. 19).

GPP

Extraction and replacement with an implant-supported prosthesis versus endodontic treatment and restoration of teeth with pulpal pathosis

A Patients with pulpal and/or periapical pathosis may be treated with either root canal therapy or extraction and replacement with an endosseous implant-supported dental prosthesis with similar survival rates (p. 20).

Grade A, Level 1+

D Both non-surgical root canal therapy followed by an appropriate restoration and single-tooth implant are acceptable treatment modalities for the treatment of abscessed teeth. The decision to treat a tooth endodontically or to replace it with an implant must be based on factors other than the treatment outcomes of the procedures themselves, such as medical history, caries, patients' preference and other socio-economic factors (p. 21).

Grade D, Level 3

Implant-supported versus tooth-supported fixed dental prosthesis

B For the fixed replacement of a single missing tooth, based on 5-year survival outcomes, an implant-supported single crown or a tooth-supported fixed dental prosthesis are viable options. Other factors apart from survival rates should be taken into consideration when deciding on the choice of replacement (p. 23).

Grade B, Level 2++

GPP Patients should receive information that tooth replacements with fixed dental prosthesis or implants are associated with incidences of biological and technical complications (p. 23).

GPP

Dental implants in posterior maxilla with sinus bone grafting

B Implants may be placed in posterior maxillary grafted sinuses via the lateral approach (p. 25).

Grade B, Level 2++

B Implants may be placed in posterior maxillary grafted sinuses via the transalveolar approach (p. 25).

Grade B, Level 2++

C Rough surface/textured implants may be placed in grafted posterior maxillary sinuses with non-autogenous bone graft (p. 25).

Grade C, Level 2+

Implants in augmented ridges

C Implants may be placed in peri-implant defects (dehiscence and fenestration) treated with guided bone regeneration techniques (p. 27).

Grade C, Level 2+

GPP Localised defects in edentulous ridges should be carefully evaluated and grafting can be considered to optimise the outcome of implant treatment (p. 27).

GPP

C Implants may be placed in sites covered with resorbable membranes (p. 27).

Grade C, Level 2+

GPP Both resorbable and non-resorbable membranes can be considered when augmenting localised defects. Special attention however should be given to the manipulation and follow-up of patients who have undergone non-resorbable membrane application in the light of its higher complication rates (p. 27).

GPP

C Implants may be placed in atrophied ridges augmented by various techniques (other than onlay grafting) (p. 28).

Grade C, Level 2+

GPP Atrophic ridges should be carefully evaluated and different grafting options must be considered as we plan for implant rehabilitation in these situations. Implant positions must be carefully planned out in grafted atrophic ridges to ensure better, long-term implant survival rate. An optimal balance of load distribution, satisfactory aesthetics and functionality must be taken into consideration (p. 28).

GPP

C The efficacy of different grafting techniques in severely atrophic edentulous sites seem to be comparable. Apart from onlay grafting in severely resorbed maxillary areas which shows higher potential for failure and complications, the other techniques proved to be equally effective (p. 28).

Grade C, Level 2+

GPP Other augmentation options should be considered before choosing onlay grafting for severely resorbed maxillary edentulous sites (p. 28).

GPP**Connection of dental implants to natural teeth**

D As the treatment of choice, a fixed dental prosthesis supported by osseointegrated implants should be connected to other osseointegrated implants, independent of natural teeth. Connection of osseointegrated implants to natural teeth via a fixed dental prosthesis may be done with adequate warning of a higher complication and failure rates (p. 29).

Grade D, Level 2+

D When implants are connected to natural teeth, rigid connection should be used, and only on teeth which are periodontally sound. Regular checks are necessary as mechanical complications and increased marginal bone loss may be expected around either implant or tooth. Modified connections retaining the rigid characteristics that have been proposed without long term results should not be used until more results are available (p. 29).

Grade D, Level 3**Placement protocol/timing**

C Dental implants should be placed in healed sockets as the treatment of choice (p. 31).

Grade C, Level 2+

C Implants may be placed into fresh extraction sockets with the patient's understanding that the survival rate is lower than that placed into healed sockets. Immediate loading of implants placed into fresh extraction sockets should not be done routinely (p. 31).

Grade C, Level 2++**Loading protocol/timing****Edentulous mandible**

A Root-form endosseous implants (two or four units) inserted for the purpose of retaining or supporting a removable dental prosthesis that are rigidly splinted together may be loaded immediately (p. 33).

Grade A, Level 1++

B Root-form endosseous implants (four or more units) inserted for the purpose of supporting a fixed one-piece full arch dental prosthesis may be loaded immediately (p. 33).

Grade B, Level 2++**Edentulous maxilla**

B Root-form endosseous implants (two or four units) inserted for the purpose of retaining or supporting a removable dental prosthesis should not be loaded immediately (p. 34).

Grade B, Level 2++

C Root-form endosseous implants (six or more units) inserted for the purpose of supporting a fixed one-piece full arch dental prosthesis may be loaded immediately (p. 34).

Grade C, Level 2+**Single tooth replacement**

A Conventional loading of a single root-form endosseous implant inserted for the purpose of supporting a single crown is the loading protocol of choice. Immediate loading of a single root-form endosseous implant inserted for the purpose of supporting a single crown may be done with caution (p. 34).

Grade A, Level 1++**Multiple-tooth partial edentulous maxilla/mandible**

B Conventional loading of multiple root-form endosseous implants inserted for the purpose of supporting a multiple-unit fixed prosthesis in the anterior or posterior maxilla/mandible is the loading protocol of choice. Immediate loading of multiple root-form endosseous implants inserted for the purpose of supporting multiple-unit fixed prosthesis in the anterior or posterior maxilla/mandible may be done with caution (p. 34).

Grade B, Level 2++

R E F E R E N C E S

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- 3 P.I. Branemark, et al., *Intra-osseous anchorage of dental prostheses. I. Experimental studies*, *Scandinavian Journal of Plastic and Reconstructive Surgery* 3 (1969) 81-100.

Available online at www.sciencedirect.com**SciVerse ScienceDirect**journal homepage: www.elsevier.com/locate/sdj**Book Review****Jean-Anthelme Brillat-Savarin's 1825 treatise on the mouth and ingestion***Gabriel Tse Feng Chong*

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ABSTRACT

This article quotes and discusses Jean-Anthelme Brillat-Savarin's musings on the mouth and ingestion as described in his book *The Physiology of Taste*. The book was first published in France in December 1825, and is still widely read as a key work in Gastronomy today. The mouth is intimately related to the acts of chewing, swallowing and eating and it would be interesting to report an early 19th century epicurean's views on the mouth.

Passages from Brillat-Savarin's book describing the functions of the teeth and tongue and the acts of tasting, chewing, and swallowing are quoted in full. Anecdotes also include one on the horrifying punishment of having one's tongue removed and another illustrating the poor oral health found among Europeans of that era.

His work offers a unique glimpse into how a 19th century gastronome viewed the oral cavity and its gastronomical functions. While some of his writings may appear archaic and antediluvian to the modern reader; others relating to, for example chewing and swallowing, are surprisingly accurate by contemporary standards. Nonetheless, the gastronomic savant seemed to know a lot right about modern stomatology!

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Introduction

Jean-Anthelme Brillat-Savarin (1 April 1755–2 February 1826) [1] (Fig. 1) is synonymous with French culinary excellence as the author of a key gastronomical text, *The Physiology of Taste* [2] (*La Physiologie du goût*) (Full title: '*The Physiology of Taste, or Meditation on Transcendent Gastronomy, a theoretical, historical and topical work, dedicated to the gastronomes of Paris by a professor, member of several literary and scholarly societies*') [1] (Figs. 2–4). Brillat-Savarin was born in Belley, France, an area



Fig. 1 – Jean-Anthelme Brillat-Savarin (1 April 1755–2 February 1826).

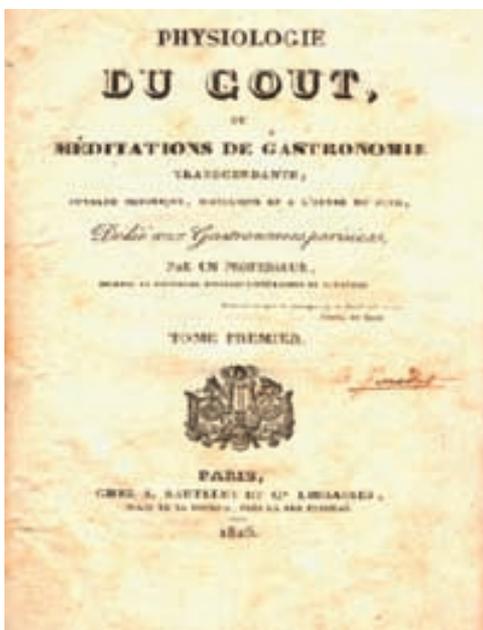


Fig. 2 – 1826 edition of *The Physiology of Taste*.



Fig. 3 – Modern editions of *The Physiology of Taste*.



Fig. 4 – Modern editions of *The Physiology of Taste*.

renowned for its food and wine. He was a lawyer, first became magistrate of Belley and was later elected mayor of the same town. He eventually fled to the New World at the outbreak of the French Revolution and later returned to France in 1797, to become a judge of the Supreme Courts of Appeal, a position that he would hold for the remainder of his life [1,3].

The gastronomic interests of his family (his parents were also lawyers) had a major influence on Brillat-Savarin at an early age and after his return to Paris, he would spend much of his time dining and entertaining his friends [3]. His dinners were reputed to be famous for their culinary excellence [4] and the reader can imagine from his descriptions, the wantonness and grandiosity of his dinners and parties as befitting someone of privileged rank in the Victorian era. For example, every year on his name-day (26 June), he would invite any young men from Bugey, his native province, who happened to be in Paris to dine at his house and treated them to Bugey wine, which was transported to Paris "specially in a barrel on the back of his old mare" [4].

Brillat-Savarin considered himself a 'man of letters' and busied himself in the leisurely pursuit of poetry, writing and gastronomy; the latter of which he considered a Science [5] and believed himself to be the first to conceive the idea of an Academy of Gastronomes [6]. He began compiling a book of his gastronomical 'meditations' and musings from which he would read extracts to a few close friends after dinner [7]. At the urging of some friends, he finally published *The Physiology of Taste* at his own expense in December 1825, a few months before his death [7]. The work was published anonymously but apparently "all of Paris soon knew who had written the remarkable work that everyone was talking about" [7]. His book contained his notions, observations, and anecdotes on gastronomic pleasures and related issues such as dieting, obesity and the oral cavity, as well as extraneous ones that have little to do with gastronomy (i.e. his musings on sleep, rest, and death).

Brillat-Savarin's treatise on the mouth and its gastronomical intentions is interesting for a couple of reasons; firstly it is written from the vantage of a privileged person living in the early 19th century, and secondly from the view point of a gastronome. Despite the author's intentions as suggested by the full title of *The Physiology of Taste*, the modern reader should be cautioned against taking this work at face value as a scientific or medical text. In my personal opinion, majority of the author's views are passed off as axioms and aphorisms, without containing any references or even substantiations. Nonetheless, it makes for interesting leisurely reading for the dentist and I have quoted excerpts of his work, in full, that relates to the oral cavity that may be of interest to the readers of this journal and would subsequently discuss them.

On teeth [8]

Man is an omnivorous animal; he possesses incisive teeth for dividing fruit, molar teeth for crushing grain, and canine teeth for tearing flesh; and it has been remarked that the closer man approaches to the primitive state, the stronger and more conspicuous are his canine teeth.

It is extremely probable that for a long time the species was frugivorous; it was confined to such a diet by necessity, for man is the clumsiest of the animals, and his means of attack are very limited as long as he is unarmed. But that instinct for improvement which is inseparable from his nature was not slow to develop; the very consciousness of his weakness led him to seek means of arming himself; he was impelled to the same end by the carnivorous instinct revealed in his canine teeth; and as soon as he was armed, he preyed on all the animals surrounding him, and made them his food...

On the tongue and the practice of oral mutilation [9]

It is no easy matter to determine the precise nature of the organ of taste. It is more complicated than it seems at first sight.

Clearly, the tongue plays an important part in the mechanism of degustation; for, endowed as it is with a certain amount of muscular energy, it serves to crush, revolve, compress, and swallow food.

In addition, through the numerous papillae scattered over its surface, it absorbs the sapid and soluble particles of the substances with which it comes into contact; but all that is not enough to complete the sensation, which requires the cooperation of several adjacent parts, namely the cheeks, the palate, and above all the nasal fossae, to which physiologists have perhaps not paid sufficient attention.

The cheeks furnish saliva, which is equally essential to mastication, and to the formation of the alimentary bolus; they, as well as the palate, are endowed with the faculty of appreciation; I am even inclined to think that in certain cases the gums have a little in themselves; and without the odoration which takes place at the back of the mouth, the sensation of taste would be dull and incomplete.

Persons born without a tongue, or whose tongue has been cut out, are not completely deprived of the sensation of taste. Examples of the former case are to be found in all the textbooks; and I learned something of the latter case from a poor wretch whose tongue had been cut out by the Algerians as a punishment for having attempted to escape from their clutches, together with some of his comrades in captivity.

This man, whom I met in Amsterdam, where he earned his living as a messenger, had received a reasonable education, and that it was quite easy to carry on a conversation with him in writing.

After noting that all the front part of his tongue, as far as the string [sic], had been removed, I asked him if he still found any enjoyment in what he ate, and if the sensation of taste had survived the cruel operation he had undergone.

He replied that what caused him the greatest fatigue was the act of swallowing, which he only performed with difficulty; that he had retained the faculty of taste to a fair degree; that he could still enjoy good food as well as any man, provided the taste was not too strong; but that very acid or bitter substances caused him intolerable pain.

He further informed me that cutting out the tongue was a common punishment in the African states; that it was particularly inflicted on persons suspected of being the

leaders in any conspiracy; and that there were special instruments designed for the purpose. I would have liked him to describe them to me; but he showed so painful a repugnance on the subject that I pressed him no further.

I reflected on what he had told me, and, going back to the ignorant times when the tongues of blasphemers were pierced or cut out, and to the period when such punishments were laid down by law, I felt justified in concluding that they were of African origin, and had been introduced by the returning Crusaders.

We have already seen how the sensation of taste is principally situated in the papillae of the tongue. Now, anatomy teaches that all tongues are not equally provided with these papillae, and that one tongue may possess three times as many as another. This circumstance explains how it is that of two guests seated at the same banqueting table, one displays the liveliest pleasure, while the other seems to be eating only under constraint; the reason is that the second guest has a poorly equipped tongue, and that the empire of taste also has its blind and deaf subjects.

On mastication and swallowing [10]

Appetite, hunger, and thirst are warning signs that the body needs new strength; and pain, that universal monitor, loses no time in tormenting us if we are unwilling or unable to obey those signs.

We accordingly indulge in eating and drinking, which together constitute ingestion, an operation which begins when the food enters the mouth, and ends when it enters the esophagus.

The whole journey is only a few inches long, but a great deal takes place before it is completed.

The solid foodstuffs are divided by the teeth; the different glands with which the mouth is lined moisten them; the tongue pounds them and mixes them together, pressing them against the palate to squeeze out the juice and taste their savor [sic], and binding them into a solid mass in the middle of the mouth after which, pushing against the lower jaw, it rises in the middle so that the mass is drawn down the slope towards the back of the mouth and received by the pharynx, which contracts in its turn, forcing it into the oesophagus, which by a peristaltic movement conveys it into the stomach.

When one mouthful has been dealt with like this, a second follows in the same fashion; the drinks swallowed in the intervals take the same road, the process of deglutition continuing until the same instinct which had initiated ingestion warns that it is time to finish. The first injunction, however, is seldom obeyed; for it is one of the privileges of man to drink when he is not thirsty, and the present-day cook knows how to make us eat when we are not hungry.

Before each morsel of food can reach the stomach, it has to avoid two dangers and the way it does this is a remarkable tour de force.

The first is the danger of being pushed back to the rear of the nostrils; but fortunately the lowering of the veil of the palate and the construction of the pharynx prevent this from happening.

The second is the danger of falling into the trachea or windpipe, across which all our food must pass; and this is a far more serious risk, for as soon as any foreign body enters the trachea, a convulsive cough begins which continues until the substance is expelled.

However, by means of an admirable mechanism, the glottis contracts during the act of swallowing; it is also shielded by the epiglottis, which covers it, and we instinctively hold our breath during deglutition, so that it may be said that generally speaking, despite this strange conformation, food reaches the stomach without much difficulty; and there the empire of the will comes to end, and digestion, properly so called, begins.

Anecdote illustrating poor oral health in the Victorian era [11]

In houses where a point is made of following the latest fashions, servants, at the end of dessert, distribute bowls of cold water among the guests, in each of which stands a goblet of hot water. Whereupon, in full view of one another, the guests plunge their fingers in the cold water, as if to wash them, fill their mouths with the hot, gargle noisily, and spit it out into the goblet or the bowl.

I am not the only person to have spoken out against this useless, indecent, and disgusting innovation.... Disgusting, for the prettiest and freshest mouth loses all its charms when it usurps the functions of the evaculatory organs: what then if the mouth is neither fresh nor pretty? And what shall be said of those monstrous chasms which open up to reveal pits that would seem bottomless, if it were not for the sight of shapeless, time-corroded stumps?...

Discussion

It is fascinating to read passages describing the teeth and tongue and the acts of chewing, swallowing and tasting from an early 19th century work. *The Physiology of Taste* is considered a key gastronomical work that has even been labeled a "gourmet's bible" [3] and still enjoys contemporary readership. Whilst the modern reader may find some of his writings archaic and antediluvian; others relating to, for example chewing and swallowing, are surprisingly accurate. Since the work was not referenced, it is not known to what degree his work was based on early 19th century medical knowledge or whether they consist purely of the author's conjectures and notions. However, the gastronomic savant seemed to know a lot right about modern stomatology!

Brillat-Savarin states that "the closer man approaches to the primitive state, the stronger and more conspicuous are his canine teeth". His statement regarding the variation in canine size may refer to an increase in the clinical crown height due to gingival recession and/or an actual intra-species variation in the size of the tooth. It has been reported that the size of the maxillary canine can be quite variable [12], where rather small canines may be mistaken for the canine-form type of lateral incisors [12]. The crown: root length ratio also varies but the usual tendency is for long

roots to be formed [12] and that in rare instances, the grooves on the root may deepen to the apex resulting in two radicles being formed [12]. However, his conclusion that the more conspicuous that one's canine teeth are, the closer one approaches the "primitive state" are probably baseless.

His statements that the "cheeks and palate are endowed with the faculty of appreciation (taste buds) and in certain cases the gums have a little in themselves" [9] are not supported by modern anatomical knowledge. Taste buds are located within the walls of the circumvallate papillae, and also found in small numbers in the fungiform and foliate papillae, mucosa of the soft palate and epiglottis [13]. He also exerts that a process of "odoration takes place at the back of the mouth, without which the sensation of taste would be dull and incomplete" [9]. No doubt the enjoyment of food depends on several factors – the taste, texture, and consistency of the food, detectable favorable odors and associations with certain pleasant memories – but it is only the taste buds that determine the various taste sensations of foodstuffs (i.e. sweet, savory, sour, bitter).

The last paragraph on Brillat-Savarin's passage on the tongue concludes that "anatomy teaches that all tongues are not equally provided with these papillae, and that one tongue may possess three times as many as another." [9] He goes on to explain that this is the reason as to why one individual may enjoy his food over another. Hunter's or Moeller's glossitis that is a result of pernicious anemia [14,15] occurs in about 50–60% of patients [15] with pernicious anemia (vit B₁₂ deficiency). The dorsal surface of the tongues of these patients may exhibit focal patchy areas of oral mucosal erythema and atrophy as well as pain and burning sensation [14,15]. The erythematous appearance of the tongue is due to the epithelial atrophy of the papillae [15], but the mucosal alteration would resolve upon the initiation of therapy [14,15]. There is no actual loss in the quantity of papillae in Hunter's or Moeller's glossitis. The glossitis associated with Plummer-Vinson syndrome, a rare form of iron deficiency may also result in atrophy of the papillae [15]; however histopathology shows only epithelial atrophy without an actual loss in the number of papillae [15]. Two conditions of the tongue that actually result in a loss of the quantity of filiform papillae are migratory glossitis and median rhomboid glossitis [16]. However, it has not been reported whether these patients actually have taste deficiencies.

When readers interpret any first-hand historical account, it is important to understand the vantage point of the author. Compared to the average person living in Europe in the late 18th/early 19th century, Jean-Anthelme Brillat-Savarin presumably must have been relatively wealthy, privileged and have held some social rank in order to have lived a life pursuing leisurely events such as gourmandism [3] and throwing dinners famed for their culinary quality [4]. Victorian era France is not the egalitarian society that it is today, and Brillat-Savarin's fellow diners were highly likely to be of equivalent social standing. The "shapeless, time-corroded stumps" [11] of teeth, which he described of his fellow diners, were presumably caused by dental caries, tooth wear, and/or the excessive consumption of wine (dental erosion). However, I would only limit my discussion to dental caries.

In Europe, dental caries at the time of writing was no longer a disease of affluence because sugar had become a common product used even by the poor after 1700 [17]. This was due to the large quantities of sugar produced by slaves in Brazil and the West Indian colonies that led to significantly lower prices [17–19]. It has been reported that annual sugar consumption per capita in England increased from almost zero in the 17th century to 4 lbs (1.8 kg) in 1704 to 18 lbs (8.2 kg) in 1800 and finally to 90 lbs (40.8 kg) by the mid-19th century [18,19]. The consumption of sugar rose rapidly due to several factors: industrialization; increased disposable income; processed foods and beverages; and the consumption of bitter beverages, such as tea and coffee, to which sugar had to be added as a sweetener [17,19].

In developing countries, there is an association between per capita sugar intake and mean levels of caries experience [20]. It has been reported that with a consumption of 25 g of sugar per day, there would be an increase of 1.0 DMFT for children aged 12 years and 1.0 dmft for 5 and 6 year olds [20]. In countries, where the annual per capita sugar consumption was below 18 kg/person (about 50 g/person/day) the DMFT was consistently below 3.0. On the other hand, those countries where consumption was in excess of 44 kg/person/year had significantly higher caries experience [20]. Using these modern figures and extrapolating them to the era when *The Physiology of Taste* was published, it would suggest that the DMFT for 12 year olds then may have been lower than 3.0. However, this mere extrapolation does not take into account various factors, such as level of dental knowledge, and availability of dental care, therefore it is very likely that the actual caries experience then was much higher than 3.0.

The etiological role of bacteria in the causation of dental caries was still unknown during the early 19th century. It was only in 1890 that W.D. Miller postulated his "acid decalcification theory"—the mixed bacteria present in the mouth produced acid from fermentable carbohydrates, which in turn demineralized the tooth structure to begin the carious process [21]. Furthermore, it was not until the 1950s, when a series of animal experiments undertaken by Orland et al. proved the link between oral bacteria and dental caries [22]. Their experiments showed that in the presence of a cariogenic diet, dental caries only developed in the teeth of rodent who were inoculated with bacteria. However, those teeth which were kept in a germ-free environment did not develop any carious lesions, despite the cariogenic diet [22].

As reported by Moore [18], in England there was a gradual change in the clinical presentation of dental caries; from its primitive pattern which persisted for about 2 millennia (mostly smooth surface caries at or near the cemento-enamel junction) to that of a modern presentation (mostly pit and fissure caries and interproximal lesions) at around the 17th century. The 'modern' presentation of dental caries was further evident by the first half of the 19th century (when *The Physiology of Taste* was published) and by the latter half of that century, the prevalence and distribution of carious lesions was comparable to that of the modern English population [18]. This post-mortem conclusion was reached by studying archeological findings and can be augmented by Brillat-Savarin's description of "shapeless, time-corroded stumps" [11] found in his fellow wealthy diners.

Conclusions

Brillat-Savarin's *The physiology of Taste*, published in 1825, is a famous gastronomical literature and contains some passages describing the functions of the teeth and tongue as well as the acts of mastication and deglutition. While some of his writings may appear archaic and antediluvian to the modern reader, others relating to, for example chewing and swallowing, are surprisingly accurate by modern standards. Moreover, one particular anecdote recounting "shapeless, time-corroded stumps" of teeth suggested that Brillat-Savarin's fellow diners may have suffered from dental caries. This description is correlated with the widespread availability of sugar in Europe by his time and other historical aspects of dental caries are also discussed.

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1. Committee on Mercury Hazards in Dentistry. *Code of Practice for Dental Mercury Hygiene*. London: Department of Health and Social Security, 1979, publication no. DHSS 79-F-372.

Tables

Tables should be labelled in Arabic numerals and titled concisely. Number all tables in the order of their citation in the text. Tables should be typed double-spaced in as simple a form as possible. Abbreviations used in the table and not defined in the text should be defined in footnotes using these symbols (in order of appearance): *, †, ‡, §, ∥, ¶.

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The number of figures should be restricted to the minimum necessary to support the textual material. Please post two sets of the original figures to the Editor. They will not be returned. The

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Use the Recommended International Non-proprietary Name for medicinal substances, unless the specific trade name of a drug is directly relevant to the discussion.

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