Immediate Loading of Screw-Retained All-Ceramic Crowns in Immediate Versus Delayed Single Implant Placement

Stefan Vandeweghe, DDS, PhD[a]/Costa Nicolopoulos, DDS, DMD[b]/Eric Thevissen, DDS, MSc[c]/
Ryo Jimbo, DDS, PhD[d]/Ann Wennerberg, DDS, PhD[e]/Hugo De Bruyn, DDS, MSc, PhD[f]

Purpose: The aim of this study was to evaluate and compare the outcomes of immediately loaded all-ceramic crown restorations supported by implants placed in both mature bone and immediate extraction sockets. ***Materials and Methods:*** Forty-three tapered, external hex implants were placed immediately after extraction or in healed bone in a convenience sample of 38 patients from two clinics, with 23 implants immediately placed after tooth extraction and 20 placed in mature bone. Thirty implants were located in the maxilla and 13 in the mandible. Each surgical implant placement was followed by the fabrication of a screw-retained all-ceramic crown (zirconia-toughened alumina cylinder and layered with porcelain) that was then put into immediate function. Each patient was recalled annually for clinical and radiographic assessments. ***Results:*** All implants were loaded immediately and all functioned successfully following a mean follow-up of 26 months. Significantly more bone loss was recorded around delayed implants compared with immediately placed ones. Smoking, platform switching, and jaw location did not influence peri-implant bone loss. Porcelain chipping was noted in the case of two crowns. ***Conclusion:*** The short-term outcome of prefabricated ceramic cylinders used to support a single screw-retained crown was regarded as successful. Immediate implant placement did not appear to increase the risk for implant failure and was accompanied by reduced peri-implant bone loss. *Int J Prosthodontics 2013;26:458–464. doi: 10.11607/ijp.3075*

Titanium has long been the gold standard material for implant abutments due to its biocompatibility, corrosion resistance, strength, and longevity.[1] However, their dark gray color can cause a discoloration of the peri-implant mucosa and compromise esthetic appearance.[2,3] High-strength ceramic abutments were introduced for esthetically demanding sites so as to overcome these problems. Apart from being biocompatible, zirconia exhibits the highest fracture toughness[4] among the dental ceramics. Moreover, ceramic abutments are less prone to plaque accumulation and offer a significantly better esthetic appearance compared with metal abutments.[5] Their shortcoming lies in their brittleness and reduced resistance to tensile forces and microstructural defects[6] caused by low temperature degradation.[7,8] To date, the survival rates of ceramic abutments have been promising, with some studies reporting 100% survival.[9,10] A recent short-term study comparing titanium and zirconia abutments in the posterior region reported no failures after 3 years.[11]

In the esthetic region, the use of cementable abutments is controversial and lacks compelling evidence. They are, however, frequently used to correct angulation concerns and for reasons of improved occlusion, fit, and esthetics.[12,13] But it is almost impossible to avoid cement residues, which may lead to biologic complications over time.[14] In addition, the retrievability of cemented restorations is extremely difficult.[15] A screw-retained all-ceramic crown may not only solve these problems, but provide high esthetics.[16] There are,

[a]*Assistant Professor, Department of Periodontology and Oral Implantology, Dental School, Faculty of Medicine and Health Sciences, University of Ghent, Ghent, Belgium; Department of Prosthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden.*
[b]*Private Practice, Glyfada, Greece.*
[c]*Periodontist, Department of Periodontology and Oral Implantology, Dental School, Faculty of Medicine and Health Sciences, University of Ghent, Ghent, Belgium.*
[d]*Associate Professor, Department of Prosthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden.*
[e]*Professor, Department of Prosthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden.*
[f]*Professor, Department of Periodontology and Oral Implantology, Dental School, Faculty of Medicine and Health Sciences, University of Ghent, Ghent, Belgium.*

Correspondence to: *Prof Dr Hugo De Bruyn, Department of Periodontology and Oral Implantology, University Hospital Ghent-P8, De Pintelaan 185, B-9000 Ghent, Belgium. Fax: +32 9 332 35 51. Email: hugo.debruyn@ugent.be*

however, concerns regarding the discontinuity of porcelain at the screw access opening, which may again result in porcelain fractures.[17] Unfortunately, with only a few case reports, scientific data on screw-retained all-ceramic crowns and partial dentures are lacking.

Although immediate loading exposes the single implant to an increased risk for failure,[18] it improves patient satisfaction by shortening treatment time and, when used in combination with immediate placement, is believed to help maintain gingival profile esthetics.[19] Some authors, however, report an increased failure risk when the implants are immediately placed and loaded.[20,21]

Therefore, the primary aim of this study was to evaluate the clinical performance of screw-retained all-ceramic single crowns with a zirconia cylindrical core. The secondary aim was to evaluate the outcomes of immediately loaded implants when placed in extraction sockets or in healed bone. This study was approved by the Ethical Committee of the University Hospital in Ghent, Belgium.

Materials and Methods

Patient Selection and Implant Distribution

A convenience sample of 38 patients (16 men and 22 women), 5 of whom were smokers, with a mean age of 49 years (standard deviation [SD]: 14, range: 20 to 82) was selected. They received 43 implants, with 23 immediately placed after tooth extraction and 20 delayed and placed in mature bone. Thirty implants (69.8%) were placed in the maxilla, while 13 (30.2%) were placed in the mandible. A detailed overview of implant location and dimensions can be seen in Fig 1 and Table 1, respectively. All implants had adjacent natural teeth, except for 5 implants (3 premolars and 2 molars) which were situated at the most distal position in the arch and were not flanked by a tooth on the distal side. All implants were loaded immediately and accounted for when all patients included in the study attended the clinical follow-up examination.

All patients were consecutively treated with a dental implant for single tooth replacement at one of two centers by two experienced surgeons from January 2007 to January 2010 (CN, ET). Preoperatively, all patients underwent clinical and radiographic examination. To be eligible for implant treatment, patients had to be free from oral or severe systemic diseases (eg, uncontrolled diabetes). If the tooth was still present and without signs of peri-apical inflammation, the patient was selected for immediate implant placement. An implant was only considered for immediate loading if implant stability at insertion reached a torque value of 40 Ncm or more.

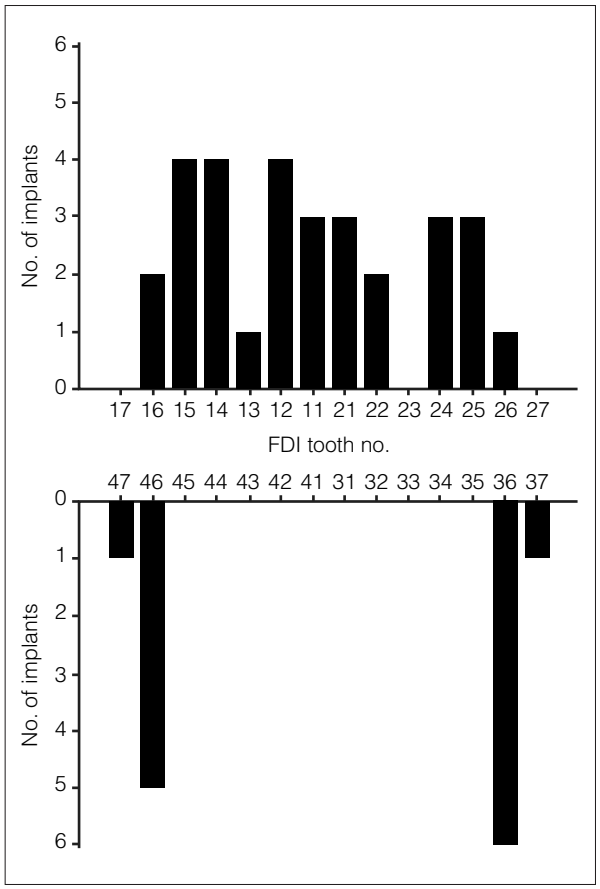

Fig 1 Implant distribution according to tooth location.

Table 1 Implant Distribution According to Diameter and Length

	Length (mm)				
Diameter (mm)	10.00	11.50	13.00	15.00	Total
4.00	3	0	6	6	15
5.00	1	0	4	8	13
6.00	0	3	8	2	13
8.00	0	0	2	0	2
Total	4	3	20	16	43

Surgical Procedure

In brief, all patients were treated with one or two single implants from the same implant system (Southern Implants). All implants had a tapered design, external hex, and moderately rough surface (1.34 μm).[22] In case of delayed implant placement, a full-thickness flap was raised to expose the underlying bone. In case of immediate placement, the tooth was atraumatically removed and the implant placed without raising a flap. The implant site was prepared

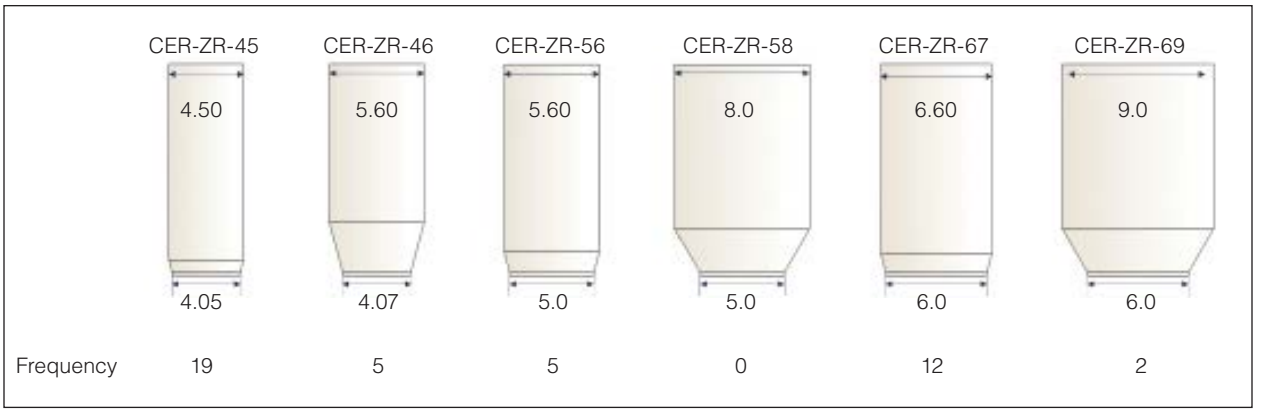

Fig 2 Overview of the available sizes (mm) of the ceramic cylinders, with the corresponding number of units used in the study.

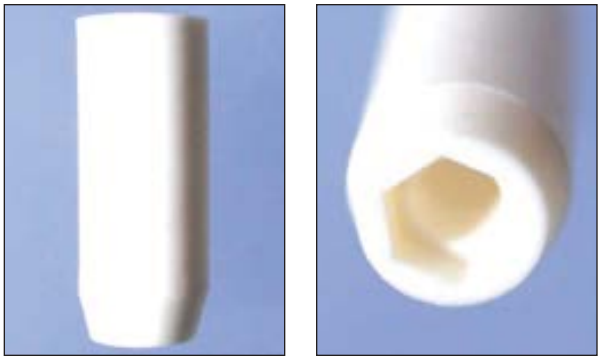

Fig 3 The all-ceramic cylinder with the hexagonal connection milled into the ceramic material.

according to the manufacturer's recommendations. All implants reached at least 40 Ncm initial stability and were therefore eligible for immediate loading. No additional bone grafts were used.

Prosthetic Treatment

Immediately after surgery, an open tray impression was taken using an adapted standard impression tray (Solo Plus Impression Tray, J&S Davis) and a polyether (Impregum, 3M ESPE) or a polyvinyl siloxane (First Quarter, Danville Materials) impression material.

The ceramic cylinder (CER-ZR, Southern Implants) that forms the substructure of the crown is made of zirconia-toughened alumina and has a bending strength of 1,400 Mpa (Figs 2 and 3). The excessive zirconia was ground away, and a ceramic bonding porcelain was added directly to the abutment.

One day later, the crowns were screwed directly onto the implant and the gold screws were torqued at 32 Ncm to avoid loosening (Fig 4). The occlusion was checked using 8-µm-thin occlusal film (Arti-Fol, Bausch). Care was taken to achieve light contact on the crown during maximal intercuspation to maximize the force on the adjacent natural teeth. Lateral or anterior guidance was obtained in the natural dentition and avoided on the crown.[23,24]

Follow-up Examination

All patients were invited yearly for a follow-up. During control examination, a digital peri-apical radiograph was taken using the long-cone technique, aiming the x-ray beam perpendicular to the film and implant to allow a clear determination of the bone level. Implants and crowns were checked for signs of mobility or porcelain fractures.

The following variables were collected from the patients' files during clinical examination: *(1)* patient's date of birth and sex; *(2)* implant type, position, date of placement, immediate or delayed placement, and time of loading; *(3)* abutment type and any complications (eg, porcelain chipping); and *(4)* the bone level as determined on the most recent radiograph and compared with a baseline radiograph taken at crown placement. Bone level measurements were done using Adobe Photoshop CS4 (Adobe Systems) after the images were calibrated on the known implant length or thread pitch. Bone loss was calculated as the difference of both radiographs.

Statistics were analyzed using PASW version 18 (SPSS, IBM) with the level of significance set at $P \leq .05$. Differences in bone loss in relation to time of placement, maxilla or mandible, smoking habits, or platform switching were analyzed using the Mann-Whitney *U* test. A multivariate analysis was done using stepwise linear regression analyses to evaluate the relationship between the different variables.

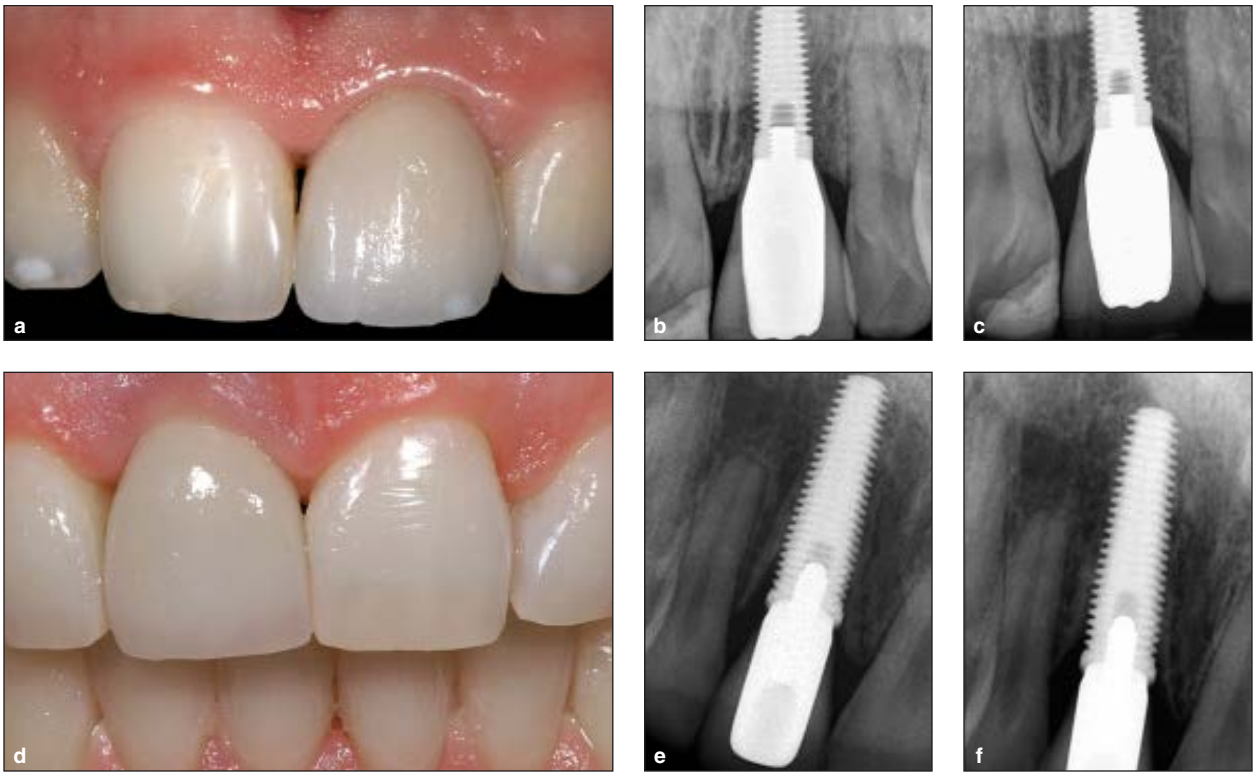

Fig 4 **(a, b, c)** Delayed and **(d to f)** immediate implant placement. **(a and d)** Clinical image of the implant crown taken during the follow-up examination after 20 months. **(b and e)** Baseline peri-apical radiograph taken at crown placement. **(c and f)** Control peri-apical radiograph taken after 20 months.

Results

All implants survived following a mean follow-up period of 26 months (SD: 11, range: 8 to 44 months). The implant distribution with respect to follow-up time is shown in Table 2. The mean bone loss was 1 mm (SD: 0.30, range: 0.24 to 1.64 mm) and was not statistically different between the maxilla and mandible (P = .781) (Table 3). According to the criteria of Albrektsson and Zarb,[25] all implants were successful and did not exceed the yearly acceptable 0.2 mm of bone loss. There was, however, statistically more peri-implant bone loss around delayed implants than around immediately placed implants (P = .016) (Fig 5). Neither smoking (P = .404) nor platform switching (P = .089) significantly affected bone loss. This was confirmed by linear regression, identifying the time of implant placement as the only significant factor affecting bone loss (P = .006), while platform switching (P = .867), arch (P = .904), and smoking (P = .963) did not.

Overall, only two prosthetic complications occurred, being two crowns that experienced porcelain chipping. On one premolar crown, the chip-off was minor and could be solved by polishing. In the other

Table 2 Implant Distribution with Respect to Follow-up Time

Follow-up	No. of implants (%)
Up to 1 y	9 (20.9)
Up to 2 y	11 (25.6)
Up to 3 y	20 (46.5)
Up to 4 y	3 (7.0)

Table 3 Mean Bone Loss, SD, and Range for the Different Examined Variables

	n	Mean (mm)	SD, range (mm)	P
Maxilla	30	0.99	0.32, 0.24–1.64	.781
Mandible	13	1.00	0.26, 0.27–1.31	
Immediate placement	23	0.88	0.31, 0.24–1.31	.016
Delayed placement	20	1.28	0.23, 0.68–1.64	
Smoking	5	1.02	0.39, 0.35–1.31	.404
Nonsmoking	38	0.99	0.29, 0.24–1.64	
Platform switching				
Yes	9	0.78	0.39, 0.24–1.24	.089
No	34	1.06	0.24, 0.35–1.64	

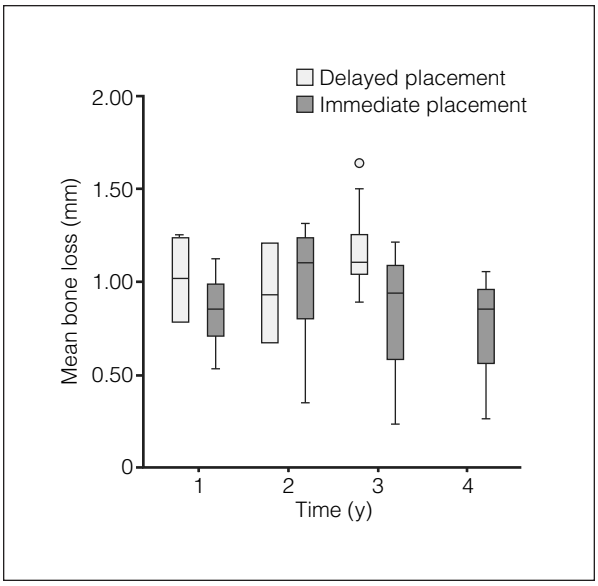

Fig 5 Boxplot representing the bone loss for delayed and immediately placed implants per year.

case, the buccal cusp of a premolar crown had broken off and therefore the crown was remade. This resulted in a crown survival rate of 97.67%.

Discussion

The need to restore a missing or failing tooth as quickly as possible has promoted both immediate placement and immediate loading. Although this may increase the risk for implant failure, according to some authors,[18] none of the implants in this study failed.

Immediately loaded single implants yield survival rates of 91% to 100% and are no different from delayed loaded implants regarding bone loss, survival, or mucosal changes.[26,27] The fact that the implants were immediately loaded with the definitive all-ceramic crown decreased even further the number of treatments and manipulations that may disturb the surrounding tissues and result in additional bone loss.[28]

In the current study, 23 implants were placed directly after tooth extraction into the socket, which resulted in significantly less bone loss compared with delayed implant placement. This is in accordance with Cooper et al[20] and might be explained by the fact that no flap was raised when the implant was placed immediately, which might have reduced the postoperative bone resorption.[29]

From an esthetic point of view, delayed loading will result in soft tissue collapse and recession, while an immediate restoration will support the tissues in their original form.[19]

Although cementable abutments allow correction of a misaligned implant direction, the one-piece screw-retained single crown is still the simplest clinical procedure at placement, with the absence of cementation problems and the advantage of retrievability for maintenance or repair.[30] Gallucci et al[31] compared screw-retained all-ceramic crowns with porcelain-fused-to-metal single crowns. Although none of the crowns fractured, two minor cases of porcelain chipping occurred in the all-ceramic group, which corresponds to the findings in this study.

All crowns were put into occlusion, but lateral or anterior guidance was avoided, which is in accordance to the guidelines suggested by Kim et al.[23] However, as the authors pointed out, there is currently no evidence-based, implant-specific concept of occlusion. Nevertheless, distributing the lateral forces over the natural teeth may have prevented more fractures.

While ceramic framework fracture is rare, chipping of the veneering porcelain is a very common complication.[32] Annual fracture rates are generally higher for fixed partial dentures (FPDs) than for single crowns and range from 2.86% to 12.2%.[33,34] Sailer et al[35] estimated the 5-year complication rate due to chipping to be 13.6% for all-ceramic FPDs, which is significantly higher than metal-ceramic FPDs (2.9%). One of the main reasons for chipping is a lack of support for the porcelain layer.[36] An anatomically shaped substructure is necessary to allow a uniform thickness of the veneering porcelain. However, as can be seen in Fig 4, this is sometimes difficult to achieve with a prefabricated cylinder, as was used in this study and the study by Gallucci et al.[31] On the other hand, the low percentage of porcelain chippings in both studies suggests that a uniform veneer thickness is maybe not as critical as was reported by other authors and is an interesting finding that necessitates confirmation in the long term.

Another reason for porcelain chipping might be related to structural flaws caused by trapping air bubbles prior to firing when building up the porcelain over the core surface.[32] Over time, low temperature degradation may also lead to fracture.[37] Although the exact mechanism is still unclear, water is reacting with the stabilizer, thereby inducing a tetragonal-to-monoclinic transformation and creating microcracks that will lead to fracture of the structure.[38]

Although no fracture of the ceramic cylinder occurred in the current study, the short-term follow-up

does not allow the authors to fully evaluate the long-term effect of the oral environment on zirconia. Therefore, it is advisable to be cautious in using zirconia restorations until long-term research is available.

Conclusion

This short-term follow-up report suggests that a screw-retained all-ceramic crown made from a prefabricated ceramic cylinder has a favorable outcome. In addition, it has the advantages of retrievability, esthetics, and avoiding cement rests. Immediate implant placement resulted in less bone loss and showed comparable success outcomes to the delayed implant placement.

Although there are concerns regarding adequate support of porcelain and porcelain chipping, the number of complications was limited, at least during the mean follow-up of 2 years of loading.

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Literature Abstract

Magnetic resonance imaging-based tumor volume measurements predict outcome in patients with squamous cell carcinoma of the mandible

This retrospective study investigated the benefit of pretreatment magnetic resonance imaging (MRI)-based tumor volume (Tv) in patients with squamous cell carcinoma (SCC) of the mandible. Sixty-two patients who underwent surgical resection for primary SCC in the mandible were examined over a 10-year period. The maximum mean Tv results were obtained over three occasions for each preoperative MRI imaging sequence, and were performed by one author. Patients were followed up for 5 years after surgical resection of the tumor. All cause-specific (ACS) and disease-free (DFS) survival were analyzed using Kaplan-Meier plots, Cox regression analysis, and Fisher exact tests. The results showed that Tv was significant in predicting ACS and DFS at 5 years. Tv was stratified into low, medium, and high risk groups to correlate with the TNM staging system, resulting in the downstaging of tumor stage in 40 of the 62 cases. Clinical and pathologic tumor sizes were not significant in predicting DFS. The authors conclude that Tv measurements using preoperative MRI correlates more accurately with ACS and DFS than clinical or pathologic TNM staging. The stratification of Tv measurements for incorporation into current TNM classification also improves reliability and removes the criterion of automatic upstaging of tumors involving mandibular bone, which is subject to much debate.

Eley KA, Watt-Smith SR, Golding SJ. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2013;115:255–262. **References:** 12.
Reprints: Ms Karen A Eley, Nuffield Department of Surgical Sciences, University of Oxford, John Radcliffe Hospital, Level 6, Headley Way, Oxford OX3 9DU, United Kingdom. **Email:** karen.a.eley@gmail.com—*Teo Juin Wei, Singapore*