Implant-Prosthodontic Classification of the Edentulous Jaw for Treatment Planning with Fixed Rehabilitations

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Purpose: This study aimed to develop a classification of edentulous jaws for use as a diagnostic tool during implant-prosthodontic treatment planning. ***Materials and Methods:*** The morphology of 200 fully edentulous alveolar ridges (100 maxillae, 100 mandibles) was assessed with cone beam computed tomography. Generic implants (length: 8 mm; diameter: 4.1 mm) were used. To develop the classification system, the feasibility of virtually placing the implants without vertical ridge augmentation was considered. Potential implant sites were evaluated in terms of ridge width and described as either type A (no horizontal augmentation required) or type B (horizontal augmentation required). A descriptive statistical analysis of subjects' age, sex, and arch classification was performed. ***Results:*** In total, 880 implants were virtually planned. Based on alveolar ridge height, four arch patterns were identified (C1 to C4), providing a basis for prosthodontic planning with either removable or fixed implant-supported restorations. The frequencies of each category were as follows: C3 (n = 62, 62%), C4 (n = 16, 16%), C2 (n = 12, 12%), and C1 (n = 10, 10%) for the maxilla and C3 (n = 36, 36%), C4 (n = 31, 31%), C1 (n = 24, 24%), and C2 (n = 9, 9%) for the mandible. ***Conclusion:*** The proposed classification of the edentulous arch represents a useful tool for communication between clinicians when planning implant-supported rehabilitations. *Int J Prosthodont 2014;27:320–327. doi: 10.11607/ijp.3791*

The resorption pattern of the alveolar process following tooth extraction has been the subject of many classification systems of the edentulous jaw. Wical and Swoope[1] presented a classification of the edentulous mandible based on 130 orthopantographic radiographs. Their findings revealed that the distance between the basal border of the mandible and the alveolar foramina corresponded to a constant third of the mandible's height when dentate. Based on their measurements, the authors concluded that the architecture of the coronal two-thirds changed markedly after extraction, whereas the apical third remained stable. Lekholm and Zarb[2] used lateral cephalometric radiographs to classify edentulous jaws based on five degrees of alveolar ridge resorption, considering both the form and bone quality of the edentulous jaws. Cawood and Howell[3] investigated morphologic jaw changes of 300 dried skulls and, in agreement with Wical and Swoope,[1] found the basal bone unchanged.[3]

Jensen[4] proposed a classification of edentulous jaws based on the feasibility of implant placement, considering radiographic and clinical parameters as well as the degree of bone remodeling. This classification mainly described implant sites in terms of bone quantity and quality, while also accounting for their proximity to vital structures. However, this study did not consider the buccolingual dimension.

A variety of prosthodontic classifications and treatment protocols for restoring edentulous arches with removable or fixed implant-supported rehabilitations have been presented in the dental literature.[2,5–14] The primary factors considered in these systems have

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been the edentulous jaw anatomy, degree of alveolar bone resorption, available sites for implant placement, and prosthodontic considerations. However, no study has considered all of these parameters collectively. Ideally, an easy-to-use classification system based on the concept of prosthetically-driven treatment would provide valuable information and simple communication tools for the treatment planning of edentulous patients.

Until recently, the focus of dental implantology was the placement of implants. Today, the focus has shifted toward prosthetically driven treatment planning.[15,16] While there is some correlation between the number of implants that can be placed in an arch and the feasible restorative options, the number of implants is not wholly determinative of the final prosthetic design. For example, while eight implants may be the optimal number to achieve a fixed first-molar–to–first-molar prosthesis in the maxilla, the same or a similar result can be achieved with as few as six implants.[17] Thus, there is need for a classification that describes the restorability of the edentulous jaw from a prosthetic perspective. Further, cantilever designs have been used in implant dentistry to avoid vital structures and extensive vertical augmentation, with a prosthetic survival rate of 95% during a follow-up period of 7.3 ± 2.6 years.[18,19]

Today, all important treatment parameters can be evaluated in advance using implant-planning computer software, which has significantly improved preoperative planning.[20–22]

The purpose of a classification system is to describe common patterns of presentation and common nomenclature.[23] Additionally, classification systems facilitate communication among the treatment team as well as between dentists and patients. As will be discussed later in this article, a classification system should not be confused with a treatment protocol.

The aim of this study was to develop and propose a prosthetically-driven classification of edentulous jaws for use as a diagnostic and communication tool during implant-supported prosthetic treatment planning. The ideal treatment was assumed to be a fixed first molar–to–first molar restoration. No distinction was made between a one-piece and segmented prosthesis.

Materials and Methods

The morphology of the residual alveolar ridge was assessed using data collected from cone beam computed tomographic (CBCT) images (i-CAT, Imaging Sciences) of 200 fully edentulous arches (100 maxillae, 100 mandibles). All scans were performed at Harvard School of Dental Medicine, Boston, Massachusetts, as part of each patient's clinical diagnostic workup for implant planning. The Committee on Human Studies of the Harvard Medical School and Harvard School of Dental Medicine approved this retrospective study (no. M22103-101).

A commercially available implant-planning application (SimPlant, Materialise Dental) was used for virtual implant planning. The anatomy of the ridge, presence or absence of vital anatomical structures, and prosthodontic options (fixed or removable) were considered.[24] A generic implant (length: 8 mm; diameter: 4.1 mm) was selected.

In developing the classification, the following criteria were considered: the feasibility of placing implants from first molar to first molar *(1)* without vertical ridge augmentation and *(2)* with or without horizontal ridge augmentation. The implants also could not impinge on any vital anatomical structures. It was elected to allow horizontal but not vertical ridge augmentation based on data showing that the former is predictable, whereas the latter yields lower predictability and significantly higher complication rates.[15]

To analyze the implant distribution, it was determined whether horizontal ridge augmentation was required at each individual implant site.[25] Each implant site was thus classified as follows:

- Type A: no horizontal augmentation required. Alveolar ridge width at the implant site allowed for implant placement while preserving at least 1 mm of native bone on the buccal and lingual aspects.
- Type B: horizontal augmentation required. Alveolar ridge width at the implant site allowed for implant placement, but less than 1 mm of native bone was present on the buccal and/or lingual aspects.

Two calibrated investigators virtually planned the ideal implant placement. Each investigator planned the treatment for 50 mandibles and 50 maxillae. A third investigator confirmed the implant placement, with small adjustments made as necessary. This third investigator also assessed the radiographic morphology of the residual alveolar ridge and recorded the following information for each edentulous arch:

- Subject's age
- Subject's sex
- Number of implants planned
- Maxillary or mandibular arch distribution according to the residual height of the alveolar ridge
- Individual implant category according to alveolar ridge's residual height
- Individual implant category according to alveolar ridge's residual width
- Implant site distribution in each edentulous arch (anterior versus posterior)

Table 1 Implant Distribution

	Anterior	Posterior	Total
Maxilla	284	182	466
Mandible	200	214	414

Table 2 Prosthetically Driven Classification of the Edentulous Arch

	Restoration feasible*			
Category	Fixed M1–M1	Fixed M1–M1 + UC	Fixed short-arch + BC	Removable
C1	x			
C2		x		
C3			x	
C4				x

M1 = first molar; UC = unilateral cantilever; BC = bilateral cantilever.
*Defined by the ability to place implants without vertical ridge augmentation.

A descriptive statistical analysis was performed. Multinomial logistic models were used to investigate any associations between the subjects' age and sex and vertical bone height.

Results

In total, 200 fully edentulous arches (100 maxillae, 100 mandibles) were assessed. A total of 880 implants (466 in the maxilla, 414 in the mandible) were planned according to the selected criteria. Table 1 shows the distribution of implants in the maxilla and mandible. Along with the total number of implants, the distribution of implants is an essential determinant of the restorative design. Figures 1 to 4 show several typical implant-prosthodontic designs. An analysis based on these distributions revealed the type of prosthetic rehabilitation that was possible.

Arch-Based Analysis

The arches were classified into one of four categories (Table 2):

- C1: an arch in which a sufficient number of implants could be planned to permit a fixed first molar–to–first molar prosthesis (Fig 1).
- C2: an arch in which a sufficient number of implants could be planned to permit a fixed first molar–to–first molar prosthesis, but with a unilateral cantilever (Fig 2).
- C3: an arch in which a sufficient number of implants could be planned to permit a fixed short-arch prosthesis. Cantilevers used bilaterally (Fig 3).
- C4: an arch in which only a removable prosthesis could be planned. In the mandible, this prosthesis could be implant supported, but not in the maxilla (Fig 4).

A significant difference was observed in terms of the distribution of categories between the maxilla and mandible (Table 3). In the maxilla, the majority of arches were classified as C3 (62%), followed by C4 (16%), C2 (12%), and C1 (10%). The median age of all maxillary arch subjects was 64.5 years (range: 36 to 92 years). Sex yielded a homogenous distribution across all categories, except for C4, in which a higher number of women (13% vs 3%) were represented (Table 4).

The majority of mandibular arches were classified as C3 (36%), followed by C4 (31%), C1 (24%), and C2 (9%). Compared with the maxillary arches, significantly more mandibular arches were categorized as C1. The median age of all mandibular arch subjects was 66.5 years (range: 41 to 92 years). In contrast to the maxilla, distribution by sex was not homogenous. More men were present in C1, whereas more women were categorized as C2, C3, and C4 (Table 5).

Implant-Based Analysis

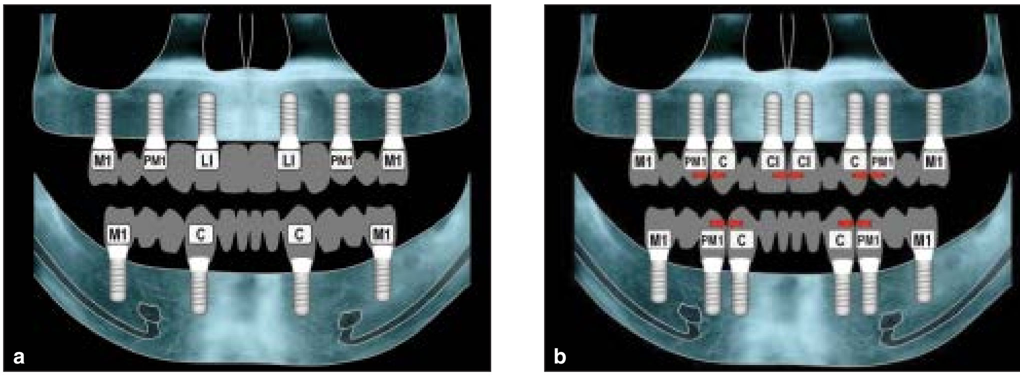
While the project's primary aim was to develop a classification of edentulous arches based on their restorability, an in-depth analysis of the implant distribution by category was also performed (Table 6).

There was a difference in the distribution of implants in the maxilla versus the mandible. A higher number of implants could be planned in the anterior maxilla than in the anterior mandible; in contrast, more implants were possible in the posterior mandible than the posterior maxilla.

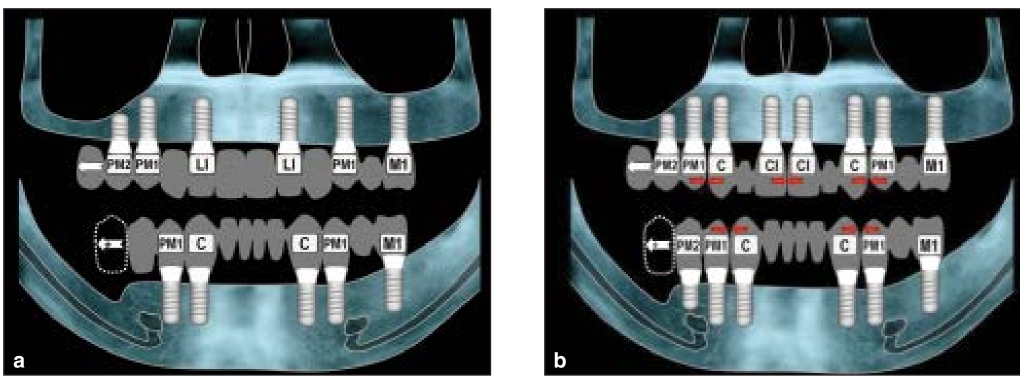
Maxillary implants. Table 7 shows the implant distribution in the maxilla. A total of 466 maxillary implants were planned.

Except for in C1 arches, the majority of implants in the anterior region required ridge augmentation. In the posterior region, the significant majority of implants did not require augmentation.

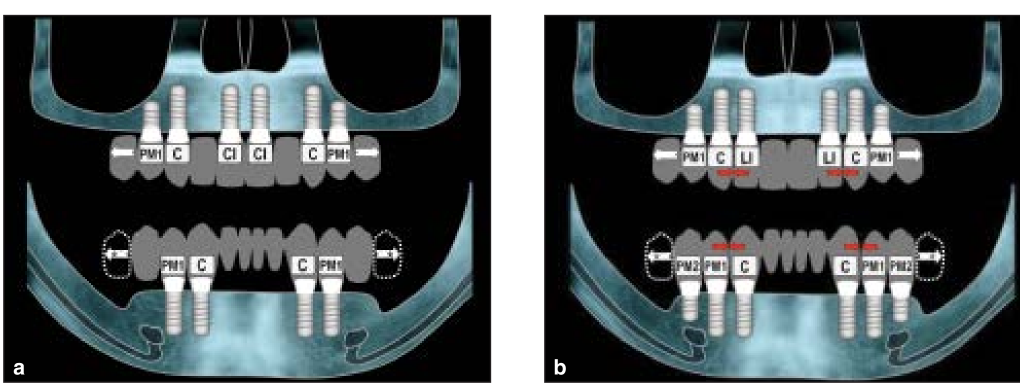
In terms of the total number of implants planned (anterior and posterior regions) in C1 arches, type A implant sites (57.5%) were more common than type B sites (42.5%). For C2 arches, 86 implants were planned. As in C1 arches, type A implant sites (67.4%) were more common than type B sites (32.6%). For C3 arches, 300 implants were planned. Once again, type A implant sites (59.3%) outnumbered type B sites (40.7%). For all maxillary implants, 60.5% were planned for type A implant sites and 39.5% for type B sites.



Figs 1a and 1b Implants permit a fixed first molar–to–first molar prosthesis: **(a)** single unit; **(b)** segmented. Red arrows indicate segmentation zones. M1 = first molar; PM1 = first premolar; C = canine; LI = lateral incisor; CI = central incisor.



Figs 2a and 2b Implants permit a fixed first molar–to–first molar prosthesis but with a unilateral cantilever: **(a)** single unit; **(b)** segmented. Red arrows indicate segmentation zones. White arrows with a gray background indicate a distal cantilever. White arrows with a black background indicate an optional cantilever (when not opposing a fixed implant prosthesis). M1 = first molar; PM2 = second premolar; PM1 = first premolar; C = canine; LI = lateral incisor; CI = central incisor.



Figs 3a and 3b Implants permit a fixed short-arch prosthesis, with cantilevers used bilaterally: **(a)** single unit; **(b)** segmented. Red arrows indicate segmentation zones. White arrows with a gray background indicate a distal cantilever. White arrows with a black background indicate an optional cantilever (when not opposing a fixed implant prosthesis). PM2 = second premolar; PM1 = first premolar; C = canine; LI = lateral incisor; CI = central incisor.

When all maxillary implants in type B sites were considered, a higher percentage (28.1%) of implants were present in the anterior segment than in the posterior segment (11.4%).

Mandibular implants. Table 8 shows the implant distribution in the mandible. A total of 414 mandibular implants were planned.

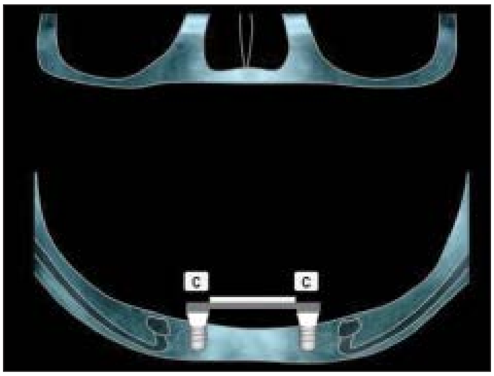


Fig 4 A removable prosthesis represents the only treatment option. In the mandible, this restoration can be implant supported. In the maxilla, only a conventional prosthesis is feasible. C = canine.

Table 3 Category Distribution by Arch

	C1	C2	C3	C4
Maxilla	10%	12%	62%	16%
Mandible	24%	9%	36%	31%

Table 4 Category Distribution in the Maxilla by Sex and Age

	C1	C2	C3	C4	Total
Sex (M/F)	6%/4%	7%/5%	34%/28%	3%/13%	60%/40%
Median age, y (range)	57.5 (40–64)	70 (57–87)	64 (36–92)	66 (53–75)	64.5 (36–92)

M = male; F = female.

Table 5 Category Distribution in the Mandible by Sex and Age

	C1	C2	C3	C4	Total
Sex (M/F)	9%/15%	5%/4%	26%/10%	21%/10%	61%/39%
Median age, y (range)	63 (47–84)	60 (41–76)	68 (53–92)	67 (50–88)	66.5 (41–92)

M = male; F = female.

Table 6 Implant Distribution by Category

Location	C1	C2	C3	C4	Total
Maxilla	80 (17.1%)	86 (18.5%)	300 (64.4%)	0 (0%)	466 (100%)
Mandible	144 (34.8%)	48 (11.6%)	160 (38.6%)	62 (15%)	414 (100%)

Table 7 Implant Distribution in the Maxilla by Category and Type

	C1 (n = 80)	C2 (n = 86)	C3 (n = 300)	C4 (n = 0)	Total (n = 466)
Type A					
Anterior	16 (20%)	23 (26.7%)	114 (38%)	0 (0%)	53 (32.8%)
Posterior	30 (37.5%)	35 (40.7%)	64 (21.3%)	0 (0%)	129 (27.7%)
Total	46 (57.5%)	58 (67.4%)	178 (59.3%)	0 (0%)	282 (60.5%)
Type B					
Anterior	24 (30%)	19 (22.1%)	88 (29.3%)	0 (0%)	131 (28.1%)
Posterior	10 (12.5%)	9 (10.5%)	34 (11.4%)	0 (0%)	53 (11.4%)
Total	34 (42.5%)	28 (32.6%)	122 (40.7%)	0 (0%)	184 (39.5%)

In both the anterior and posterior regions, 82.6% of the implants were planned for type A sites, whereas 17.4% were planned for type B sites.

Compared with the maxilla, where 11.4% of posterior sites required augmentation, a lower percentage (9.9%) of mandibular posterior regions were classified as type B. The same was true for anterior implants, where only 7.5% of sites in the mandible were classified as type B versus 28.1% of sites in the anterior maxilla.

Regarding the total number of mandibular implants, type A implant sites (83.3%) outnumbered type B sites (16.7%) in C1 arches. For C2 arches, 48 implants were planned. Of these, 66.6% were planned for type A sites, and 33.4% were planned for type B sites. For C3 arches, 160 implants were planned. Type A implant sites (85.6%) were much more common than type B sites (14.4%). For C4 arches, 62 implants were planned, with 85.5% type A implant sites and 14.5% type B sites.

Neither sex (P = .42) nor age (P = .18) was significantly associated with vertical bone height in the mandible. Similarly, neither sex (P = .94) nor age (P = .39) was significantly associated with vertical bone height in the maxilla.

Discussion

This study classified the edentulous ridge according to the ideal final prosthesis that could be planned. Only the vertical bone height was considered. While an insufficient buccolingual ridge width may pose difficulties for implant placement, lateral bone augmentation procedures have been shown to be highly predictable and can frequently be performed simultaneously with implant placement.[26,27]

The dynamic process through which a person becomes edentulous plays an important role in determining the final anatomy of the edentulous jaw. This remodeling process is influenced by a number of factors, including anatomical, metabolic, and prosthetic considerations as well as the degree of edentulism.[28–30] In general, the present findings are in accordance with clinical experience. For example, the distribution of implants shows that far fewer implants could be planned in the posterior maxilla than in any other site (see Table 8). This result is due to the expansion of the maxillary sinuses and the alveolar ridge resorption after tooth extraction, which often leads to a more severe atrophy of the maxilla.[31,32]

Cantilevers were included in the classification because there is no significant contraindication to their use. The most frequent complications for this design include abutment or screw loosening, loss of retention, and veneer chipping, all of which can be easily repaired.[18,19] However, additional factors such as cantilever arm length and implant location must be considered when planning cantilever prostheses.[33] One option to avoid the use of cantilevers would be the placement of distally angulated implants. This approach was not used in the present study due to the complexity of the surgical and prosthetic procedures.[34–36]

The difference between the number of men and women classified as C1 and C2 was minimal, but substantially more female patients were categorized as C3 and C4 (ie, the categories with more vertical bone loss). This result is in spite of the fact that men tend to lose teeth at an earlier age.[37] The greater number of women with C3 and C4 arches cannot be explained by age differences; the mean age of "mandibular males" was 64.3 years, while that of "mandibular females" was 67.8 years. The mean ages in the maxillary group were 63.4 years for men and 65.1 years for women. Therefore, it remains unclear why more women showed C3 and C4 arches.

In both the maxilla and mandible, C3 and C4 were the dominant categories (see Table 3). A significant finding was that for C4 arches, which required a removable prosthesis, different treatments were available for the mandible than for the maxilla. In all cases for the mandible, a sufficient number of implants could be planned to permit an implant-supported removable overdenture, whereas it was not possible to plan a sufficient number of implants in the maxilla. This difference results from the fact that only two implants are necessary to support an overdenture in the mandible, whereas four implants are required in the maxilla.[38] In terms of individual implant sites, type A ridges were the most common for both arches. Type B sites were found more frequently in anterior areas than in posterior regions. This result is in agreement with the authors' clinical experience, where maxillary posterior implants require ridge augmentation less frequently than anterior sites due to the resorption pattern of the maxilla.

Table 8 Implant Distribution in the Mandible by Category and Type

	C1 (n = 144)	C2 (n = 48)	C3 (n = 160)	C4 (n = 62)	Total (n = 414)
Type A					
Anterior	39 (27.1%)	15 (31.2%)	62 (38.7%)	53 (85.5%)	169 (40.8%)
Posterior	81 (56.2%)	17 (35.4%)	75 (46.9%)	0.0 (0%)	173 (41.8%)
Total	120 (83.3%)	32 (66.6%)	137 (85.6%)	53 (85.5%)	342 (82.6%)
Type B					
Anterior	9 (6.3%)	3 (6.3%)	10 (6.3%)	9 (14.5%)	31 (7.5%)
Posterior	15 (10.4%)	13 (27.1%)	13 (8.1%)	0.0 (0%)	41 (9.9%)
Total	24 (16.7%)	16 (33.4%)	23 (14.4%)	9 (14.5%)	72 (17.4%)

In contrast to the maxilla, type B mandibular sites were found to be more prevalent in the posterior region than in the anterior region. This, too, is in accordance with clinical experience, where mandibular ridge augmentation for placement of a 4.1-mm-diameter implant is more frequently needed in posterior areas due to anatomical considerations such as the alveolar ridge morphology (lingual concavities, presence of mental foramen, mandibular nerve). In the anterior mandible, the basal bone is wider than the alveolar process.

It must be emphasized that a classification system should not be confused with a treatment modality. A good classification system provides an indication of what treatments are possible but does not prescribe the actual treatment choice. Thus, in the present classification, a patient with a C1 mandible is eligible for a fixed first molar–to–first molar prosthesis. However, for reasons of his choosing (eg, financial concerns), the patient may elect for treatment involving two or three interforaminal implants and an implant-supported overdenture. Such a choice does not change the patient's classification within this system.

Lekholm and Zarb's[2] classification system, which has been widely used in clinical practice and as a research tool, is based on the correlation between bone density and implant survival. In the present study, the classification system proposed does not evaluate bone density. This decision was made because the proposed classification system relies on the analysis of CBCT scans. Hounsfield units, on which bone density is based, are not accurately represented by CBCT. It has been shown that bone density values from CBCT scans are not accurate because they are affected by the position of the object in the machine.[39] Large errors have been demonstrated when using gray scale values quantitiatvely.[40] In addition, artifacts challenge the accurate conversion of density values into Hounsfield units.[41] Thus, bone density was not evaluated in the present study.

One limitation of this study is that it did not account for the length of time that a particular arch or implant site had been edentulous. Thus, it was not possible to investigate the presence of statistically significant correlations between the period of edentulism and the vertical and horizontal bone loss. However, since the purpose of this study was to classify the arches from a prosthetically driven perspective, the authors do not consider this limitation to be critical. After all, when planning a prosthetic rehabilitation, the clinician must work with whatever anatomical condition the patient presents, regardless of how long he or she has been edentulous.

Conclusions

This article proposed a prosthetically driven classification system of the edentulous jaw. The classification system is easy to use and should facilitate communication among practitioners as well as between practitioners and patients. For communication with patients, the authors recommend the use of this classification in conjunction with representative images, such as those shown in this article.

Acknowledgments

The authors express their gratitude to Professor Rebecca Betensky, Department of Biostatistics, Harvard School of Public Health, Harvard University, for her assistance with the statistical analysis. The authors reported no conflicts of interest related to this study.

References

1. Wical KE, Swoope CC. Studies of residual ridge resorption. I. Use of panoramic radiographs for evaluation and classification of mandibular resorption. J Prosthet Dent 1974;32:7–12.
2. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark PI, Zarb GA, Albrektsson T (eds). *Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry.* Chicago, IL: Quintessence, 1985:199–209.
3. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg 1988;17:232–236.
4. Jensen O. Site classification for the osseointegrated implant. J Prosthet Dent 1989;61:228–234.
5. Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1–132.
6. Jemt T. Fixed implant-supported prostheses in the edentulous maxilla. A five-year follow-up report. Clin Oral Implants Res 1994; 5:142–147.
7. MacEntee MI, Walton JN. The economics of complete dentures and implant-related services: A framework for analysis and preliminary outcomes. J Prosthet Dent 1998;79:24–30.
8. Zitzmann NU, Marinello CP. Treatment plan for restoring the edentulous maxilla with implant-supported restorations: Removable overdenture versus fixed partial denture design. J Prosthet Dent 1999;82:188–196.
9. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. Clin Oral Implants Res 2000;11(suppl 1): 108–125.
10. Weingart D, Bruggenkate CM. Treatment of fully edentulous patients with ITI implants. Clin Oral Implants Res 2000;11(suppl 1): 69–82.
11. Payne AG, Tawse-Smith A, Kumara R, Thomson WM. One-year prospective evaluation of the early loading of unsplinted conical Brånemark fixtures with mandibular overdentures immediately following surgery. Clin Implant Dent Relat Res 2001;3:9–19.
12. Belser UC, Bernard JP, Buser D. Implants in the esthetic zone. In: Lang NP and Lindhe J (eds). Clinical *Periodontology and Implant Dentistry.* Oxford: Blackwell; 2008:1146–1174.
13. Gallucci GO, Bernard JP, Bertosa M, Belser UC. Immediate loading with fixed screw-retained provisional restorations in edentulous jaws: The pickup technique. Int J Oral Maxillofac Implants 2004;19:524–533.
14. Gallucci GO, Bernard JP, Belser UC. Treatment of completely edentulous patients with fixed implant-supported restorations: Three consecutive cases of simultaneous immediate loading in both maxilla and mandible. Int J Periodontics Restorative Dent 2005;25:27–37.
15. Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. Int J Oral Maxillofac Implants 2009;24 (suppl):272–278.
16. Tyndall DA, Price JB, Tetradis S, Ganz SD, Hildebolt C, Scarfe WC. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol 2012;113:817–826.
17. Lambert FE, Weber HP, Susarla SM, Belser UC, Gallucci GO. Descriptive analysis of implant and prosthodontic survival rates with fixed implant-supported rehabilitations in the edentulous maxilla. J Periodontol 2009;80:1220–1230.
18. Greenstein G, Cavallaro J Jr. Cantilevers extending from unilateral implant-supported fixed prostheses: A review of the literature and presentation of practical guidelines. J Am Dent Assoc 2010;141:1221–1230.
19. Romanos GE, Gupta B, Eckert SE. Distal cantilevers and implant dentistry. Int J Oral Maxillofac Implants 2012;27:1131–1136.
20. Katsoulis J, Pazera P, Mericske-Stern R. Prosthetically driven, computer-guided implant planning for the edentulous maxilla: A model study. Clin Implant Dent Relat Res 2009;11:238–245.
21. Ganz SD. Presurgical planning with CT-derived fabrication of surgical guides. J Oral Maxillofac Surg 2005;63:59–71.
22. Avrampou M, Mericske-Stern R, Blatz MB, Katsoulis J. Virtual implant planning in the edentulous maxilla: Criteria for decision making of prosthesis design. Clin Oral Implants Res 2013;24 (suppl):152–159.

23. Pieramici DJ, Sternberg P Jr, Aaberg TM Sr, et al. A system for classifying mechanical injuries of the eye (globe). The Ocular Trauma Classification Group. Am J Ophthalmol 1997;123:820–831.
24. Casentini P, Wismeijer D, Chiapasco M. Treatment options for the edentulous arch. In: Wismeijer D, Casentini P, Gallucci G, Chiapasco M (eds). *ITI Treatment Guide. Vol 4: Loading Protocols in Implant Dentistry: Edentulous Patients.* Chicago, IL: Quintessence, 2010:35–56.
25. Fu JH, Wang HL. Horizontal bone augmentation: The decision tree. Int J Periodontics Restorative Dent 2011;31:429–436.
26. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants 2009; 24(suppl):237–259.
27. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: Clinical results with different bone grafts and bone-substitute materials. Int J Oral Maxillofac Implants 2009;24(suppl):218–236.
28. Atwood DA. Postextraction changes in the adult mandible as illustrated by microradiographs of mid-sagital sections and serial cephalometric roentgenograms. J Prosthet Dent 1963;13: 810–824.
29. Baylink DJ, Wergedal JE, Yamamoto K, Manzke E. Systemic factors in alveolar bone loss. J Prosthet Dent 1974;31:486–505.
30. Enlow DH, Bianco HJ, Eklund S. The remodeling of the edentulous mandible. J Prosthet Dent 1976;36:685–693.
31. Percac S, Nikolić V. Influence of teeth loss on morphometric characteristics of the maxilla. Acta Stomatol Croat 1991;25:199–205.
32. Hoffmann KD. Anatomic considerations in the partially and fully edentulous maxilla. Atlas Oral Maxillofac Surg Clin North Am 1994;2:31–39.
33. Kim P, Ivanovski S, Latcham N, Mattheos N. The impact of cantilevers on biological and technical success outcomes of implant-supported fixed partial dentures. A retrospective cohort study. Clin Oral Implants Res 2014;25:175–184.
34. Salvi GE, Brägger U. Mechanical and technical risks in implant therapy. Int J Oral Maxillofac Implants 2009;24(suppl):69–85.
35. Sorrentino R, Gherlone EF, Calesini G, Zarone F. Effect of implant angulation, connection length, and impression material on the dimensional accuracy of implant impressions: An in vitro comparative study. Clin Implant Dent Relat Res 2010;12 (suppl 1):63–76.
36. Ata-Ali J, Peñarrocha-Oltra D, Candel-Marti E, Peñarrocha-Diago M. Oral rehabilitation with tilted dental implants: A metaanalysis. Med Oral Patol Oral Cir Bucal 2012;17:582–587.
37. Al-Shammari KF, Al-Khabbaz AK, Al-Ansari JM, Neiva R, Wang HL. Risk indicators for tooth loss due to periodontal disease. J Periodontol 2005;76:1910–1918.
38. Sadowsky SJ. Treatment considerations for maxillary implant overdentures: A systematic review. J Prosthet Dent 2007;97: 340–348.
39. Eskandarloo A, Abdinian M, Salemi F, Hashemzadeh Z, Safaei M. Effect of object location on the density measurement in cone-beam computed tomography versus multislice computed tomography. Dent Res J 2012;9(suppl 1):S81–S87.
40. Pauwels R, Nackaerts O, Bellaiche N, et al. Variability of dental cone beam CT grey values for density estimations. Br J Radiol 2013;86:20120135.
41. Molteni R. Prospects and challenges of rendering tissue density in Hounsfield units for cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:105–119.

Literature Abstract

Poor oral health and quality of life in older US adults with diabetes mellitus

This cross-sectional study examined the association between health-related quality of life (HRQOL), dentate status, and receipt of dental care in US adults ages 65 and older with diabetes mellitus (DM) using Behavioral Risk Factor Surveillance System (BRFSS) data. Oral health measures included length of time since last dental visit, number of permanent teeth removed due to caries or periodontal disease, and years since last dental cleaning. These measures were evaluated in correspondence with self-rated health measures. It was shown that worse oral health measures were most consistently associated with worse self-rated health measures, more physically unhealthy days, followed by more activity limitation days. The authors concluded that poor oral health, specifically fewer permanent teeth and lack of recent dental care, were associated with worse HRQOL in older US adults with DM. They emphasized the need for expanding health care coverage to include dental care focusing on its availability as well as its method of preventing dental caries and periodontal disease in this potentially vulnerable population.

Huang DL, Chan KC, Young BA. *J Am Geriatr Soc* 2013;61:1782–1788. **References:** 28. **Reprints:** Deborah L. Huang, Geriatric Research, Education and Clinical Center (S-182-GRECC), Veterans Affairs Puget Sound Health Care System, 1660 S Columbian Way, Seattle, WA 98108, USA. Email: huangdx@u.washington.edu—*Huong Nguyen, Ann Arbor, Michigan, USA*