Macro design morphology of endoseous dental implants

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Statement of problem. The identification of dental implant bodies in patients without available records is a considerable problem due to increased patient mobility and to the large number of implant systems with different designs.
Purpose. The purpose of this study was to document the designs of selected implants to help clinicians identify these implants from their radiographic images.
Material and methods. More than 50 implant manufacturers were contacted and asked to provide implants with dimensions as close as possible to 3.75 mm (diameter) × 10 mm (length). Forty-four implants were donated, separated into threaded and nonthreaded categories, and further sorted into tapered and nontapered categories. The implants were examined visually, and features on the entire circumference and length of each implant were recorded and categorized as coronal, midbody, or apical.
Results. A series of tables describe the 44 implants according to coronal, midbody, and apical features.
Conclusion. The results of this project offer dentists basic knowledge of the design of selected dental implants. Such knowledge can aid the radiographic identification of these implants. (J Prosthet Dent 2002;87:543-51.)

CLINICAL IMPLICATIONS

The identification of dental implant systems in patients without available records is necessary for successful restoration and in forensic dentistry. This study documents the basic design of a significant number of implants, thereby enabling dentists to identify implants from radiographic images.

The use of dental implants to replace the form and function of lost natural dentition has become a significant treatment option.[1] Various manufacturers have responded to enthusiasm for this protocol by developing new implant designs to improve treatment outcomes. Binon[2] indicated that more than 90 root-form implants are available "in a variety of diameters, lengths, surfaces, platforms, interfaces, and body designs." While dentistry has benefitted from these developments, keeping up with the continuous influx of new implants is difficult. The identification of older and newly developed designs can pose a problem for the restorative dentist treating a patient with no records or for the forensic dentist attempting to identify a victim.[3]

Radiographic imaging is a useful adjunct in all phases of implant treatment. The burgeoning acceptance of radiographic devices has been attributed, in part, to the increasingly sophisticated imaging techniques used in preoperative treatment planning, intraoperative assessment, and postoperative assessment.[4] Radiographs also could be adjuncts in implant identification.

Sewerin[3] stated that a dentist must be familiar with implant designs and with the principles of radiographic image formation before radiographs can be used for implant identification. This study documents the 3-dimensional design of selected implants. Different horizontal rotations or vertical inclinations of the implant relative to the radiographic beam can produce numerous 2-dimensional representations of the 3-dimensional design. The information provided in this study will facilitate a clinical understanding of the 2-dimensional representation of implants seen in radiographs.

MATERIAL AND METHODS

Letters were sent to more than 50 implant manufacturers requesting implants with dimensions as close as possible to 3.75 mm (diameter) × 10 mm (length). Forty-four implants were donated (Table I). Some

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Table I. Implants used in this study and their manufacturers

Implant name	Implant manufacturer
Ace Cylinder 09222012	Ace Dental Implant System, Brockton, Mass.
Ace Screw 20101022	Ace Dental Implant System
Astra Fixture 4.0	Astra Tech Inc, Lexington, Mass.
Astra Fixture ST 4.5	Astra Tech Inc
Bicon	Bicon Dental Implants, Boston, Mass.
Biohorizons 4 mm D1	Biohorizons Implant System Inc, Birmingham, Ala.
Biolock IHSSHA410	Biolock International Inc, Deerfield Beach, Fla.
Brånemark SDCA 023	Nobelpharma AB, Goteberg, Sweden
Brånemark MkII SDCA 220	Nobelpharma AB
Brånemark MkIll 25977	Nobelpharma AB
Friatec-2 stepped cylinder	Friadent, Irvine, Calif.
Friatec-2 stepped screw	Friadent
Innova 01B-9I1	Innova, Toronto, Ontario, Canada
Integral 0802	Sulzer Calcitek, Carlsbad, Calif.
Spline 1980	Sulzer Calcitek
Imtec 406981	Imtec Corporation, Ardmore, Okla.
Imtec 406981	Imtec Corporation
ITI HC 042.108 S	Institut Straumann AG, Waldenburg, Switzerland
ITI Solid Screw 042.242 S	Institut Straumann AG
LaminOss	Impladent Ltd, Holliswood, N.Y.
IMZ TPS 8039SR	Interpore International, Irvine, Calif.
Minimatic IHCSHA315	Minimatic Implant Technology, Boca Raton, Fla.
Minimatic IHPSS410	Minimatic Implant Technology
O Company 4010TE	O Company Inc, Albuquerque, N.M.
O Company 4010	O Company Inc
Osteoimplant 375010	Osteo-Implant Corporation, New Castle, Pa.
Paragon Bio-Vent BV10 (00112)	Paragon Implant Company, Encino, Calif.
Paragon Micro-Vent MTH10 (01141)	Paragon Implant Company
Paragon Complete Screw-Vent CSVB10 (01129)	Paragon Implant Company
Parc Press-fit Star V057	Park Dental Research Corp, New York, N.Y.
Parc Starlock Star V003	Park Dental Research Corp
Parc Starvent Star V044	Park Dental Research Corp
Restore R9005-40-10	Lifecore Biomedical Inc, Chaska, Minn.
Sargon	Sargon Dental Implants, Beverly Hills, Calif.
Replace 43101	Sterioss Dental Implants, Yorba Linda, Calif.
Sterioss Cyl 2810 TPS	Sterioss Dental Implants
Sterioss 2210	Sterioss Dental Implants
Sterngold Implamed 911117	Sterngold Implamed Dental Implant Systems, Attleboro, Mass.
Sterngold Implamed 921236	Sterngold Implamed Dental Implant Systems
Sustain 410030-42-10	Lifecore Biomedical Inc
Tenax 10X-S	Tenax Dental Implant System, Collingwood, Ontario, Canada
3i Cylinder TP413	Implant Innovations Inc, Palm Beach Gardens, Fla.
3i Osteotite OSS 410	Implant Innovations Inc
3i TG 2410	Implant Innovations Inc

manufacturers sent multiple implants of various designs.

The implants were separated into threaded and nonthreaded categories and then further sorted into tapered and nontapered. Within each group, the implants were arranged alphabetically, and each implant was assigned a number. All implants were placed in a storage box with multiple sections, each marked with the name and number of each implant. The division of the implants is represented in Figure 1 (to relate implant number and name, see Tables II through IV).

The implants were examined individually. Features were chosen arbitrarily to help describe the implants and were categorized as coronal, midbody, or apical. Each of these categories represented one third of the implant. The coronal features (Table II) included a description of the prosthetic interface, the flange (the area between the prosthetic interface and the implant body), and any unique characteristics in the coronal

Table II. Coronal features of implants used in study

Implant number	Implant name	External hex	Internal hex	Morse taper	Other	Wider flange	Straight flange	Flared flange	Unique feature
1	Friatec-2 stepped cylinder		✓				✓		
2	Innova 01B-9I1	✓					✓		
3	Ace Cylinder O9222012	✓					✓		
4	Biolock IHSSHA410	✓				✓			
5	Imtec 406981	✓					✓		
6	IMZ TPS 8039SR				✓		✓		
7	Integral 0802				✓		✓		
8	ITI HC 042.108 S			✓				✓	
9	Minimatic IHCSHA315	✓				✓			
10	O Company 4010TE				✓		✓		Groove just below flange
11	Paragon Bio-Vent BV10 (00112)		✓				✓		
12	Parc Press-fit Star V057				✓		✓		
13	Sterioss Cyl 2810 TPS	✓				✓			
14	Sterngold Implamed 921236	✓					✓		
15	Tenax 10X-S				✓			✓	
16	3i Cylinder TP413	✓				✓			
17	Friatec-2 stepped screw		✓				✓		
18	Paragon Micro-Vent MTH10 (01141)		✓				✓		
19	Replace 43101	✓				✓			
20	Restore R9005-40-10	✓				✓			
21	Ace Screw 20101022	✓					✓		
22	Astra Fixture 4.0			✓			✓		
23	Astra Fixture ST 4.5			✓				✓	Fine threads on entire flange
24	Bicon				✓				No flange
25	Biohorizons 4 mm D1	✓				✓			
26	Brånemark SDCA 023	✓				✓			
27	Brånemark MkII SDCA 220	✓				✓			
28	Brånemark MkIll 25977	✓				✓			
29	Imtec 406981	✓				✓			
30	ITI Solid Screw 042.242 S			✓				✓	
31	LaminOss				✓				Elliptical flange
32	Minimatic IHPSS410	✓				✓			
33	O Company 4010				✓		✓		
34	Osteoimplant 375010	✓				✓			
35	Paragon Complete Screw-Vent CSVB10 (01129)				✓	✓			
36	Parc Starlock Star V003				✓	✓			
37	Parc Starvent Star V044				✓			✓	
38	Sargon	✓				✓			
39	Spline 1980				✓	✓			
40	Sterioss 2210				✓	✓			
41	Sterngold Implamed 911117	✓					✓		
42	Sustain 410030-42-10	✓					✓		
43	3i Osteotite OSS 410	✓				✓			
44	3i TG 2410			✓				✓	Apical part of flare grooved

Table III. Midbody features of implants used in study

Implant number	Implant name	Tapered	Non-tapered	Threaded	Non-threaded	V-shaped threads	Square threads	Reverse buttress threads	Grooves	Unique feature
1	Friatec-2 stepped cylinder	✓			✓				3	Stepped
2	Innova 01B-9I1	✓			✓					
3	Ace Cylinder O9222012		✓		✓					
4	Biolock IHSSHA410		✓		✓					Diamond-shaped matrix
5	Imtec 406981		✓		✓					
6	IMZ TPS 8039SR		✓		✓					
7	Integral 0802		✓		✓					
8	ITI HC 042.108 S		✓		✓					
9	Minimatic IHCSHA315		✓		✓				4	
10	O Company 4010TE		✓		✓					
11	Paragon Bio-Vent BV10 (00112)		✓		✓				3	
12	Parc Press-fit Star V057		✓		✓				∞	Multiple short grooves
13	Sterioss Cyl 2810 TPS		✓		✓				2	
14	Sterngold Implamed 921236		✓		✓					
15	Tenax 10X-S		✓		✓					
16	3i Cylinder TP413		✓		✓					
17	Friatec-2 stepped screw	✓		✓		✓			3	Stepped
18	Paragon Micro-Vent MTH10 (01141)	✓		✓		✓				2 types of coatings and threads
19	Replace 43101	✓		✓				✓		Very thin threads
20	Restore R9005-40-10	✓		✓				✓		
21	Ace Screw 20101022		✓	✓		✓				
22	Astra Fixture 4.0		✓	✓		✓				
23	Astra Fixture ST 4.5		✓	✓		✓				
24	Bicon		✓	✓		✓				
25	Biohorizons 4 mm D1		✓	✓			✓			
26	Brånemark SDCA 023		✓	✓		✓				
27	Brånemark MkII SDCA 220		✓	✓		✓				
28	Brånemark MkIII 25977		✓	✓		✓				
29	Imtec 406981		✓	✓		✓				
30	ITI Solid Screw 042.242 S		✓	✓				✓		
31	LaminOss		✓	✓		✓				Very wide threads
32	Minimatic IHPSS410		✓	✓				✓		
33	O Company 4010		✓	✓		✓				
34	Osteoimplant 375010		✓	✓		✓				
35	Paragon Complete Screw-Vent CSVB10 (01129)		✓	✓		✓				Top treated, bottom machined
36	Parc Starlock Star V003		✓	✓				✓		Threads a combination of reverse buttress and square
37	Parc Starvent Star V044		✓	✓				✓		
38	Sargon		✓	✓				✓		Expanding screw in middle of body
39	Spline 1980		✓	✓		✓				
40	Sterioss 2210		✓	✓				✓		Very thin threads
41	Sterngold Implamed 911117		✓	✓		✓				
42	Sustain 410030-42-10		✓	✓			✓			Threads on top half of body
43	3i Osteotite OSS 410		✓	✓		✓				Top machined, bottom treated
44	3i TG 2410		✓	✓		✓				

Table IV. Apical features of implants used in study

Implant number	Implant name	V-shaped apex	Flat apex	Curved apex	Round hole	Oblong hole	Apical chamber	Grooves	Unique feature
1	Friatec-2 stepped cylinder			✓				3	Grooves continuous with body
2	Innova 01B-9I1		✓						
3	Ace Cylinder O9222012			✓	8				2 rows of holes
4	Biolock IHSSHA410		✓				✓		
5	Imtec 406981			✓	4				
6	IMZ TPS 8039SR			✓		4			
7	Integral 0802			✓	4				
8	ITI HC 042.108 S		✓		3		✓		
9	Minimatic IHCSHA315		✓				✓	4	Grooves continuous with body
10	O Company 4010TE			✓				2	2 grooves with 1 dimple each
11	Paragon Bio-Vent BV10 (00112)			✓	3		✓		Holes at end of body grooves
12	Parc Press-fit Star V057		✓						
13	Sterioss Cyl 2810 TPS			✓	2				Holes and grooves alternate
14	Sterngold Implamed 921236			✓		4			
15	Tenax 10X-S	✓							
16	3i Cylinder TP413			✓		4			
17	Friatec-2 stepped screw	✓						3	Grooves continuous with body
18	Paragon Micro-Vent MTH10 (01141)			✓	2				
19	Replace 43101			✓					
20	Restore R9005-40-10		✓				✓		
21	Ace Screw 20101022		✓			2	✓	4	
22	Astra Fixture 4.0		✓					3	
23	Astra Fixture ST 4.5		✓					3	
24	Bicon		✓						
25	Biohorizons 4 mm D1		✓					4	
26	Brånemark SDCA 023		✓		2		✓	4	
27	Brånemark MkII SDCA 220		✓					3	Very wide grooves
28	Brånemark MkIII 25977		✓					3	Very wide grooves
29	Imtec 406981		✓		2		✓	4	
30	ITI Solid Screw 042.242 S			✓					
31	LaminOss			✓					
32	Minimatic IHPSS410		✓		2		✓	4	
33	O Company 4010			✓				2	Dimples in grooves
34	Osteoimplant 375010		✓		2		✓	4	
35	Paragon Complete Screw-Vent CSVB10 (01129)		✓			2	✓	2	Holes in grooves
36	Parc Starlock Star V003			✓	2			4	
37	Parc Starvent Star V044			✓				3	
38	Sargon								Split flared apex. Expanding screw in middle
39	Spline 1980		✓					3	
40	Sterioss 2210		✓		2			2	Holes in grooves
41	Sterngold Implamed 911117		✓		2		✓	4	
42	Sustain 410030-42-10			✓					4 apical dimples
43	3i Osteotite OSS 410		✓					4	
44	3i TG 2410		✓					4	

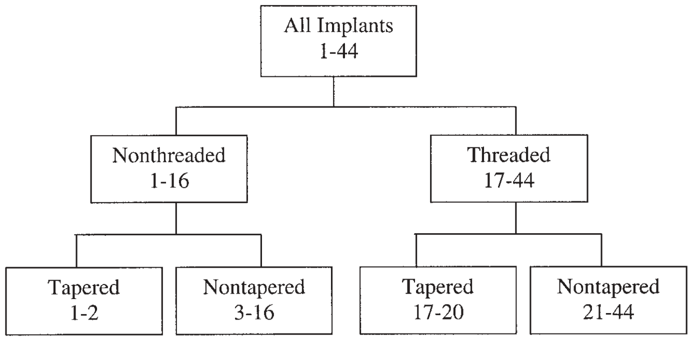

Fig. 1. Division of implants.

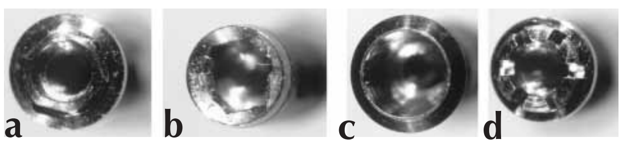

Fig. 2. *(a)* External hex in Brånemark SDCA 023. *(b)* Internal hex in Paragon Bio-Vent BV10 (00112). *(c)* Morse taper in ITI Solid Screw 042.242 S. *(d)* Spline interface in Spline 1980.

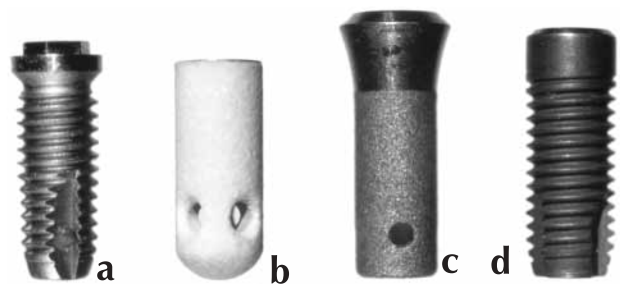

Fig. 3. *(a)* Wider flange in Brånemark SDCA 023. *(b)* Straight flange in IMZ TPS 8039 SR. *(c)* Flared flange in ITI HC 042.108 S. *(d)* Straight flange in Astra Fixture 4.0.

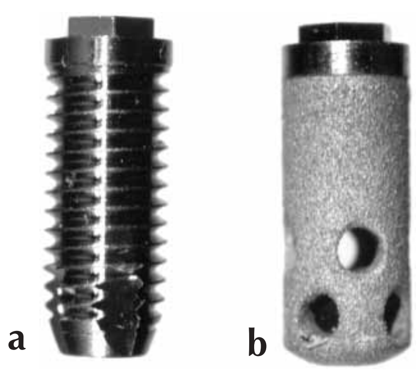

Fig. 4. *(a)* Threaded Osteoimplant 375010. *(b)* Nonthreaded Ace Cylinder 09222012.

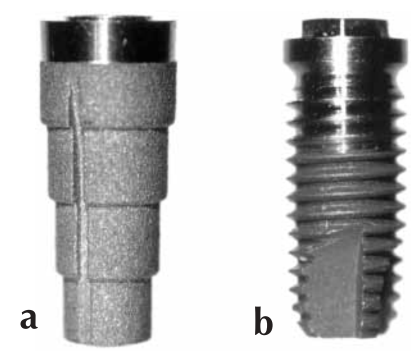

Fig. 5. *(a)* Tapered Friatec-2 stepped cylinder. *(b)* Nontapered 3i Ossteotite OSS410.

area. The prosthetic interface was described as an external hex, internal hex, Morse taper, or "other" (Fig. 2). The latter included all prosthetic interfaces not mentioned, such as the spline interface of the Spline 1980. The flange was described as wider (flange was wider than the implant body), straight (straight transition from the implant body to the flange), or flared (smooth flare from the implant body to the prosthetic interface) (Fig. 3). When there was doubt as to whether the flange was wider or straight, the outer ends of the implant threads were examined with a ruler and magnification. If the lateral end of the threads and the outer end of the flange coincided, the flange was considered straight.

Table III lists the midbody features: threaded or nonthreaded (Fig. 4), tapered or nontapered (Fig. 5), the shape of the threads when present, the presence of grooves, and any unique characteristics. Three shape categories were established for thread design (Fig. 6): v-shaped point = both arms of the threads were equal in length and ended in a point; square = the arms of the threads were nearly parallel and ended in a flat; and reverse buttress = one arm of the thread (usually the upper) was longer than the other and the 2 arms met in a point, creating a Christmas tree effect.

Table IV lists the apcial features: the shape of the apex, the presence of any holes, the presence of an apical chamber (Fig. 7), the presence of grooves, and any

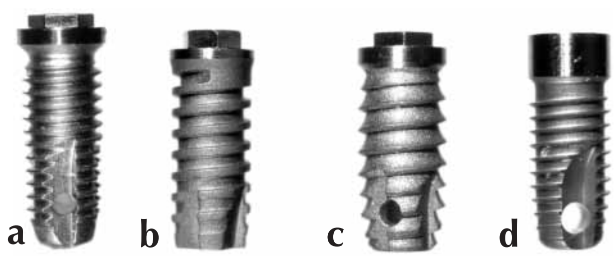

Fig. 6. *(a)* V-shaped threads in Brånemark SDCA 023. *(b)* Square threads in Biohorizons 4 mm D1. *(c)* Reverse buttress threads in Minimatic IHPSS410. *(d)* Reverse buttress threads in Sterioss 2210.

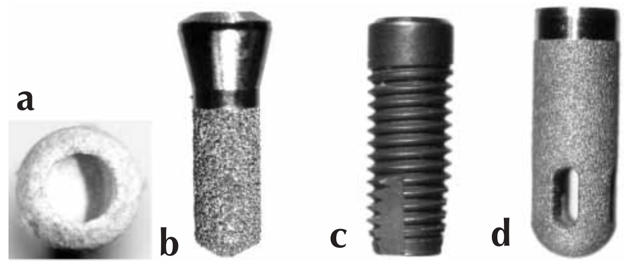

Fig. 7. *(a)* Apical chamber in Minimatic IHCSHA315. *(b)* V-shaped apex in Tenax 10-S. *(c)* Flat apex in Astra Fixture 4.0. *(d)* Curved apex in Integral 0802.

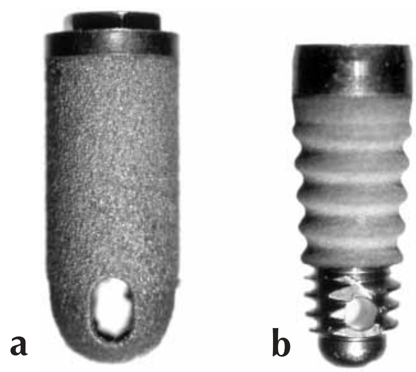

Fig. 8. *(a)* Oblong hole in Sterngold Implamed 921236. *(b)* Round hole in Paragon Micro-Vent MTH10 (01141).

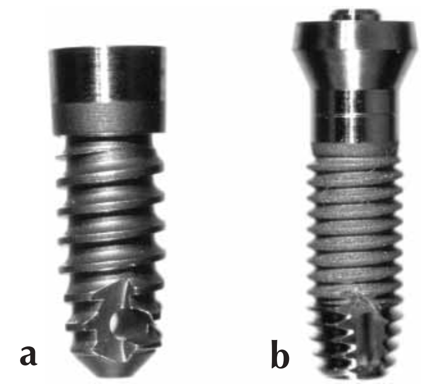

Fig. 9. *(a)* Parc Starlock V003 threads were classified as reverse buttress even though ends of threads are square. *(b)* Paragon Complete Screw-Vent CSVB10 (01129) flange was described as wider even though top is flared.

unique characteristics. Three shape categories were established (Fig. 7): v-shaped = the apex ended in a point; flat = the tip was flat; and curved = the apex was neither v-shaped nor flat, regardless of the amount of curvature. The holes were described as oblong or round (Fig. 8).

RESULTS

Tables II through IV describe the 44 implants according to coronal, midbody, and apical features, respectively.

DISCUSSION

Many implants have perforations, grooves, apical chambers, and threads that influence the radiographic image of the implant. Some features may be unique and enable recognition of specific products, but many features may confuse the interpretation of an implant image.[5] Such confusion results from the fact that multiple images can be produced by the same implant depending on the relationship of the feature in question to the radiographic beam.

Sewerin[3] demonstrated the complexity of radiographic images with a Brånemark Mark I implant. He explained that, because vertical cuts or grooves are present apically, the apical part of the implant could appear conical in a radiographic image. The implant appears most cylindrical when the grooves are perpendicular to the radiographic beam. As the orientation of the grooves to the radiographic beam changes, the shape of the apical part changes and looks tapered to various degrees at different horizontal rotations.

Knowledge of implant designs could aid in the radiographic identification of implants. Consider the Brånemark standard implant at different horizontal rotations to the x-ray beam. The implant has 2 holes and a chamber in the apical region. It can be predicted that the apical perforations may appear differently depending on the degree of rotation of the implant.[6] If the longitudinal axes of the apical holes are perpendicular to the film plane, they will appear as a radiolucent circle on the radiograph as the 2 perforations coincide and the radiographic beam passes through both holes, without obstruction, along the same line. If the implant is horizontally rotated approximately 45 degrees, 2 less radiolucent circles will appear. As at altered rotations, the holes will not line up with the radiographic beam, and the beam therefore will pass through each hole individually, creating 2 images. As part of the implant body overlaps

Fig. 10. Partially grooved flange of 3i TG 2410 implant.

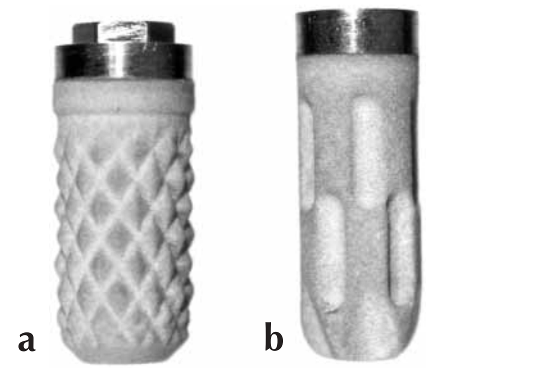

Fig. 11. *(a)* Matrix-like pattern on body of Biolock IHSSHA410 implant could appear as pseudo-threads on radiograph. *(b)* Multiple grooves on body of Parc Press-fit V057 could appear as pseudo-threads on radiograph.

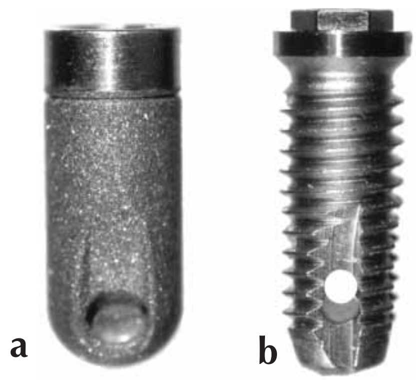

Fig. 12. *(a)* Dimple in apical area of O Company 4010TE. *(b)* Hole in apical area of Brånemark SDCA 023.

the holes on both sides, the holes will not be completely radiolucent and may vary in shape. If the longitudinal axes of the holes are at 90 degrees to the radiographic beam, or parallel to the film, only half of each hole will face the beam. The image will be seen as 2 semicircular radiolucencies at the edge of the implant body, with the radiolucency of the apical chamber in between. The apical chamber will be clear in this view because it will not be masked by the image of the holes.

When an implant is described as having 2 holes in the apical area, they actually are 2 openings of the same channel on different surfaces of the implant. Four holes would correlate to 2 channels, and so on. These openings are described as "holes" for ease of understanding.

Given the lack of standardized terminology used to describe implant features in the literature, a few implant classifications in Tables II through IV may confuse some readers. Parc Starlock Star V003 implants, for example, have threads that appear to be reverse buttresses but that have a flat end like square threads (Fig. 9). These implants were classified as reverse buttress because that seemed to be the more striking feature. Similarly, the flange of the Paragon Complete Screw-Vent CSVB10 (01129) implant was described as wider even though the top portion is flared. The former description seemed more appropriate because the flare is not a smooth flare from the body of the implant to the prosthetic interface (Fig. 9).

Familiarity with implant design not only helps with radiographic identification but also may be an asset in clinical judgment of a radiographic image. Consider the 3i TG 2410 implant (Fig. 10), which has grooves only on the apical half of the flared flange. A clinician unfamiliar with this design feature might assume (incorrectly) that a radiograph with grooves apparent only on the apical half is of no diagnostic value, as the coronal threads cannot be viewed. Similarly, Biolock IHSSHA410 and Parc Press-fit V057 implants have a matrix-like pattern and multiple grooves on the entire body, respectively (Fig. 11). Both implants could produce a pseudo-threaded image on the radiograph and confuse a clinician unfamiliar with their design. Yet another example is the O Company 4010TE implant, which has a dimple in the apical area rather than a round hole, like the Brånemark SDCA 023 (Fig. 12). The dimple will produce relatively radiolucent circle(s) or parts thereof depending on the horizontal rotation of the implant in the radiograph, but never the completely radiolucent circle(s) or parts thereof produced by the hole in the Brånemark SDCA 023.

Due to resource, space, and time limitations, all implant systems on the market could not be included in this study. The inclusion or exclusion of any particular system is not meant to infer its superiority or inferiority.

CONCLUSIONS

The principles of radiographic image formation are understood by most clinicians. This project was undertaken to add to that knowledge base by documenting the basic design features of selected implants. This information should aid in the identification of implants from their radiographic images.

The donation of all implants by their respective manufacturers is acknowledged and appreciated.

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