Radiographic identification of threaded 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 features that would help dentists identify threaded implant bodies 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, 28 of which were identified as threaded. Radiographs were made of these implants at 0°, 30°, 60°, and 90° horizontal rotation combined with –20°, –10°, 0°, +10°, and +20° vertical inclination relative to the radiographic beam and film. A total of 20 images per implant were taken and examined to identify consistent, unique features that would aid in implant identification. At a 20° vertical inclination, vital features of implants were distorted enough to be deemed unrecognizable. Therefore, only those observations made from radiographs between –10° and +10° vertical inclination were used for implant identification purposes.
Results. All implants could be recognized from radiographs made between –10° and +10° vertical inclination. A series of tables and flowcharts describe the implants according to their identifying features.
Conclusion. Information from this study should help dentists identify threaded endoseous implants from their radiographic images. (J Prosthet Dent 2002;87:563-77.)

CLINICAL IMPLICATIONS

Information from this study should help clinicians identify threaded endoseous implants from their radiographic images when no patient records are available. This capability may increase the efficiency of restoration, aid in emergency situations, and be useful in forensic identification.

Variations in radiographic images of implant bodies at different horizontal rotations and vertical inclinations to the radiographic beam and film can be attributed to implant design.[1-3] This variability means that a clinician would have to be familiar with all possible images of an implant before he/she could use any one radiographic image to identify it. The aim of this investigation was to study multiple radiographic images of a significant number of implants and document their identifying features. A flowchart of these features would simplify the implant identification process.

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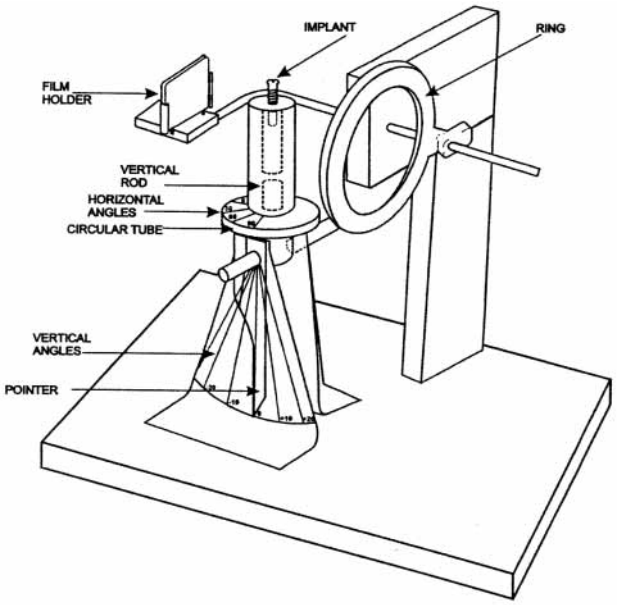

Fig. 1. Device used to conduct study.

Table I. Implants used in this study and their manufacturers

Implant name	Implant manufacturer
Ace Screw 20101022	Ace Dental Implant System, Brockton, Mass.
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.
Brånemark SDCA 023	Nobelpharma AB, Goteberg, Sweden
Brånemark MkII SDCA 220	Nobelpharma AB
Brånemark MkIII 25977	Nobelpharma AB
Friatec-2 stepped screw	Friadent, Irvine, Calif.
Imtec 406981	Imtec Corporation, Ardmore, Okla.
ITI Solid Screw 042.242 S	Institut Straumann AG, Waldenburg, Switzerland
LaminOss	Impladent Ltd, Holliswood, N.Y.
Minimatic IHPSS410	Minimatic Implant Technology, Boca Raton, Fla.
O Company 4010	O Company Inc, Albuquerque, N.M.
Osteoimplant 375010	Osteo-Implant Corporation, New Castle, Pa.
Paragon Micro-Vent MTH10 (01141)	Paragon Implant Company, Encino, Calif.
Paragon Complete Screw-Vent CSVB10 (01129)	Paragon Implant Company
Parc Starlock Star V003	Park Dental Research Corp, New York, N.Y.
Parc Starvent Star V044	Park Dental Research Corp
Replace 43101	Sterioss Dental Implants, Yorba Linda, Calif.
Restore R9005-40-10	Lifecore Biomedical Inc, Chaska, Minn.
Sargon	Sargon Dental Implants, Beverly Hills, Calif.
Spline 1980	Sulzer Calcitek, Carlsbad, Calif.
Sterioss 2210	Sterioss Dental Implants
Sterngold Implamed 911117	Sterngold Implamed Dental Implant Systems, Attleboro, Mass.
Sustain 410030-42-10	Lifecore Biomedical Inc
3i Osteotite OSS 410	Implant Innovations Inc, Palm Beach Gardens, Fla.
3i TG 2410	Implant Innovations

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, 28 of which were identified as threaded (Table I). The morphological design characteristics of all 44 implants were described in a previous article.[4]

A special device (Fig. 1) was fabricated to make standardized radiographs of the 28 threaded implants at different horizontal rotations and vertical inclinations. The implants were mounted on a resin cylinder 4 cm long and 1.5 cm wide with a dimple on one end to hold the implant and a cylindrical opening in the middle of the rod at the other end. The implant was mounted in the dimple on the resin rod with a glue gun, and a surveyor was used to confirm that the implant was perpendicular to the base. Distinctive features of the implant, such as apical holes, were placed perpendicular to the radiographic beam as a baseline. The resin rod was mounted in the center of a circular table 4 cm wide, such that the opening at the opposite end of the resin rod fit on a narrow rod (0.5 cm wide and 1 cm long) that extended from the center of the table. This was done in such a manner that the resin rod could be rotated 360° on the table rod.

The table was marked every 30°. The resin rod had a vertical mark on its side so that its rotation relative to the table could be documented. This table was further mounted such that the whole apparatus could be inclined through 40° (–20° to +20°) in the vertical plane. An aiming ring from a radiographic film holding system (XCP; Dentsply-Rinn, Elgin, Ill.) was mounted 5 cm from the center of the clear rod, and the film-holding instrument was mounted 4.5 cm from the center of the rod on a base. The focal spot–to–object distance was 25 cm, and the focal spot–to–film distance was 29.5 cm. The film and tube were always parallel to each other, and only the inclination of the implant changed. The entire setup was designed to mimic clinical situations in which the operator is not familiar with the inclination of the implant but has control over film and tube position.

Optimal radiographic exposure factors were determined subjectively by imaging an extracted premolar. A premolar was chosen because its size is between that of an incisor and a molar. The tooth was placed on the rod, and radiographs were made at 0.16, 0.20, 0.25,

Table II. Radiographic features of the coronal part of the implants (–20° to +20°)

Implant number	Implant name	External hex	Internal hex	Morse taper	Other	Wider flange	Straight flange	Flared flange	Unique feature
1	Friatec-2 stepped screw				✓0-2		✓		
2	Paragon Micro-Vent MTH10 (01141)				✓0-2		✓		
3	Replace 43101	✓0-2				✓0-2			
4	Restore R9005-40-10	✓0-2				✓0-2			
5	Ace Screw 20101022	✓0-2					✓		
6	Astra Fixture 4.0			✓0-2			✓		
7	Astra Fixture ST 4.5			✓0-2				✓0 -2	Fine threads on entire flange
8	Bicon				✓0-2				No flange
9	Biohorizons 4 mm D1	✓0-2				✓0-2			
10	Brånemark SDCA 023	✓0-2				✓0-2			
11	Brånemark MkII SDCA 220	✓0-2				✓0-2			
12	Brånemark MkIII 25977	✓0-2				✓0-2			
13	Imtec 406981	✓0-2				✓0-2			
14	ITI Solid Screw 042.242 S			✓0-2				✓0-1	
15	LaminOss				✓0-2				Elliptical flange
16	Minimatic IHPSS410	✓0-2				✓0-2			
17	O Company 4010				✓0-2		✓		
18	Osteoimplant 375010	✓0-2					✓		
19	Paragon Complete Screw-Vent CSVB10 (01129)				✓0-2	✓0-2			
20	Parc Starlock Star V003				✓0-2	✓0-2			
21	Parc Starvent Star V044				✓0-2			✓0-2	
22	Sargon	✓0-2				✓0-2			
23	Spline 1980				✓0-2	✓0-2			
24	Sterioss 2210				✓0-2	✓0-2			
25	Sterngold Implamed 911117	✓0-2					✓		
26	Sustain 410030-42-10	✓0-2					✓		
27	3i Osteotite OSS 410	✓0-2				✓0-2			
28	3i TG 2410			✓0-2				✓0-2	Apical part of flare grooved

and 0.32 seconds. An exposure time of 0.20 seconds, a kVp of 63, and an mA of 8 were chosen subjectively to simulate a clinical situation. All radiographs were made at these exposures. Ultra speed radiographic film (D speed; Eastman Kodak, Rochester, N.Y.) was used in a standard radiographic unit (Prostyle; Prostyle Intra, Planmecca USA Inc, Woodale, Ill.) and processed in an automated machine (AT2000; Air Techniques Inc, Hicksville, N.Y.).

Radiographs for each implant were numbered 1 through 20. All radiographs were made in the same sequence, starting at 0° horizontal rotation and –20° (20° toward the cone) vertical inclination. The vertical inclination was changed to –10°, 0°, +10°, and +20° while the horizontal rotation remained constant. At 0° vertical inclination, the radiographic beam was perpendicular to both the implant and the film. The horizontal rotation was then changed to 30°, 60°, and 90°; at each

Table III. Radiographic features of the midbody of the implants (–20° to +20°)

Implant number	Implant name	Tapered	Non-tapered	Threaded	Non-threaded	V-shaped threads	Square threads	Reverse buttress threads	Unique feature
1	Friatec-2 stepped screw	✓		✓0-2		✓0-3			Stepped
2	Paragon Micro-Vent MTH10 (01141)	✓		✓0-2		✓0-3			2 types of threads (v at apex)
3	Replace 43101	✓		✓0-2				✓0-3	Very thin threads
4	Restore R9005-40-10	✓		✓0-2				✓0-3	
5	Ace Screw 20101022		✓	✓0-2		✓0-3			
6	Astra Fixture 4.0		✓	✓0-2		✓0-3			
7	Astra Fixture ST 4.5		✓	✓0-2		✓0-3			
8	Bicon		✓	✓0-2		✓0-3			Fish skeleton–like body
9	Biohorizons 4 mm D1		✓	✓0-2			✓0-2		
10	Brånemark SDCA 023		✓	✓0-2		✓0-3			
11	Brånemark MkII SDCA 220		✓	✓0-2		✓0-3			
12	Brånemark MkIII 25977		✓	✓0-2		✓0-3			
13	Imtec 406981		✓	✓0-2		✓0-3			
14	ITI Solid Screw 042.242 S		✓	✓0-2				✓0-3	
15	LaminOss		✓	✓0-2		✓0-3			Very wide threads
16	Minimatic IHPSS410		✓	✓0-2				✓0-3	
17	O Company 4010		✓	✓0-2		✓0-3			
18	Osteoimplant 375010		✓	✓0-2		✓0-3			
19	Paragon Complete Screw-Vent CSVB10 (01129)		✓	✓0-2		✓0-3			
20	Parc Starlock Star V003		✓	✓0-2				✓0-3	
21	Parc Starvent Star V044		✓	✓0-2				✓0-3	
22	Sargon		✓	✓0-2				✓0-3	Expanding screw in middle
23	Spline 1980		✓	✓0-2		✓0-3			
24	Sterioss 2210		✓	✓0-2				✓0-3	Very thin threads
25	Sterngold Implamed 911117		✓	✓0-2		✓0-3			
26	Sustain 410030-42-10		✓	✓0-2			✓0-3		Threads on coronal half of body
27	3i Osteotite OSS 410		✓	✓0-2		✓0-3			
28	3i TG 2410		✓	✓0-2		✓0-3			

stop, the vertical inclination was put into the same series of angles described above (from –20° to +20°).

Before the radiographs were made, mounting sheets were prepared for all implants. Each sheet was labeled with the name of the implant, and each pocket was numbered to coincide with the number of the film. Upon completion of a series of radiographs but prior to their being developed, the sequence of the numbers was verified. The mounting sheet was taken into the dark room, and films were mounted into the corresponding pocket as they came out of the developer to eliminate the possibility of mislabeling or misidentifying radiographs. Films were read on a lighted box with a viewscope (Pearson Dental Supply Company, Sylmar, Calif.) at ×2 magnification; extraneous light was blocked out.

Table IV. Radiographic features of the apical part of the implants (–20° to +20°)

Implant number	Implant name	V-shaped apex	Flat apex	Curved apex	Round hole	Oblong hole	Apical chamber	Grooves	Unique feature
1	Friatec-2 stepped screw	✓0-3							
2	Paragon Micro-Vent MTH10 (01141)			✓0-1	✓0-3				
3	Replace 43101			✓0-1					
4	Restore R9005-40-10		✓0-1				✓0-1		
5	Ace Screw 20101022		✓0-1			✓0-3	✓0-3		
6	Astra Fixture 4.0		✓0-1						
7	Astra Fixture ST 4.5		✓0-1						
8	Bicon		✓0-1						
9	Biohorizons 4 mm D1		✓0-1						
10	Brånemark SDCA 023		✓0-1		✓0-3		✓0-1		
11	Brånemark MkII SDCA 220		✓0-1					✓0-1	Apical part has curved indent
12	Brånemark MkIII 25977		✓0-1					✓0-1	Apical part has curved indent
13	Imtec 406981		✓0-1			✓0-3	✓0-3	✓0-3	
14	ITI Solid Screw 042.242 S			✓0-1					
15	LaminOss			✓0-1					
16	Minimatic IHPSS410		✓0-1		✓0-3		✓0-2		
17	O Company 4010			✓0-1	✓0-3				
18	Osteoimplant 375010		✓0-1		✓0-3		✓0-1		
19	Paragon Complete Screw-Vent CSVB10 (01129)		✓0-1			✓0-3	✓0-2		
20	Parc Starlock Star V003			✓0-1	✓0-3				
21	Parc Starvent Star V044			✓0-1					
22	Sargon								Split, flared apex with expanding screw in middle
23	Spline 1980		✓0-1					✓0-1	Straight cut on one side
24	Sterioss 2210		✓0-1		✓0-3				
25	Sterngold Implamed 911117		✓0-2		✓0-3		✓0-2		
26	Sustain 410030-42-10			✓0-1					
27	3i Osteotite OSS 410		✓0-1					✓0-2	Grooves create tapered look
28	3i TG 2410		✓0-1				✓0-3	✓0-2	

Observations were recorded on 4 data collection sheets, 1 each for coronal, midbody, apex, and screw chamber features. On each form, the 20 angle combinations were listed vertically and the chosen features horizontally. A check mark was placed in the proper box when a certain feature was present at a certain angle. The radiographs were also analyzed with an arbitrary, subjective, nonparametric scale of 0 to 3. The baseline was 0 and included features at the 0°, 0° angle (0° horizontal rotation with the beam directed perpendicular to the implant). An image at a different angle that showed no change from the base-

Table V. Radiographic features of the screw chamber of the implants (–20° to +20°)

Implant number	Implant name	Straight	Stepped	Threaded	Non-threaded	Curved end	Flat end	V-shaped end	Unique feature
1	Friatec-2 stepped screw		✓0-2		✓				Screw chamber indistinct
2	Paragon Micro-Vent MTH10 (01141)		✓0-2	✓0-3		✓0-2			
3	Replace 43101	✓		✓0-3					
4	Restore R9005-40-10	✓			✓				
5	Ace Screw 20101022	✓		✓0-3		✓0-1			
6	Astra Fixture 4.0	✓		✓0-3		✓0-2			
7	Astra Fixture ST 4.5	✓		✓0-3			✓0-2		
8	Bicon								No screw chamber
9	Biohorizons 4 mm D1		✓0-1	✓0-3			✓0-1		Screw chamber ¾ length of body
10	Brånemark SDCA 023	✓		✓0-3		✓0-2			
11	Brånemark MkII SDCA 220	✓		✓0-3		✓0-2			
12	Brånemark MkIII 25977	✓		✓0-3		✓0-2			
13	Imtec 406981	✓		✓0-3		✓0-2			
14	ITI Solid Screw 042.242 S	✓		✓0-3		✓0-2			
15	LaminOss								No screw chamber
16	Minimatic IHPSS410	✓		✓0-3		✓0-2			
17	O Company 4010	✓			✓	✓0-2			
18	Osteoimplant 375010	✓		✓0-3		✓0-2			
19	Paragon Complete Screw-Vent CSVB10 (01129)	✓			✓	✓0-2			Ends in flange
20	Parc Starlock Star V003		✓0-2		✓				
21	Parc Starvent Star V044	✓			✓				Ends in flange
22	Sargon	✓		✓0-3					Has no bottom, just expanding screw
23	Spline 1980	✓		✓0-3		✓0-2			
24	Sterioss 2210	✓		✓0-2		✓0-2			Ends at 2nd or 3rd thread
25	Sterngold Implamed 911117	✓		✓0-3		✓0-2			
26	Sustain 410030-42-10	✓		✓0-3		✓0-2			
27	3i Osteotite OSS 410	✓		✓0-3		✓0-2			
28	3i TG 2410	✓		✓0-3		✓0-2			

line was also labeled 0. An image was labeled 1 when only slight variation from the baseline was observed with all baseline features visible but no additional features present; 2 when large variation from the baseline was observed with all baseline features visible but no additional features present; and 3 when some baseline features were absent or additional features were present, thus changing the image. This methodology made it easy to observe variation at different angles from the table and allowed each implant to act as its own control (image at 0°,0°). The principal investigator made, processed, and mounted all radiographs and then compiled all data under the guidance of mentors.

RESULTS

Data were compiled for inclinations from –20° to +20° (Tables II through V) and for inclinations from

Table VI. Radiographic features of the coronal part of the implants (–10° to +10°)

Implant number	Implant name	External hex	Internal hex	Morse taper	Other	Wider flange	Straight flange	Flared flange	Unique feature
1	Friatec-2 stepped screw				✓0-1		✓		
2	Paragon Micro-Vent MTH10 (01141)				✓0-1		✓		
3	Replace 43101	✓0-1				✓0-1			
4	Restore R9005-40-10	✓0-1				✓0-1			
5	Ace Screw 20101022	✓0-1					✓		
6	Astra Fixture 4.0			✓0-1			✓		
7	Astra Fixture ST 4.5			✓0-1				✓0-1	Fine threads on entire flange
8	Bicon				✓0-1				No flange
9	Biohorizons 4 mm D1	✓0-1				✓0-1			
10	Brånemark SDCA 023	✓0-1				✓0-1			
11	Brånemark MkII SDCA 220	✓0-1				✓0-1			
12	Brånemark MkIII 25977	✓0-1				✓0-1			
13	Imtec 406981	✓0-1				✓0-1			
14	ITI Solid Screw 042.242 S			✓0-1				✓0-1	
15	LaminOss				✓0-1				Elliptical flange
16	Minimatic IHPSS410	✓0-1				✓0-1			
17	O Company 4010				✓0-1		✓		
18	Osteoimplant 375010	✓0-1					✓		
19	Paragon Complete Screw-Vent CSVB10 (01129)				✓0-1	✓0-1			
20	Parc Starlock Star V003				✓0-1	✓0-1			
21	Parc Starvent Star V044				✓0-1			✓0-1	
22	Sargon	✓0-1				✓0-1			
23	Spline 1980				✓0-1	✓0-1			
24	Sterioss 2210				✓0-1	✓0-1			
25	Sterngold Implamed 911117	✓0-1					✓		
26	Sustain 410030-42-10	✓0-1					✓		
27	3i Osteotite OSS 410	✓0-1				✓0-1			
28	3i TG 2410			✓0-1				✓0-1	Apical part of flare grooved

–10° to +10° (Tables VI-IX). The presence of selected features was noted along with the range of variation for each feature at different angles. The prosthetic interface was described in the data forms for completion of description. It was not, however, included in implant identification because in normal clinical conditions it is covered with either the healing cap or the abutment and thus not visible. Similarly, the shape of the end of the screw chamber, though described, could be used for identification only rarely due to the extreme subtlety of this feature.

In nonthreaded implants, the spiral image around the screw chamber always indicates that it is threaded. The same cannot be assumed for threaded implants, as this spiral image could be the superimposition of the threads of the body. In this study, the screw chamber was considered threaded only when

Table VII. Radiographic features of the midbody of the implants (–10° to +10°)

Implant number	Implant name	Tapered	Non-tapered	Threaded	Non-threaded	V-shaped threads	Square threads	Reverse buttress threads	Unique feature
1	Friatec-2 stepped screw	✓		✓0-1		✓0-2			Stepped
2	Paragon Micro-Vent MTH10 (01141)	✓		✓0-1		✓0-2			2 types of threads (v at apex)
3	Replace 43101	✓		✓0-1				✓0-1	Very thin threads
4	Restore R9005-40-10	✓		✓0-1				✓0-1	
5	Ace Screw 20101022		✓	✓0-1		✓0-2			
6	Astra Fixture 4.0		✓	✓0-1		✓0-2			
7	Astra Fixture ST 4.5		✓	✓0-1		✓0-2			
8	Bicon		✓	✓0-1		✓0-2			Fish skeleton–like body
9	Biohorizons 4 mm D1		✓	✓0-1			✓0-2		
10	Brånemark SDCA 023		✓	✓0-1		✓0-2			
11	Brånemark MkII SDCA 220		✓	✓0-1		✓0-2			
12	Brånemark MkIII 25977		✓	✓0-1		✓0-2			
13	Imtec 406981		✓	✓0-1		✓0-2			
14	ITI Solid Screw 042.242 S		✓	✓0-1				✓0-2	
15	LaminOss		✓	✓0-1		✓0-1			Very wide threads
16	Minimatic IHPSS410		✓	✓0-1				✓0-2	
17	O Company 4010		✓	✓0-1		✓0-1			
18	Osteoimplant 375010		✓	✓0-1		✓0-1			
19	Paragon Complete Screw-Vent CSVB10 (01129)		✓	✓0-1		✓0-1			
20	Parc Starlock Star V003		✓	✓0-1				✓0-2	
21	Parc Starvent Star V044		✓	✓0-1				✓0-2	
22	Sargon		✓	✓0-1				✓0-2	Expanding screw in middle
23	Spline 1980		✓	✓0-1		✓0-2			
24	Sterioss 2210		✓	✓0-1				✓0-2	Very thin threads
25	Sterngold Implamed 911117		✓	✓0-1		✓0-2			
26	Sustain 410030-42-10		✓	✓0-1			✓0-2		Threads on coronal half of body
27	3i Osteotite OSS 410		✓	✓0-1		✓0-1			
28	3i TG 2410		✓	✓0-1		✓0-2			

the teeth of the threads were visible in the radiographic image.

Results were established for threaded, tapered implants (Fig. 2, *A*) and threaded, nontapered implants (Fig. 2, *B*). Because the number of implants in the threaded, nontapered category was large, their features are presented separately in Table X. The "identifying" features were present at all inclinations (–10° to +10°); the "other" features were not apparent at all inclinations.

DISCUSSION

In reference to Table X, it is important to remember that implants with identifying features would have to be eliminated from a group or subgroup before implants without identifying features could be identified. As an example, consider the implants that are threaded, are nontapered, and have v-shaped threads and wider flanges. Of the 7 implants in this group, 5 have identifying features. If these 5 were eliminated, information in the "other features" column could be used to distinguish

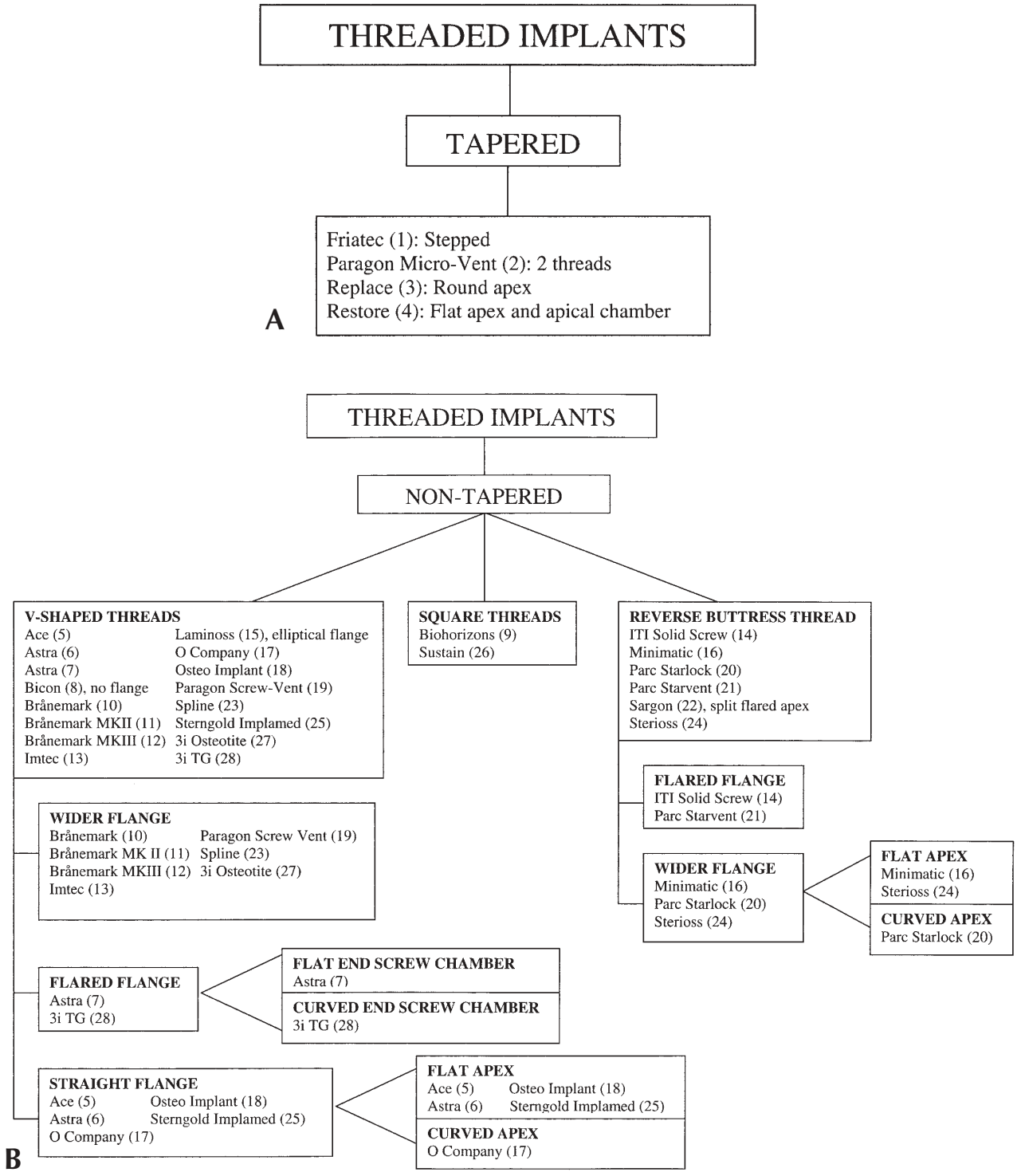

Fig. 2. A, Flowchart for identification of threaded, tapered implants. Number assigned to implant in parentheses. **B,** Flowchart for identification of threaded, nontapered implants. Number assigned to implant in parentheses.

between the remaining 2 implants, only 1 of which has an apical chamber. If the implants with distinguishing features had not been eliminated, more implants in the group would have an apical chamber, making identification based on this feature alone difficult.

A few implants in this study were identified easily by their distinctive designs. Little variability was evident in the radiographic images of the Bicon, LaminOss, and Sargon implants, for example, regardless of the vertical inclination in relation to the radiographic

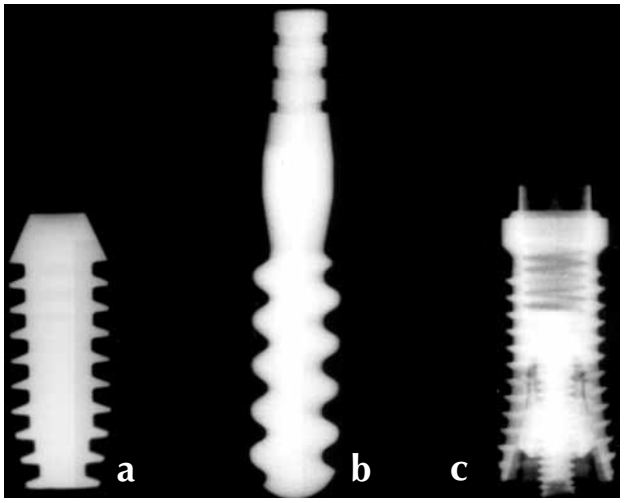

Fig. 3. *(a)* Bicon implant, *(b)* LaminOss implant, and *(c)* Sargon implant.

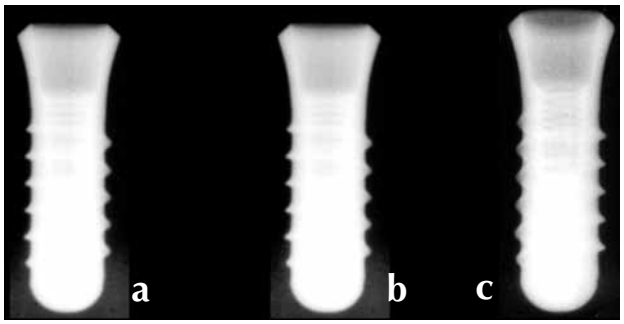

Fig. 4. ITI Solid Screw 042.242 S at *(a)* 0°, 0°; *(b)* 30°, 0°; and *(c)* 0°, –10°.

beam and film (Fig. 3). The identification of most other implants was challenging because of similarities in their designs and the production of different images with changes in rotation and vertical inclination. These differences can be attributed to a change in the relationship of the apical features of the implants to the radiographic beam and film. The ITI solid screw 042.242, which has no apical features, exhibited minimal change with horizontal rotation and only slight change in thread morphology with variations in vertical inclination (Fig. 4). As such, the ITI solid screw was readily identifiable.

The Sterngold Implamed 911117 is an excellent example of how apical features can complicate implant identification. This implant has 2 round holes, an apical chamber, and 4 grooves in the apical area. These features create a variety of images depending on the rotation of the implant, even when the vertical inclination remains unchanged (Fig. 5). If the hole faces the radiographic beam and is perpendicular to it (vertical inclination 0°), the beam passes directly through the 2 holes 180° apart. The implant appears cylindrical with a radiolucent circle and a relatively radiolucent chamber below it. At 30° horizontal rotation, 2 overlapping, relatively radiolucent circles and a relatively radiolucent chamber below them can be seen; at 60°, the 2 relative radiolucencies in the apical area are still visible but the chamber is not. At 90°, the implant appears slightly tapered in the apical area with 2 relative semicircular radiolucencies at the edges and a very clear image of the chamber as a relative radiolucency.

Although the apical part of the radiographic images obviously cannot be used to identify the Sterngold Implamed 911117, the implant is nonetheless readily identifiable. It belongs to a subgroup of 4 implants (Fig. 2, *B*), and within this subgroup (Table X), only 2 implants have flanges 1 mm long: the Sterngold Implamed 911117 and the Osteoimplant 375010. The latter has a screw chamber with a bulb-like end. If this chamber is not present, then the implant must be the Sterngold Implamed 911117.

A taper on the Sterngold Implamed 911117 appears when 2 grooves are parallel to the film. If this image were the only one available, a clinician unfamiliar with the criteria used to place implants in certain categories might be tempted to place this implant in the tapered group. As noted in a previous article,[4] it is critical that only the middle third of an implant be used to identify it as tapered or nontapered. Implant identification can then proceed based on Figure 2.

The features of some dental implants are very subtle and require close examination. The taper of the Replace 43101, for example, is gradual and not as obvious as that of the Paragon Micro-Vent MTH10 (01141) (Fig. 6). Similarly, the threads of the Minimatic IHPSS410, Sterioss 2210, and Replace 43101 are all classified as reverse buttress, but the threads of the Minimatic implant are much coarser than those of the other two (Fig. 7). The threads of the Minimatic implant are also directed apically, creating a Christmas tree–like image, whereas the threads of the Sterioss and Replace implants are directed upward and thereby reverse the image. The Sterngold Implamed 911117 and Astra Fixture 4.0 threaded implants have flanges that may appear wider but are actually straight (Fig. 8). Under magnification, it becomes obvious that the ends of the threads and flange line up.

Considerable distortion of the apical features and thread shapes at vertical inclinations greater than 10° was observed in this study. Circular holes at the apex appeared oblong, for example, and determining thread shape became increasingly difficult at increased vertical inclinations. Such problems could lead to false identification. Given this possibility, the clinician should approximate the angle at which a radiograph was made before using it for implant identification. The observation of predictable changes in images of the threads,

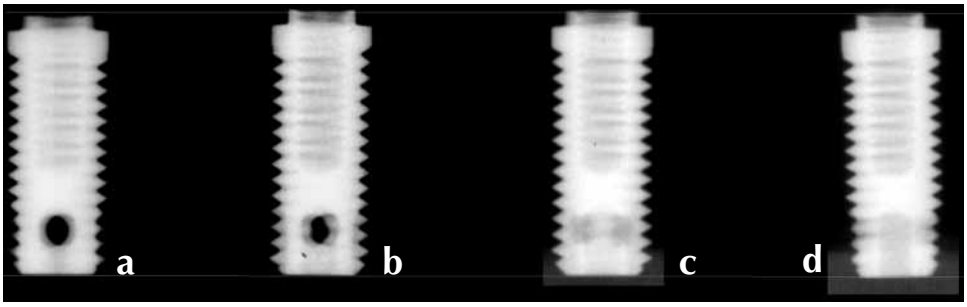

Fig. 5. Sterngold Implamed 911117 at *(a)* 0°, 0°; *(b)* 30°, 0°; *(c)* 60°, 0°; and *(d)* 90°, 0°.

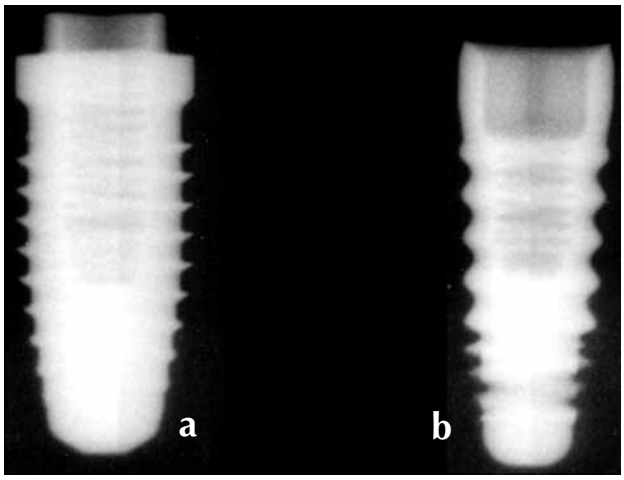

Fig. 6. *(a)* Tapered Replace 43101 and *(b)* Tapered Paragon Micro-Vent MTH10 (01141).

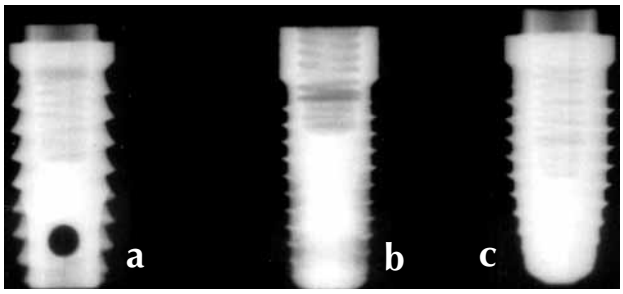

Fig. 7. Reverse buttress threads in *(a)* Minimatic IHPSS410, *(b)* Sterioss 2210, and *(c)* Replace 43101.

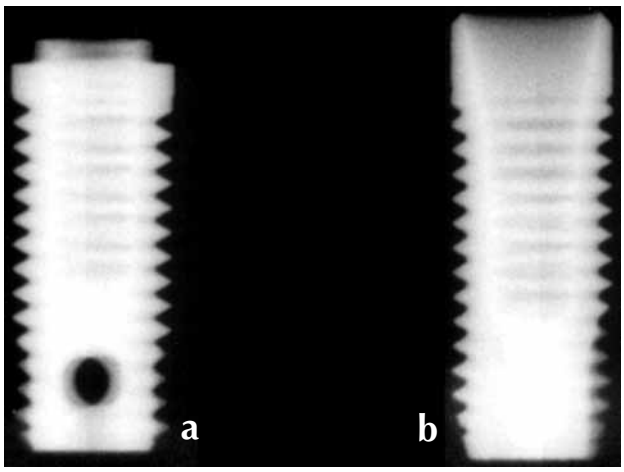

Fig. 8. Straight flange in *(a)* Sterngold Implamed 91117 and *(b)* Astra Fixture 4.0.

apical chamber, and internal prosthetic interfaces of the implant enables approximation of the vertical inclination of implants relative to the beam and film.

With threaded implants, the radiographic appearance of the threads can be used to determine the vertical inclination of the implant relative to the film and beam (Fig. 4). Sewerin[5] investigated this possibility with images of Brånemark implant threads and found that 81% of recordings estimated by clinicians differed by ≤2° when the clinicians were provided with a set of reference radiographs.

The apical chamber also can be used to estimate the vertical inclination of an implant to the beam and film. When present and not covered by another feature, the apical chamber of an implant usually appears as a relative radiolucency in the apical area at 0° vertical angulation. Regardless of whether the apical chamber can be seen at 0°, the circumference of the chamber becomes increasingly visible at the apex at increased vertical angulations because the 2 sides of the implant do not overlap (Fig. 9). A visible circumference of the apical chamber therefore indicates that the radiographic beam is not at a right angle to the axis of the implant in that particular radiograph. This would also be true if the implant were not parallel to the film. The degree to which the apical chamber circumference is visible should give an astute clinician an approximate idea of the implant inclination to the film and beam. This information could also help in implant identification when the presence of an apical chamber is suspected, as changing the beam angulation might help clarify the apical chamber and thus identify the implant. The internal hex (or any other internal prosthetic interface, if present and visible) also becomes increasingly identifiable at increased vertical angles (Fig. 10).

Studies have demonstrated that the accuracy of bone height measurements is compromised even at

Table VIII. Radiographic features of the apical part of the implants (–10° to +10°)

Implant number	Implant name	V-shaped apex	Flat apex	Curved apex	Round hole	Oblong hole	Apical chamber	Grooves	Unique feature
1	Friatec-2 stepped screw	✓0-3							
2	Paragon Micro-Vent MTH10 (01141)			✓0-1	✓0-3				
3	Replace 43101			✓0-1					
4	Restore R9005-40-10		✓0-1				✓0-1		
5	Ace Screw 20101022		✓0-1			✓0-3	✓0-3		
6	Astra Fixture 4.0		✓0-1						
7	Astra Fixture ST 4.5		✓0-1						
8	Bicon		✓0-1						
9	Biohorizons 4 mm D1		✓0-1						
10	Brånemark SDCA 023		✓0-1		✓0-3		✓0-1		
11	Brånemark MkII SDCA 220		✓0-1					✓0-1	Apical part has curved indent
12	Brånemark MkIII 25977		✓0-1					✓0-1	Apical part has curved indent
13	Imtec 406981		✓0-1			✓0-3	✓0-3	✓0-3	
14	ITI Solid Screw 042.242 S			✓0-1					
15	LaminOss			✓0-1					
16	Minimatic IHPSS410		✓0-1		✓0-3		✓0-2		
17	O Company 4010			✓0-1	✓0-3				
18	Osteoimplant 375010		✓0-1		✓0-3		✓0-1		
19	Paragon Complete Screw-Vent CSVB10 (01129)		✓0-1			✓0-3	✓0-2		
20	Parc Starlock Star V003			✓0-1	✓0-3				
21	Parc Starvent Star V044			✓0-1					
22	Sargon								Split, flared apex with expanding screw in middle
23	Spline 1980		✓0-1					✓0-1	Straight cut on one side
24	Sterioss 2210		✓0-1		✓0-3				
25	Sterngold Implamed 911117		✓0-2		✓0-3		✓0-2		
26	Sustain 410030-42-10			✓0-1					
27	3i Osteotite OSS 410		✓0-1					✓0-2	Grooves create tapered look
28	3i TG 2410		✓0-1				✓0-3	✓0-2	

very small deviations from parallelism between the implant body axis and film plane.[6,7] This discrepancy is further increased with a greater width of the alveolar process. Based on a theoretical and experimental model, it was reported that distortion between bone margins varied between 0.1 mm at 1° vertical angulation and 4.8 mm at 20° vertical angulation depending on the width of the alveolar ridge and buccolingual position of the implant body. It was also reported that ignoring differences in projection angles may lead to a

Table IX. Radiographic features of the screw chamber of the implants (–10° to +10°)

Implant number	Implant name	Straight	Stepped	Threaded	Non-threaded	Curved end	Flat end	V-shaped end	Unique feature
1	Friatec-2 stepped screw		✓0-1		✓				Screw chamber indistinct
2	Paragon Micro-Vent MTH10 (01141)		✓0-1	✓0-2		✓0-1			
3	Replace 43101	✓		✓0-3					
4	Restore R9005-40-10	✓			✓				
5	Ace Screw 20101022	✓		✓0-2		✓0-1			
6	Astra Fixture 4.0	✓		✓0-3		✓0-1			
7	Astra Fixture ST 4.5	✓		✓0-2			✓0-1		
8	Bicon								No screw chamber
9	Biohorizons 4 mm D1		✓0-1	✓0-3			✓0-1		Screw chamber ¾ length of body
10	Brånemark SDCA 023	✓		✓0-3		✓0-1			
11	Brånemark MkII SDCA 220	✓		✓0-3		✓0-1			
12	Brånemark MkIII 25977	✓		✓0-3		✓0-1			
13	Imtec 406981	✓		✓0-3		✓0-1			
14	ITI Solid Screw 042.242 S	✓		✓0-2		✓0-1			
15	Laminoss								No screw chamber
16	Minimatic IHPSS410	✓		✓0-2		✓0-1			
17	O Company 4010	✓			✓	✓0-1			
18	Osteoimplant 375010	✓		✓0-3		✓0-1			
19	Paragon Complete Screw-Vent CSVB10 (01129)	✓			✓	✓0-1			Ends in flange
20	Parc Starlock Star V003		✓0-1		✓				
21	Parc Starvent Star V044	✓			✓				Ends in flange
22	Sargon	✓		✓0-3					Has no bottom, just expanding screw
23	Spline 1980	✓		✓0-2		✓0-1			
24	Sterioss 2210	✓		✓0-1		✓0-1			Ends at 2nd or 3rd thread
25	Sterngold Implamed 911117	✓		✓0-3		✓0-1			
26	Sustain 410030-42-10	✓		✓0-2		✓0-1			
27	3i Osteotite OSS 410	✓		✓0-2		✓0-1			
28	3i TG 2410	✓		✓0-2		✓0-1			

false impression of bone growth or to an underestimation of bone loss around implants. If an implant is depicted from an oblique view, the bone adjacent to the fixture will appear more condensed than it would if the projection angle were 90°. The fact that changing the angle of the radiographic beam can result in different images of the same clinical situation underscores the importance of being able to estimate angulation based on the visibility of certain implant features.

Another important clinical application of this skill is confirmation of implant-abutment and abutment-prosthesis seating. Ormaechea et al[8] reported that a 5° vertical angle of the x-ray tube to the implant axis did not significantly affect the identification of openings ≤50 μm. A 15° vertical angulation of the x-ray tube,

Table X. Features of implants categorized in Figure 2, *B*

Implant name	Identifying features	Other features
V-shaped threads, wider flange		
Branemark		Apical chamber, round hole
Brånemark MkII	Semicircular cut laterally at apical end	
Brånemark Mk III	Semicircular cut laterally at apical end	
Imtec	Flange 2 mm	Oblong hole
Paragon Screw-Vent	Long flange, straight and then wider	Oblong hole
Spline	Straight cut laterally at apical end	
3i Osteotite		No apical chamber, round hole
V-shaped threads, flared flange, flat end to screw chamber		
Astra 4.5	Fine threads on entire flange	Flange almost ½ body length
V-shaped threads, flared flange, curved end to screw chamber		
3i TG	Grooves on apical half of flange only	
V-shaped threads, straight flange, flat apex		
Ace	No Morse taper, flange 2 mm	Oblong hole, apical chamber
Astra	Morse taper, flange 2 mm	No hole or apical chamber
Sterngold Implamed	Flange 1 mm	Round hole, apical chamber
Osteoimplant	Screw chamber bulb-like end, flange 1 mm	Round hole, apical chamber
V-shaped threads, straight flange, curved apex		
O Company	Flange 2 mm	
Square threads		
Biohorizons	Screw chamber ¾ body length and stepped	
Sustain	Threads in only coronal part of implant	
Reverse buttress threads, flared flange		
ITI Solid Screw	Morse taper	Screw chamber extends into body
Parc Starvent	Screw chamber in flange	No Morse taper
Reverse buttress threads, wider flange, flat apex		
Minimatic	Screw chamber ½ body length, coarse threads, flange 1 mm	Apical chamber
Sterioss	Screw chamber ⅓ body length, very fine threads, flange 2 mm	
Reverse buttress threads, wider flange, curved apex		
Parc Starlock	Stepped screw chamber	

however, significantly affected the identification of 100 to 150 μm openings. Familiarity with images of the apical chamber and threads at various degrees of angulation could help the clinician recognize radiographs with >10° angulation and so avoid misestimating abutment or prosthesis seating.

The only implants that could not be distinguished from each other were the Brånemark MkII and MkIII. This is not an issue because the restorative components of these 2 implants are common.

Application of the in vitro data gathered in this study may be limited by possible variations in film density, film processing, projection angulations, and implant rotations in the clinical setting. 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 data gathered in this study should make the identification of unknown threaded implants easier for the clinician. The ability to estimate radiograph angulation may improve clinical judgment about the comparability of radiographs at recall and help confirm abutment and/or prosthesis seating.

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

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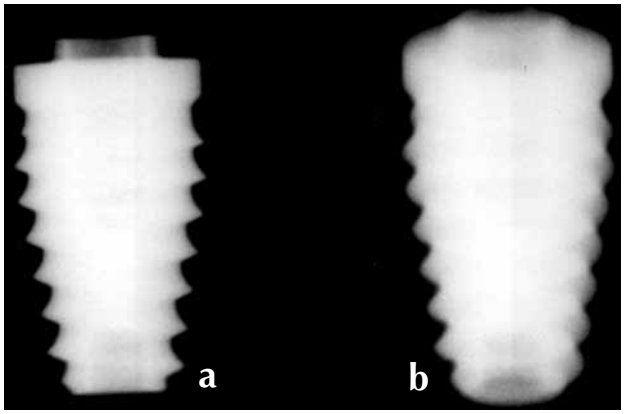

Fig. 9. Apical chamber in Restore R9005-40-10 at *(a)* 0°, 0° and *(b)* 0°, –10°

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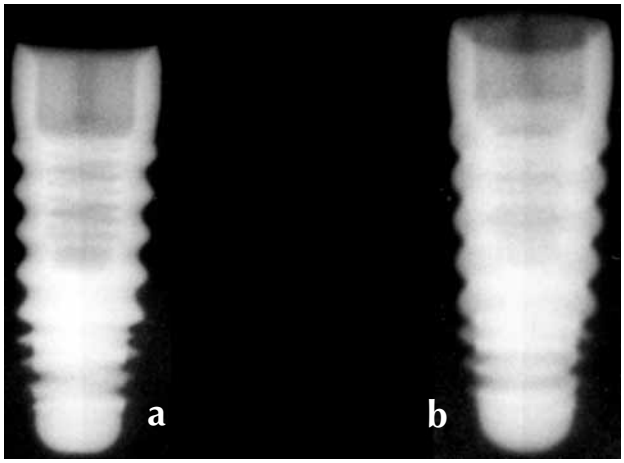

Fig. 10. Internal hex in Paragon Micro-Vent MTH10 (01141) at *(a)* 90°, 0° and *(b)* 90°, –10°.

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