Radiographical Evaluation of the Gap at the Implant-Abutment Interface

HARRIS PAPAVASSILIOU, DDS, MSC*
STEFANOS KOURTIS, DDS, DR. ODONT†
JULIA KATERELOU, DDS, MSC‡
VASILLIOS CHRONOPOULOS, DDS, MSC, DR. ODONT§

ABSTRACT

Introduction: The detection of marginal gaps at the implant-abutment interface is a common clinical task in prosthodontic treatment. For the detection of the gap intraorally, especially under thick soft tissues the most common method is dental radiography.

Objective: The objective of this experimental study was to investigate the accuracy of conservative dental radiography to detect marginal gaps at the implant-abutment interface. For these reasons radiographs were taken on internal and external hex implants with different experimental gaps and inclinations.

Materials and Methods: The abutment (with a space created by plastic sheets 0.5 and 0.2 mm in thickness) was screwed on the implant, and the implant was placed into a box filled with silicone impression material. The X-ray film was placed parallel to the implant at the back of the box, the borders of the box were marked to the base and the box. A ruler of 10 cm was fixed at a long X-ray tube to ensure parallelism to the implant, X-ray film. Sets of radiographs were made at 0°, 5°, 10°, 15°, 20°, 25°, 30° (to the abutment) and –5°, –10°, –15°, –20°, –25°, –30° (to the implant) degrees.

The X-ray images were observed with visual examination, under magnification, and in higher magnification in a slide projector. The phenomenal and the true gap at the implant-abutment interface were calculated in order to determine the distortion.

Results: There were significant differences between the internal and external hex implants because of the different morphology of the implants. The detecting ability to diagnose a gap at the implant-abutment interface varied significantly with the angulation degree of the X-ray tube. At inclinations to the implant (– inclination) the gap diminished earlier than those inclinations to the prosthetic abutment (+ inclinations). In all examinations the gap was not detectable at angulations higher than 20°. In visual examination at 25° and 30° an average clinician could diagnose the distortion.

Conclusions: The X-ray diagnosis of gap at the interface can be significantly influenced by the inclination of the X-ray tube in relation to the long axis of the implant. To achieve accurate results, the use of a paralleling device is advocated in order to achieve greater detection ability.

*Clinical instructor, Department of Prosthodontics, University of Athens, Athens, Greece
†Assistant professor, Department of Prosthodontics, University of Athens, Athens, Greece
‡Clinical instructor, Department of Oral and Maxillofacial Radiology, University of Athens, Athens, Greece
§Assistant professor, Department of Prosthodontics, University of Athens, Athens, Greece

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CLINICAL RELEVANCE

Dental radiography is often used for detection of marginal gaps at the implant-abutment interface. The angulation of the X-ray beam may lead to inaccurate diagnosis in gap detection. The use of a paralleling device is indicated for evaluation of marginal accuracy. The geometry of the implant (internal or external hexagon) influences the gap evaluation.

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INTRODUCTION

The absolute and passive fit of an abutment to an implant has been considered as prerequisite for long-term clinical success. Misfit of the abutment can lead to plaque accumulation, difficulty to remove cement, and stress in the cervical area of the implant.[1]

Gaps at the interface do not allow even distribution of occlusal forces at the whole implant surface, resulting in non-axial loading of implants, and fixation screws.

Various methods have been suggested for the control of the fit. These methods include probing with dental explorers, visual control, use of periotest device, etc.[2,3]

The most popular method for the verification of the gap at the implant-abutment interface has been shown to be intraoral radiography.

Specific techniques, such as using a paralleling device should be used to ensure proper angulation of the X-ray film and the radiographic tube, but their use in daily practice is often neglected.

PURPOSE

The purpose of this study was to evaluate the detective ability of dental radiography in gaps at the abutment-implant interface at different inclinations.

A further objective was to investigate the influence of the implant geometry (internal–external hex) on the detection of the created gaps.

MATERIALS AND METHODS

The list of materials used in this experimental study is shown in Table 1.

TABLE 1. LIST OF MATERIALS AND DEVICES USED IN THE EXPERIMENTAL PART.

Material/device	Manufacturer	City/country
Radiographic device Gendex Opalix	Gendex dental systems	Milano, Italy
Dental X-ray film Insight	Kodak Co.	New York, USA
Developing device XR04	Durr dental AG	Bissingen, Germany
Xive implant D3,8/L11	Friadent-Dentsply Co.	Mannheim, Germany
Xive straight abutment D 3,8/DH 2 mm	Friadent-Dentsply Co.	Mannheim, Germany
Branemark implant D4/L13 mm	Nobel Biocare Co.	Gotteborg, Sweden
Branemark straight abutment D4/DH 2 mm	Nobel Biocare Co.	Gotteborg, Sweden
Impression Silicone putty Optosil	Bayer Co.	Levercusen, Germany
Slide projector carousel S-AV 2000–30	Kodak Co.	New York, USA

Figure 1. Creation of gap between the implant and the abutment by means of a thermoplastic sheet of known thickness.

Figure 2. The implant placed in a box filled with silicone impression material.

Specimen Fabrication

Thermoplastic omnivac sheets of 0.2 and 0.5 mm in thickness were cut and a hole of 3 mm was created with a laboratory hand piece to allow proper fit and screwing of the abutment on the implant (Figure 1). The thermoplastic sheet was placed between the implant and the abutment to create the desired gap of known dimension and the fixing screw was tightened to the indicated torque.

A plastic box (10 × 6 × 2.5 cm) was filled with silicone impression material up to the top.

An angle measuring device was stabilized at the edges of the box. The system was placed in horizontal position on a bench and the sides of the box stable were marked on the bench in order to keep stable the place and position of the box during the experimental procedure.

Orientation of the Implant and X-ray Film

The implant with the omnivac sheet at the interface was embedded in the impression material before its setting. Attention was given in the parallel placement of the implant with the X-ray film. The film was placed at the external bottom side of the plastic box and was marked to ensure exact positioning of all films (Figure 2).

The film was stabilized under the box with sticky tape.

The X-ray film was placed in a new position when the angulation of the X-ray tube exceeded 20° because the implant vanished from the film because of projection.

The X-ray tube was placed above the system of the base (box) at 0°. At the end of the tube a straight measuring ruler of 10 cm was adapted vertical to the implant and the X-ray film (Figure 3). The ruler enabled exact measurement at the tube angulation to the implant.

The inclinations of the X-ray beam that were used for both gaps (0.5 and 0.2 mm) were: 0°, +5°, +10°, +15°, +20°, +25°, +30° (inclination to the prosthetic abutment) and

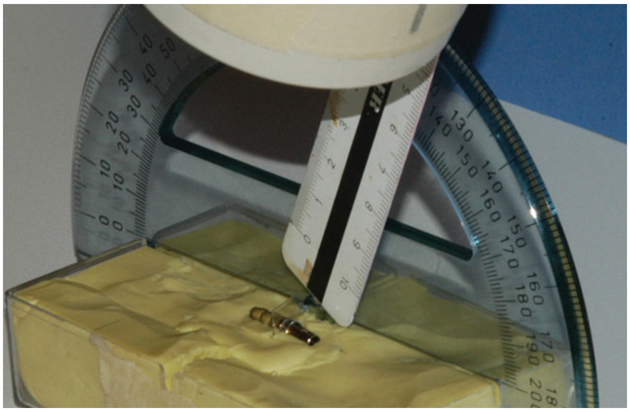

Figure 3. Determining the inclination of the beam to the implant.

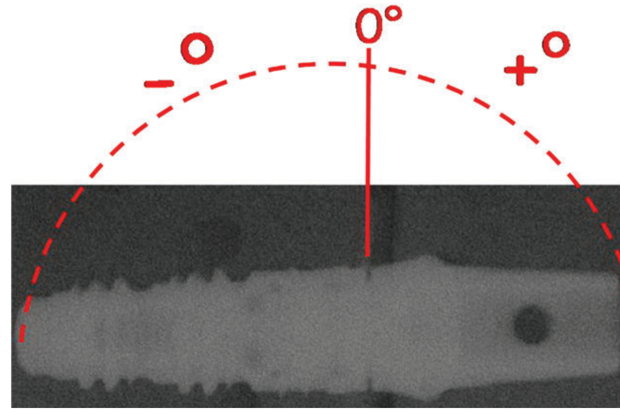

Figure 4. Positive and negative angulations (positive to the prosthetic abutment and negative to the implant) of the beam.

–5°, –10°, –15°, –20°, –25°, –30° (inclination to the implant) (Figure 4).

The same inclinations for both gaps were used for the internal and the external hex implants.

A total of 78 X-rays were taken, 13 for the internal hex implant with the gap of 0.5 mm and 13 for the gap of 0.2 mm. 13 X-rays for the external hex implant with the gap of 0.5 mm and 13 for the gap of 0.2 mm.

As a control group, 13 X-rays were taken at different inclinations for both internal and external hexed implants with no gap between the implant and the prosthetic abutment. The experimental procedure was repeated three times in order to confirm the results.

Evaluation of the X-rays
Three methods were used for the evaluation of the X-rays:

1. Simple visual examination without magnification.
2. Visual examination with a magnifying lens.
3. Examination in higher magnification by projection of the X-rays with a slide projector.

The evaluation was blinded and was performed by another clinician. Evaluation of the X-rays with visual observation or with magnifying lens allowed simple detection of the gap. At the observation of the X-rays under higher magnification (with slide projector) the phenomenal gap at horizontal (*x*-value) and vertical axis (*y*-value) were measured (Figures 5 and 6).

X-value represented the distance from the hexagon to the edge of the implant and *y*-value represented the distance from the base of the prosthetic abutment to the top of the implant.

RESULTS

Internal Hex Implant
With simple visual observation the phenomenal gap of 0.5 mm in +20° diminished and at +25° could not be

Figure 5. Distance y.

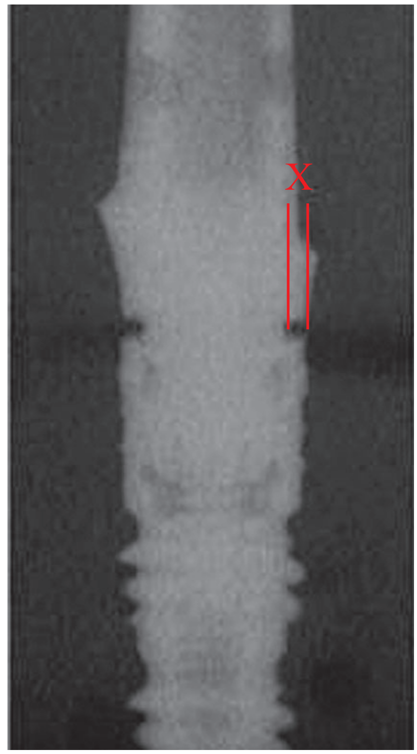

Figure 6. Distance x.

detected. At inclinations to the implant at −15° the gap diminished and was not perceivable at 20° (Figures 7–11).

The gap of 0.2 mm at +10° was difficult to diagnose and vanished at +15°. At −5° the gap diminished and at −10° no phenomenal gap could be detected (Figures 12–16).

External Hex Implant

Simple visual observation differences were noticed in the detection of the phenomenal gap due to different geometry of the implant, prosthetic abutment, and differences of the implant-abutment connection. The gap of 0.5 mm could clearly be distinguished at the mesial and distal sides of the prosthetic abutment up to +10°. At +15° only a trained clinician could diagnose the gap at the implant-abutment connection. At +20° the phenomenal gap could not be diagnosed (Figures 17–21). At negative (−) inclinations the phenomenal gap was not visible at −15°.

The 0.2 mm gap was clearly diagnosed at +5° and at +10° mesially and distally at the implant abutment connection. At +15° only a trained clinician could diagnose the improper fit at the interphase. At −10° inclination the gap was not visually detectable (Figures 22–26).

Visual Examination under Magnification

By visual examination in internal hex implants, using a magnifying lens, the phenomenal gap of 0.5 mm diminished at +20° and at +30° was not detectable. At negative (−) inclinations, the gap diminished at −10° and at −25° was not diagnosed.

The gap of 0.2 mm at +10° was difficult to distinguish, at +15° could not be diagnosed, and in (−) inclination at −10° the gap disappeared.

With a magnifying lens, the gap of 0.5 mm at the external hex implants was clearly observed

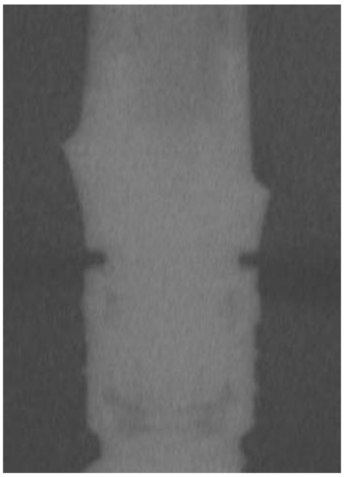

Figure 7. Radiograph of internal hex implant with 0.5 mm gap at 0°.

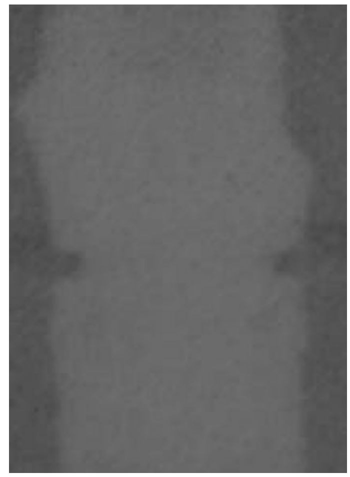

Figure 8. Radiograph of internal hex implant with 0.5 mm gap at +5°.

until +10° at the mesial-distal area of the interphase. At +15° an experienced clinician could hardly distinguish the improper fit, and at +20° the gap vanished. At (–) inclination in –10° the gap could not clearly be diagnosed, and at –20° disappeared. The 0.2 mm was distinguished up to +15°. At +20° degrees only a trained eye could see the gap. At –10° the gap was not diagnosed.

Projection of the X-rays with a Slide Projector

For detailed measurement of the gap, the X-rays were framed and projected on a large screen.

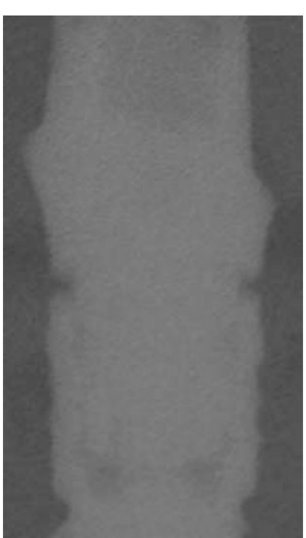

Figure 9. Radiograph of internal hex implant with 0.5 mm gap at +15°.

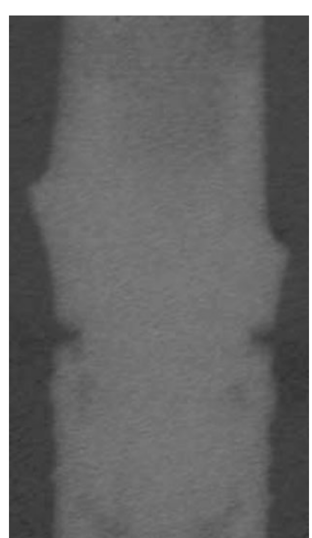

Figure 10. Radiograph of internal hex implant with 0.5 mm gap at –5°.

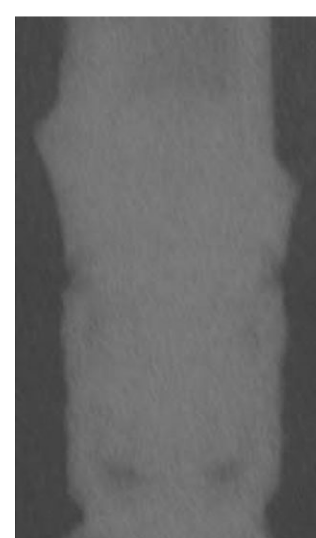

Figure 11. Radiograph of internal hex implant with 0.5 mm gap at –15°.

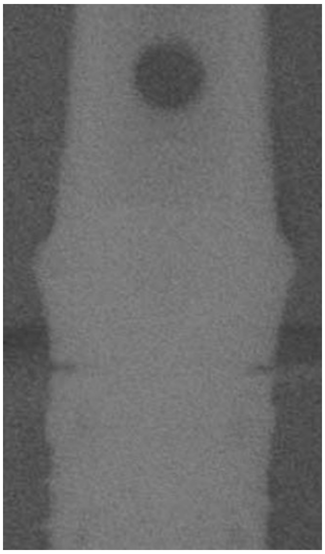

Figure 12. Radiograph of internal hex implant with 0.2 mm gap at 0°.

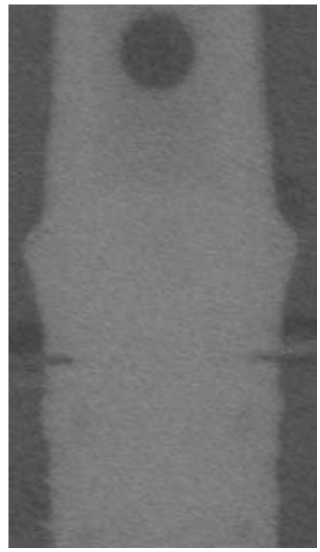

Figure 13. Radiograph of internal hex implant with 0.2 mm gap at +5°.

Figure 14. Radiograph of internal hex implant with 0.2 mm gap at +15°.

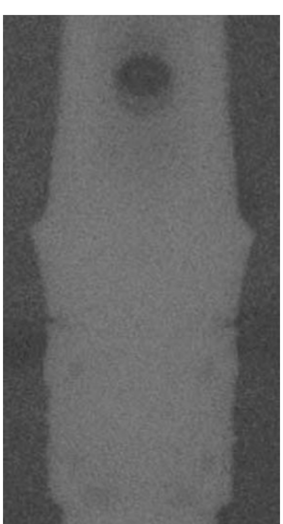

Figure 15. Radiograph of internal hex implant with 0.2 mm gap at –5°.

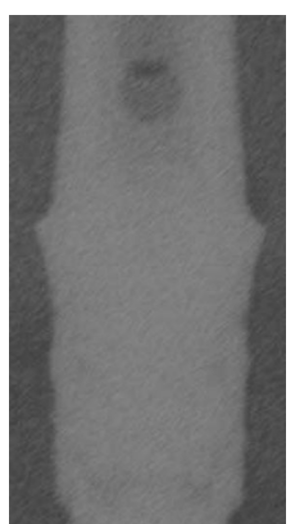

Figure 16. Radiograph of internal hex implant with 0.2 mm gap at –15°.

The projector was at standard distance from the screen so the magnification remained stable in all the X-rays. The gap dimensions, as measured under projection are reported in Tables 2–5.

The experimental procedure was repeated three times and the results were compared to evaluate the accuracy of the method.

Knowing the created standardized gap, the true dimensions of the implant, prosthetic abutment (true length), and measuring the projected image in constant

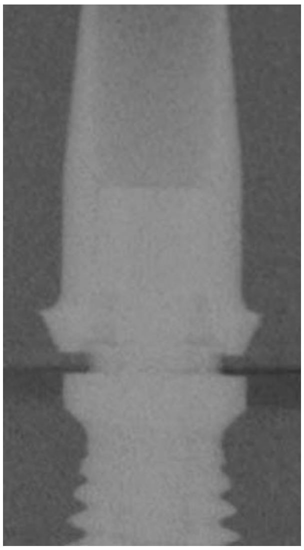

Figure 17. Radiograph of external hex implant with 0.5 mm gap at 0°.

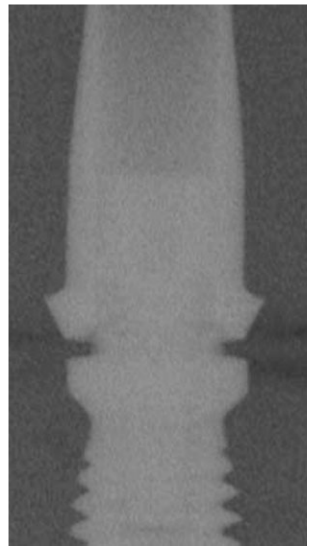

Figure 18. Radiograph of external hex implant with 0.5 mm gap at +5°.

Figure 19. Radiograph of external hex implant with 0.5 mm gap at +15°.

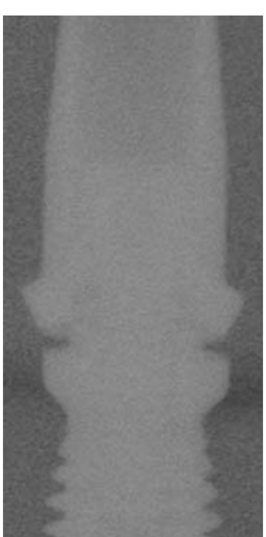

Figure 20. Radiograph of external hex implant with 0.5 mm gap at –5°.

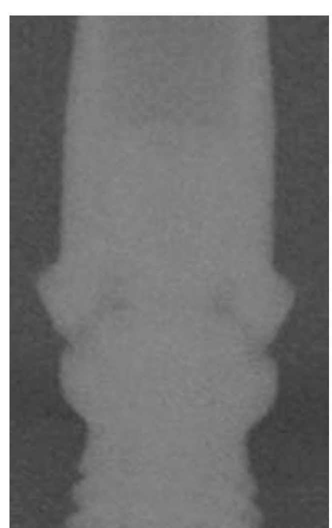

Figure 21. Radiograph of external hex implant with 0.5 mm gap at –15°.

magnification, the distortion in the projection was calculated using a simple method of three.

For example the internal hex implant at 0° the true gap (*y*) was 0.5 mm and was projected as a phenomenal gap (*y*) of 7.5 mm the magnification was 15× and remained stable in all the three sets of X-rays taken.

At the same implant the real gap at +10° was again 0.5 mm but the phenomenal gap (*y*) was 6.5 mm.

The magnification remained stable (15×), but the projection revealed

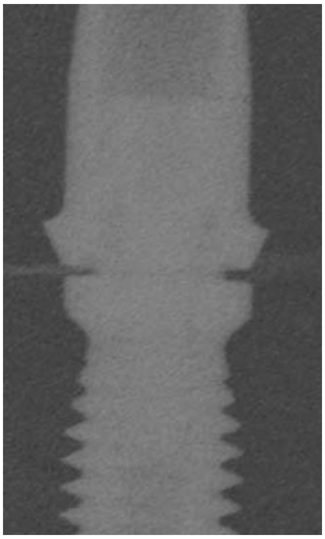

Figure 22. Radiograph of external hex implant with 0.2 mm gap at 0°.

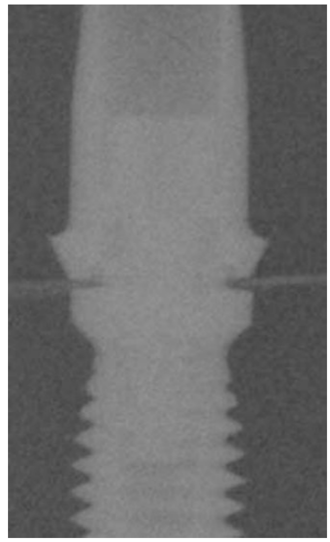

Figure 23. Radiograph of external hex implant with 0.2 mm gap at +5°.

Figure 24. Radiograph of external hex implant with 0.2 mm gap at +15°.

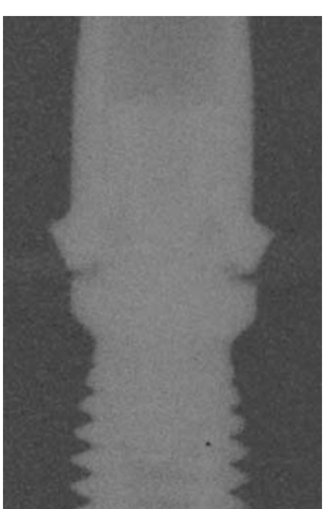

Figure 25. Radiograph of external hex implant with 0.2 mm gap at –5°.

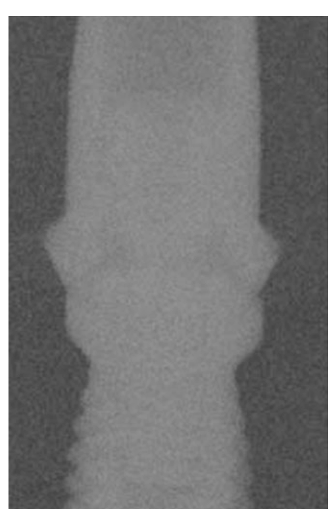

Figure 26. Radiograph of external hex implant with 0.2 mm gap at –15°.

that the gap dimensions were changed. This change in the phenomenal size was caused by the distortion of the image inclination of the X-ray tube.

Different angles create an overlap of the phenomenal gap from the top of the abutment that was projected on the gap.

The projection was calculated as a % using the following equation:

$$\text{Magnification} = \frac{\text{Phenomenal gap at } \chi^\circ}{\text{Phenomenal gap at } 0^\circ} \times 100$$

TABLE 2. INTERNAL HEX IMPLANT, 0.5-mm GAP.

Specimen INT.HEX	Degrees °	L r mm	L ph mm	Gap r.y mm	Gap ph.y mm	Dist.y %	W.r.x mm	W.ph.x mm	Dist.x %
Xive 3.8 mm	0	7.5	15	0.5	7.5	0	1	10	0
	5	7.5	15	0.5	7.5	0	1	10	0
	10	7.5	15	0.5	6.5	13.4	1	8	20
	15	7.5	15	0.5	4.5	40	1	6	40
	20	7.5	15.5	0.5	2.0	73.4	1	5	50
	25	7.5	16	0.5	—	—	1	—	—
	30	7.5	17	0.5	—	—	1	—	—
	–5	7.5	15	0.5	7.0	6.7	1	7	30
	–10	7.5	15	0.5	6.0	20	1	7	30
	–15	7.5	16	0.5	3.0	60	1	3	70
	–20	7.5	16.5	0.5	2.0	73.4	1	—	—
	–25	7.5	17	0.5	—	—	1	—	—
	–30	7.5	17.5	0.5	—	—	1	—	—

Dist y = (Distortion in *y*-axis) Distortion in *y*-axis; Dist. x = (Distortion in *x*-axis) Distortion in *x*-axis; Gap ph.y = (Gap phenomenal *y*) Phenomenal gap in *y* dimension (countable); Gap r.y = (Gap real *y*) Real gap in *y* dimension (standard); L ph = (Length phenomenal) Phenomenal height of the prosthetic abutment (countable); L r = (Length real) Real height of the prosthetic abutment (standard); W.ph.x = (Width phenomenal in *x*-axis) Phenomenal width in *x*-axis (countable); W.r.x = (Width real in *x*-axis) Real width in *x*-axis (stable).

TABLE 3. INTERNAL HEX IMPLANT 0.2-mm GAP.

Specimen INT HEX	Degrees °	L r mm	L ph mm	Gap r.y mm	Gap ph.y mm	Dist.y %	W.r.x mm	W.ph.x mm	Dist.x %
Xive 3.8 mm	0	7.5	15	0.2	4.0	0	1	10	0
	5	7.5	15	0.2	2.0	50	1	10	0
	10	7.5	15	0.2	1.0	75	1	8	20
	15	7.5	15	0.2	—	—	1	—	—
	20	7.5	15.5	0.2	—	—	1	—	—
	25	7.5	16	0.2	—	—	1	—	—
	30	7.5	17	0.2	—	—	1	—	—
	–5	7.5	15	0.2	2.0	50	1	5	50
	–10	7.5	15	0.2	1.0	75	1	—	—
	–15	7.5	16	0.2	—	—	1	—	—
	–20	7.5	16.5	0.2	—	—	1	—	—
	–25	7.5	17	0.2	—	—	1	—	—
	–30	7.5	17.5	0.2	—	—	1	—	—

Dist y = (Distortion in *y*-axis) Distortion in *y*-axis; Dist. x = (Distortion in *x*-axis) Distortion in *x*-axis; Gap ph.y = (Gap phenomenal *y*) Phenomenal gap in *y* dimension (countable); Gap r.y = (Gap real *y*) Real gap in *y* dimension (standard); L ph = (Length phenomenal) Phenomenal height of the prosthetic abutment (countable); L r = (Length real) Real height of the prosthetic abutment (standard); W.ph.x = (Width phenomenal in *x*-axis) Phenomenal width in *x*-axis (countable); W.r.x = (Width real in *x*-axis) Real width in *x*-axis (stable).

TABLE 4. EXTERNAL HEX IMPLANT 0.5-mm GAP.

Specimen EXT.HEX	Degrees °	L r mm	L ph mm	Gap r.y mm	Gap ph.y mm	Dist.y %	W.r.x mm	W.ph.x mm	Dist.x %
BRANEMARK 4 mm	0	8	15	0.5	8	0	1.1	10	0
	5	8	15	0.5	7	12.5	1.1	10	0
	10	8	15.5	0.5	6	25	1.1	10	0
	15	8	15.5	0.5	5	37.5	1.1	7	30
	20	8	16	0.5	2	75	1.1	2	80
	25	8	16.5	0.5	—	—	1.1	—	—
	30	8	17.5	0.5	—	—	1.1	—	—
	–5	8	15	0.5	6	25	1.1	10	0
	–10	8	15	0.5	4	50	1.1	2	80
	–15	8	15.5	0.5	2	75	1.1	—	—
	–20	8	16	0.5	—	—	1.1	—	—
	–25	8	16.5	0.5	—	—	1.1	—	—
	–30	8	17.5	0.5	—	—	1.1	—	—

Dist y = (Distortion in *y*-axis) Distortion in *y*-axis; Dist. x = (Distortion in *x*-axis) Distortion in *x*-axis; Gap ph.y = (Gap phenomenal *y*) Phenomenal gap in *y* dimension (countable); Gap r.y = (Gap real *y*) Real gap in *y* dimension (standard); L ph = (Length phenomenal) Phenomenal height of the prosthetic abutment (countable); L r = (Length real) Real height of the prosthetic abutment (standard); W.ph.x = (Width phenomenal in *x*-axis) Phenomenal width in *x*-axis (countable); W.r.x = (Width real in *x*-axis) Real width in *x*-axis (stable).

TABLE 5. EXTERNAL HEX IMPLANT 0.2-mm GAP.

Specimen EXT.HEX	Degrees °	L r mm	L ph mm	Gap r.y mm	Gap ph.y mm	Dist.y %	W.r.x mm	W.ph.x mm	Dist.x %
BRANEMARK 4 mm	0	8	15	0.2	5	0	1.1	10	0
	5	8	15	0.2	5	0	1.1	10	0
	10	8	15.5	0.2	4	20	1.1	10	0
	15	8	15.5	0.2	3	40	1.1	5	50
	20	8	16	0.2	2	60	1.1	—	—
	25	8	16.5	0.2	—	—	1.1	—	—
	30	8	17.5	0.2	—	—	1.1	—	—
	–5	8	15	0.2	4	20	1.1	10	0
	–10	8	15	0.2	2	60	1.1	2	80
	–15	8	15.5	0.2	—	—	1.1	—	—
	–20	8	16	0.2	—	—	1.1	—	—
	–25	8	16.5	0.2	—	—	1.1	—	—
	–30	8	17.5	0.2	—	—	1.1	—	—

Dist y = (Distortion in *y*-axis) Distortion in *y*-axis; Dist. x = (Distortion in *x*-axis) Distortion in *x*-axis; Gap ph.y = (Gap phenomenal *y*) Phenomenal gap in *y* dimension (countable); Gap r.y = (Gap real *y*) Real gap in *y* dimension (standard); L ph = (Length phenomenal) Phenomenal height of the prosthetic abutment (countable); L r = (Length real) Real height of the prosthetic abutment (standard); W.ph.x = (Width phenomenal in *x*-axis) Phenomenal width in *x*-axis (countable); W.r.x = (Width real in *x*-axis) Real width in *x*-axis (stable).

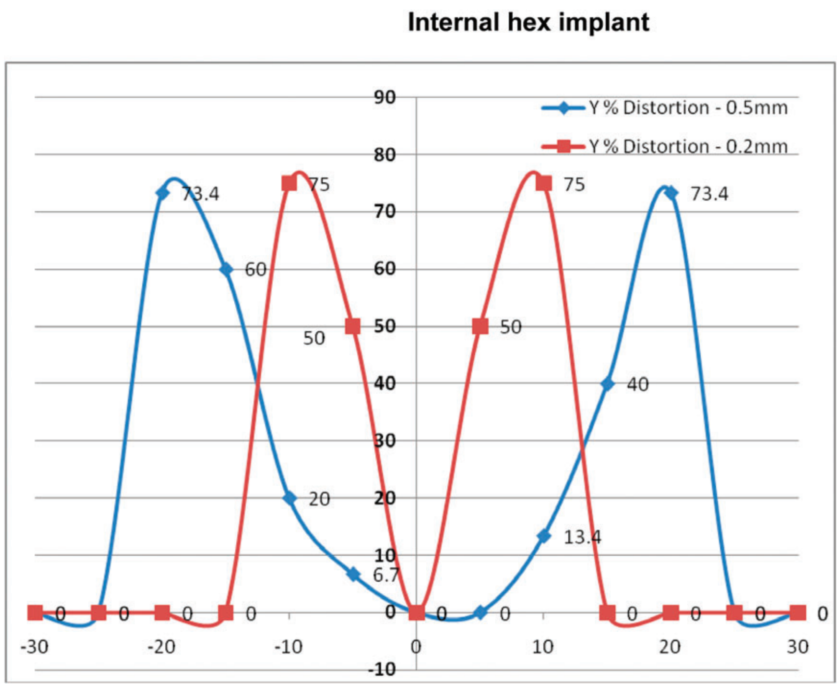

Figure 27. Fluctuation of the y*-value (distortion) for the internal hex implant, depending on the beam inclination (+/– degrees) for the two gaps that were used. At the horizontal axis the inclinations of the beam to the implant are shown. At the vertical axis the* y*-values of distortion are shown.*

The distortion was expressed in % and was calculated as the deduction from the result of the magnification in the equation mentioned above from 100 (ex. 100 ~ 86.6 = 13.14). The result could be either + or – and depended on the phenomenal gap of the control specimen (implant at 0°). At the experiment all three results were negative (–) because the phenomenal gap was always greater than the real gap.

The numerical results are shown in Tables 2–5. The fluctuation of x and y distortion (as calculated from Tables 2–5) is shown in Figures 27–30.

DISCUSSION

The most reliable method for the verification of a gap between the implant and the prosthetic abutment has been the intraoral radiography. Intraoral radiography, however, shows certain limitations, and false diagnosis of the X-ray may occur.

A certain degree of angulation between the implant-abutment connection and the X-ray film is always possible.[4,5] In order to achieve radiographical images with minimal distortion, the golden rule is the use of a paralleling device to ensure proper angulation of the X-ray film and the radiographical tube device.[6]

In former studies,[7–9] it has been proven that marginal gap of 0.1 mm is clearly distinguished in a radiograph taken at 0°. At an inclination of 5° the gap was not clearly seen and over 20° the gap was not recognizable. In a gap of 0.5 mm the gap was clearly seen at 0° and was easy to diagnose at angulations from 1° to 20°.

The gaps at the implant abutment connection that have been used as a criterion for the detection ability vary among authors: May and colleagues[7] used gaps of 25.4 μm–101 μm, Cameron and colleagues[8] used one gap of 0.7 mm as reference point, and Sewerin[9] used gaps varying from 0.05 to 0.5 mm.

The gaps used in the present study were 0.2 and 0.5 mm both for internal and external hexagon implant, in angulations varying

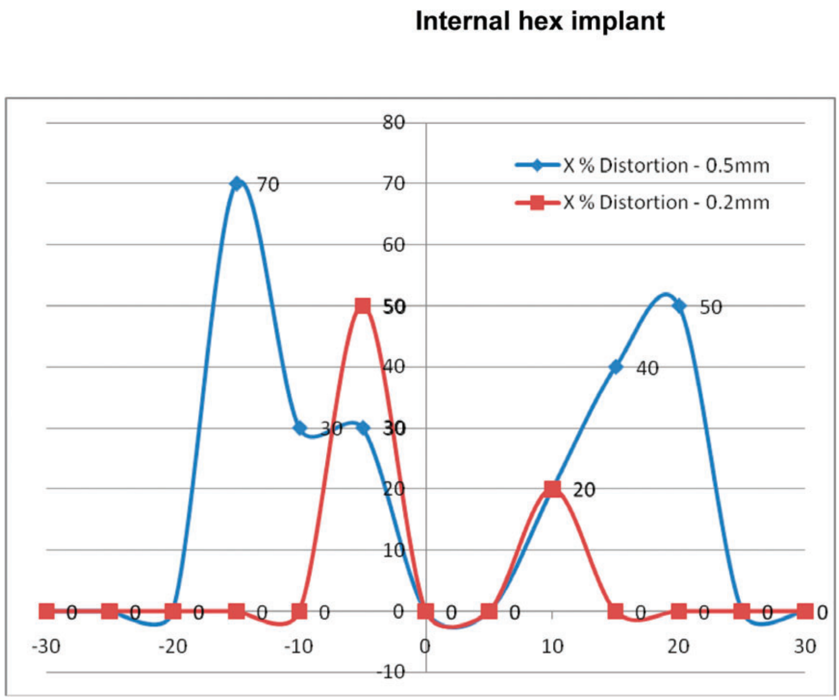

Figure 28. Fluctuation of the x-value (distortion) for the internal hex implant, depending on the beam inclination (+/– degrees) for the two gaps that were used. At the horizontal axis the inclinations of the beam to the implant are shown. At the vertical axis the x-values of distortion are shown.

from 0° to 30° (to the prosthetic abutment) and from 0° to –30° (to the implant).

The X-ray observation was made with methods already used in other studies including visual examination with no magnification and visual examination under magnification using a magnifying lens. An innovation for measurement of the phenomenal gaps was the examination in higher magnification, using a slide projector under standardized set up.

In the visual examination and the examination with a magnifying lens at +30° and –30° a trained eye could diagnose the projection of the implant and the prosthetic abutment and conclude that angulation was improper.

Using all three methods of X-ray observation, no gap at angulations over 30° could be distinguished.

In smaller angulations the existing gap was recognized on the X-rays and was visible (with visual examination and magnifying lens) but appeared distorted in dimensions.

The distortion in each X-ray that was not calculated by other authors imposed the need of higher magnifications in order to take specific measurements for the calculation of the distortion, by projecting the X-rays with a slide projector.

The differences that were observed between the internal and external hex implant were due to different morphology of the prosthetic abutment. Consequently, the projection on the X-ray was also different and the diagnosis of the gap was more complicated.

The different size of the gap influenced the diagnostic ability as concluded in the present and in other studies.[7–9]

For example, the gap of 0.2 mm was more difficult to diagnose at 15° and at 20°. The gap of 0.5 mm could not be diagnosed in 20° and was not diagnosable at 25°.

The gap in (–) angulations vanished in smaller inclinations com-

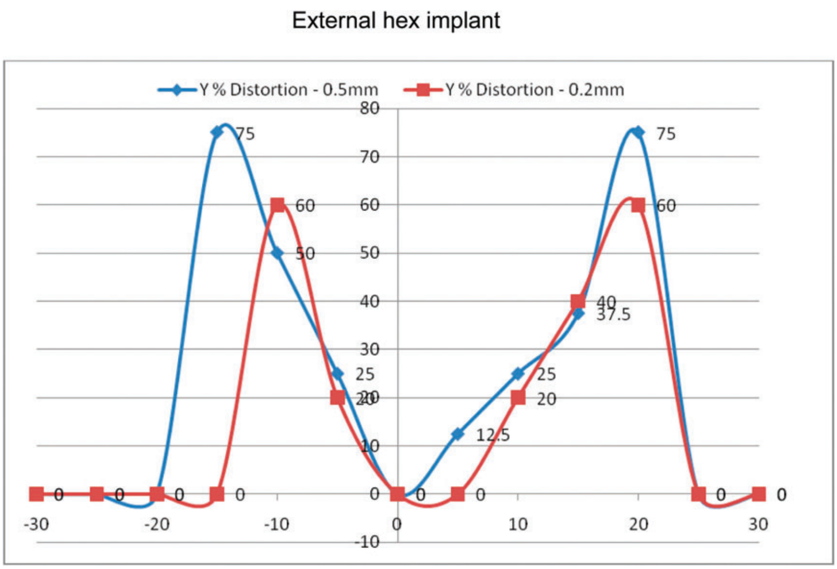

Figure 29. Fluctuation of the y-value (distortion) for the external hex implant, depending on the beam inclination (+/– degrees) for the two gaps that were used. At the horizontal axis the inclinations of the beam to the implant are shown. At the vertical axis the y-values of distortion are shown.

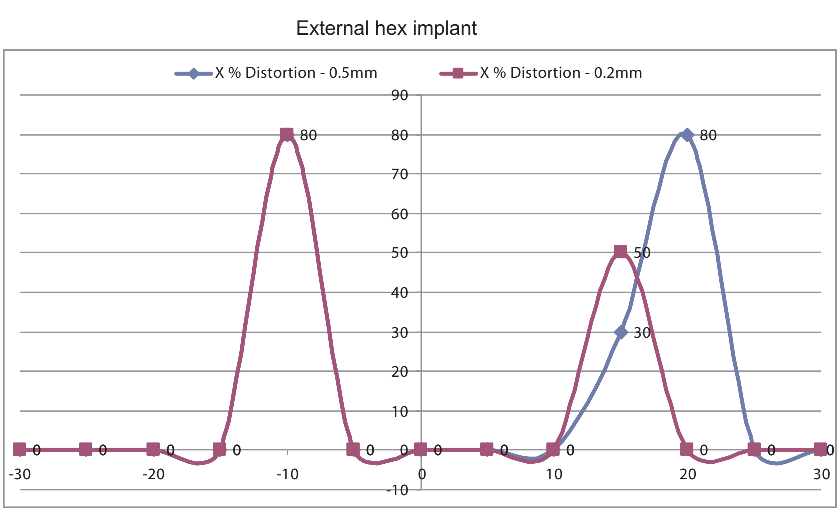

Figure 30. Fluctuation of the x-value (distortion) for the external hex implant, depending on the beam inclination (+/– degrees) for the two gaps that were used. At the horizontal axis the inclinations of the beam to the implant are shown. At the vertical axis the x-values of distortion are shown.

pared with (+) inclinations, due to the geometrical projection of the implant and its distortion inside the prosthetic abutment.

In all studies including radiography the implant was considered as the reference point because the true dimensions were known and standardized.[10,11]

In this study, besides the known dimensions of the implant and the prosthetic abutment, the true size of the gap in the implant-abutment connection was given.

Knowing the true dimensions of the implant and the prosthetic abutment (true length, phenomenal length), the distortion in the projection was calculated with the simple method of tree (slide projector). The results and conclusions of this method were in accordance with other studies.[8,9,12]

The discussion of results and their clinical significance is difficult; taking into consideration that the error often made in intraoral X-rays caused by wrong angulation is one of the most difficult parameters to control.[5]

If the implant is not in a parallel position to the film, the image of the X-ray appears distorted. So the evaluation of the gap between the implant-abutment connection is more difficult and not accurate.

Anatomical features of each patient like the shape of the palate or the width of the dental crest may cause additional distortion if the X-ray film has been placed in a convex position.

Despite these restrictions, intraoral radiography remains a valuable diagnostic method in implantology, and further research studies are necessary. Standardization of the X-ray device is necessary and the use of a paralleling device is strictly advocated.

The best angulation of the radiographical tube for a correct diagnosis of the mesial and distal defects is 0° (vertically to the long axis of the implant).

Only a slight deviation from the vertical projection at the size of +10° is allowed.

In clinical practice standardized intraoral radiography cannot always be ensured, and comparison of older and new X-rays may contribute to an accurate diagnosis.

CONCLUSIONS

1. Evaluating the three methods of observation, no gap could be diagnosed in inclinations greater than 20°. In smaller inclinations, the gap was depicted in the X-rays, and it could be seen with or without magnification but appeared distorted in dimension.
2. In external hex implants, the diagnosis of the gap was more complicated. In angulation with inclination to the implant (– degrees), the gap disappeared faster compared with inclination to the prosthetic abutment (+ degrees).
3. In all cases the film must be vertical to the X-ray beam or have inclination less than +15° or −10°.
4. The use of a paralleling device in intraoral X-ray for the verification of an existing gap in the implant-abutment connection is always advocated.

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Reprint requests: Stefanos Kourtis, DDS, Dr. Odont, 14 Plaza Chrys. Smyrnis 14, 17121 Athens, Greece; Tel/Fax: 30-210-9357306; email: stefkour@dent.uoa.gr

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