RESEARCH

Evaluation of the RB–RB/LB–LB mnemonic rule for recording optimally projected intraoral images of dental implants: an *in vitro* study

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Objective: The aim of this study was to evaluate a simple mnemonic rule (the RB–RB/LB–LB rule) for recording intra-oral radiographs with optimal projection for the control of dental implants.

Methods: 30 third-year dental students received a short lesson in the RB–RB/LB–LB mnemonic rule. The rule is as follows: if right blur then raise beam (RB–RB), *i.e.* if implant threads are blurred at the right side of the implant, the X-ray beam direction must be raised towards the ceiling to obtain sharp threads on both implant sides; if left blur then lower beam (LB–LB), *i.e.* if implant threads are blurred at the left side of the implant, the X-ray beam direction must be lowered towards the floor to obtain sharp threads on both implant sides. Intra-oral radiographs of four screw-type implants placed with different inclination in a Frasaco upper or lower jaw dental model (Frasaco GmbH, Tett nang, Germany) were recorded. The students were unaware of the inclination of the implants and were instructed to re-expose each implant, implementing the mnemonic rule, until an image of the implant with acceptable quality (subjectively judged by the instructor) was obtained. Subsequently, each radiograph was blindly assessed with respect to sharpness of the implant threads and assigned to one of four quality categories: (1) perfect, (2) not perfect, but clinically acceptable, (3) not acceptable and (4) hopeless.

Results: For all implants, from one non-perfect exposure to the following, a higher score was obtained in 64% of the cases, 28% received the same score and 8% obtained a lower score. Only a small variation was observed among exposures of implants with different inclination. On average, two exposures per implant (range: one to eight exposures) were needed to obtain a clinically acceptable image.

Conclusion: The RB–RB/LB–LB mnemonic rule for recording intra-oral radiographs of dental implants with a correct projection was easy to implement by inexperienced examiners. *Dentomaxillofacial Radiology* (2012) **41**, 298–304. doi: 10.1259/dmfr/20861598

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Introduction

Follow-up radiographs of dental implants should be performed at regular intervals after implant placement with the main purpose to assess peri-implant crestal

bone level and surrounding bone conditions as well as the implant reconstruction components.^{1–3} Usually, intra-oral radiography is the method of choice because this technique provides the sharpest image of the bone-to-implant contact. To ensure a correct estimate of the peri-implant crestal bone level and to be able to assess the adaptation between the implant reconstruction components, the radiation beam must be perpendicular to the long axis of the implant and the film or digital

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receptor must be placed parallel to this axis.¹ Nevertheless, it may be a challenge to obtain optimal images owing to the fact that implants may not always be inserted with an inclination corresponding to that of the alveolar process or have the same inclination as the neighbouring teeth. This might especially be the case in fully edentulous patients owing to the consequences of previous disease, but also in single tooth replacements in agenesis sites where variable amounts of alveolar bone may be missing. It is obvious that the correct alignment of the radiation beam may be difficult to predict while the implant is still submerged or before the prosthetic restoration has been mounted. Moreover, even after placement of the implant suprastructure, the implant axis cannot always be determined from a clinical examination because the abutment and restoration may be angulated in relation to the implant.

When evaluating radiographic images of screw-type implants, it is not difficult to determine whether the alignment of the tube has been correct in relation to the implant long axis. An image displaying sharp threads with no overlaps on both sides of the implant reflects an optimal projection in the vertical plane. On the other hand, blurred threads on either side indicate that the direction of the radiation beam had either an obtuse or

an acute angle in relation to the implant. Since all screw-type implants are inserted by a clockwise turn of the screw, threads appearing mostly blurred on the left or right side of the implant indicate that the radiation angle was obtuse or acute in relation to the long axis of the implant.⁴ Based on this principle, a simple mnemonic rule can be applied in order to correct the inclination of the X-ray tube to obtain a second image with sharp implant threads. The rule may be memorized by a simple acronym, RB–RB/LB–LB: if right blur then raise beam, *i.e.* if implant threads are mostly blurred at the right side of the implant, the X-ray beam direction must be raised towards the ceiling to obtain sharp threads on both implant sides (Figure 1a); if left blur then lower beam, *i.e.* if implant threads are mostly blurred at the left side of the implant, the X-ray beam direction must be lowered towards the floor to obtain sharp threads on both implant sides (Figure 1b). Of course, the film holder must also be repositioned so that the radiation beam is kept at a right angle to the film/digital receptor. The RB–RB/LB–LB rule applies irrespective of whether the implant is placed in the upper or lower jaw.

The purpose of this study was to evaluate the use of the RB–RB/LB–LB mnemonic rule for recording optimally projected intra-oral images of dental implants.

Figure 1 (a) The RB–RB/LB–LB rule: if implant threads are mostly blurred at the right side of the implant (right blur), the angle was acute and the radiation beam direction must be raised (raise beam) towards the ceiling (to aim perpendicular to the long axis of the implant). (b) The RB–RB/LB–LB rule: if implant threads are mostly blurred at the left side of the implant (left blur), the angle was obtuse and the radiation beam direction must be lowered (lower beam) towards the floor (to aim perpendicular to the long axis of the implant)

Materials and methods

30 pre-graduate dental students were instructed in recording intra-oral radiographs of dental implants as part of their radiology course in the sixth semester. Over an 8-day period, 16 groups with 2 students each (only 1 student in 2 cases) were given a short instruction lasting approximately 10 min by means of an oral presentation including 8 PowerPoint slides. The slides denoted the necessity for a sharp periapical image in follow-up examinations of dental implants with a focus on optimal projection geometry. In this context the RB–RB/LB–LB mnemonic rule was also explained and the students received a standard screw to visualize the concept and to rehearse the rule by eye before implementing it in practice (Figure 2).

Immediately after the instruction session, all students recorded intra-oral images of four implants placed in a Frasaco dental model (Frasaco GmbH, Tett nang, Germany), which was fixed in a phantom head together with an antagonist model (Figure 3). One upper and

one lower model jaw were prepared. Half of the students worked with the lower jaw model and the other half with the upper jaw model. 4 teeth in each model (right second molar (17), right first molar (16), left canine (23) and left first molar (26) in the upper jaw, and right first molar (46), right canine (43), left first molar (36) and left second molar (37) in the lower jaw) were removed and replaced by screw-type dental implants (Nobel Biocare AB, Gothenburg, Sweden). One implant in each model (position 23 and 43) was placed parallel to the inclination of the adjacent teeth and the inclination of the alveolar process (*i.e.* straight implant). The other three were placed with a distal, buccal or lingual/palatal inclination of approximately 25°. The implants were fixed in the alveolus by the use of a silicone impression material and covered on the top by wax so that the inclination of the implants was not discernible to the students.

For the examination a standard film holder (Take-All™; Denbur, Inc., Oak Brook, IL) and a digital photostimulable phosphor plate system (Digora; Soredex, Tuusula, Finland) were used (Figure 4). The size of the imaging plates was 22 × 31 mm (size 0).

The students were instructed to re-expose each implant until an acceptable image of the implant was obtained. This meant that a second (and third and fourth, etc.) exposure was performed using the RB–RB/LB–LB rule when the first exposure showed a distinct blur or overlap of the threads in the right or left implant side or in both sides. Moreover, a re-exposure was performed when fewer than three threads on both sides were visible (*i.e.* in cases of incorrect positioning of the receptor or cone cuts). The same instructor for all students judged whether the image was acceptable or should be re-exposed. The students were allowed 80 min to record the images of the four implants in the dental model.

Subsequently, a dentist not involved in the study evaluated all the images blind without knowledge of

Figure 2 For the instruction of the RB–RB/LB–LB rule, a standard screw was used as a teaching tool that may facilitate the understanding of the principle. (a) Viewing the screw at a right angle, sharp threads are displayed on both sides. (b) Viewing the screw from above (acute angle), blurred threads are displayed on the right side. (c) Viewing the screw from below (obtuse angle), blurred threads are displayed on the left side. The rule applies irrespective of how the screw is turned (whether the implant is placed in the upper or lower jaw)

Figure 3 A lower jaw Frasaco dental model with four implants placed in a phantom head

Figure 4 A standard film holder and a digital photostimulable phosphor plate system were used for recording the implants

which number in a sequence the exposure had (first, second etc). The images were assessed with regard to sharp display of the implant threads in both sides allocating each image to one of four quality categories: (1) perfect (sharp threads at both implant sides); (2) not perfect, but clinically acceptable (minor blur of the threads in either of the implant sides, no overlaps); (3) not acceptable (blurred threads in one or both implant sides); and (4) hopeless (overlap of the threads in one or both sides and/or fewer than three threads on both sides visible). An atlas containing four examples of images for each score (Figure 5) was used as a reference when scoring the images. The observer repeated the evaluation after 1 week. The reproducibility of the two scorings was tested by kappa statistics. In cases of disagreement between the first and the second score, three additional observers scored the image and a consensus was reached.

In order to assess whether the students were able to implement the RB–RB/LB–LB rule, it was evaluated whether a re-exposure obtained a higher, the same or a lower score than the previous exposure. Medians and ranges for the number of exposures needed to obtain a perfect/acceptable image (scores 1 or 2) were calculated for each implant site and differences between the straight implant and the three angulated implants were compared using the Mann–Whitney *U*-test.

Results

A high agreement between the scores of the first and second evaluations of implant image quality was found (kappa = 0.861) and on no occasion was there more than one step difference between the two scores.

Table 1 shows the scores for all images obtained from the eight implant sites. One group of students did not manage to obtain an acceptable image of two out of the four implants and one group did not manage to obtain an acceptable image of one out of the four implants within the available time frame of 80 min. A

Category 1: perfect

Category 2: not perfect, but clinically acceptable

Category 3: not acceptable

Category 4: hopeless

Figure 5 An atlas with four examples of images for each score was used as a reference when scoring the implant image quality

perfect image at first exposure was obtained in 5 of 64 cases (8%) and in 14 cases (22%) a perfect image was obtained at second exposure. Table 2 shows the number and percentage of cases obtaining a higher, the same and a lower score from first exposure to second exposure, from second exposure to third exposure etc. A higher score for the following exposure for all implants was given in 64% of the cases, while only 8% of the re-exposures were of lower quality compared with the previous exposure (Table 2). Only little variation regarding the percentages of improvement or worsening of image quality after re-exposure was observed among the implants with varying inclination. For all implant sites, two exposures (range: one to eight exposures) per implant were needed on average to obtain a perfect/acceptable image (score 1 or 2). Only minor variation was seen among the sites; however, the buccally inclined implant in the lower jaw required fewest exposures with a median of one ($p > 0.11$).

Discussion

For proper monitoring of dental implants after their placement, it is a prerequisite that the clinician has

Table 1 The scores for all images taken of the 8 implant sites by the 16 groups of students

<i>Inclination</i>	<i>Tooth</i>	<i>Group</i>	<i>First exp.</i>	<i>Second exp.</i>	<i>Third exp.</i>	<i>Fourth exp.</i>	<i>Fifth exp.</i>	<i>Sixth exp.</i>	<i>Seventh exp.</i>	<i>Eighth exp.</i>
Straight	23	1	2	2	—	—	—	—	—	—
		2	2	2	—	—	—	—	—	—
		3	4	2	1	—	—	—	—	—
		4	3	4	1	—	—	—	—	—
		5	3	2	2	—	—	—	—	—
		6	3	3	3	2	—	—	—	—
		7	3	2	1	(2)	—	—	—	—
		8	4	2	—	—	—	—	—	—
	43	9	2	1	—	—	—	—	—	—
		10	4	4	3	—	—	—	—	—
		11	3	2	—	—	—	—	—	—
		12	2	3	—	—	—	—	—	—
		13	1	(2)	(2)	—	—	—	—	—
		14	3	2	2	—	—	—	—	—
		15	4	3	3	2	2	—	—	—
		16	4	2	2	1	—	—	—	—
Buccal	17	1	4	4	2	1	—	—	—	—
		2	2	2	2	4	2	1	—	—
		3	2	1	—	—	—	—	—	—
		4	2	2	1	—	—	—	—	—
		5	4	2	—	—	—	—	—	—
		6	4	2	2	—	—	—	—	—
		7	2	1	—	—	—	—	—	—
		8	3	3	2	—	—	—	—	—
	37	9	1	(3)	(1)	—	—	—	—	—
		10	2	3	1	—	—	—	—	—
		11	1	—	—	—	—	—	—	—
		12	2	1	—	—	—	—	—	—
		13	1	(1)	—	—	—	—	—	—
		14	3	4	3	2	—	—	—	—
		15	2	1	—	—	—	—	—	—
		16	2	1	—	—	—	—	—	—
Lingual/palatal	16	1	4	3	4	—	—	—	—	—
		2	4	2	1	—	—	—	—	—
		3	4	1	(2)	(2)	—	—	—	—
		4	2	—	—	—	—	—	—	—
		5	1	—	—	—	—	—	—	—
		6	2	2	1	—	—	—	—	—
		7	4	3	1	—	—	—	—	—
		8	4	4	2	—	—	—	—	—
	36	9	4	4	2	2	—	—	—	—
		10	4	2	3	—	—	—	—	—
		11	4	4	3	1	(1)	—	—	—
		12	4	2	2	1	—	—	—	—
		13	4	2	—	—	—	—	—	—
		14	2	1	—	—	—	—	—	—
		15	4	3	2	1	(2)	—	—	—
		16	2	3	1	—	—	—	—	—
Distal	26	1	4	1	(1)	—	—	—	—	—
		2	4	3	2	1	(1)	—	—	—
		3	2	2	—	—	—	—	—	—
		4	4	3	2	—	—	—	—	—
		5	2	2	—	—	—	—	—	—
		6	2	2	2	1	—	—	—	—
		7	4	1	(1)	(1)	—	—	—	—
		8	2	1	—	—	—	—	—	—
	46	9	4	2	2	1	—	—	—	—
		10	4	4	3	4	4	4	4	4
		11	4	1	—	—	—	—	—	—
		12	2	—	—	—	—	—	—	—
		13	4	1	—	—	—	—	—	—
		14	3	2	—	—	—	—	—	—
		15	4	1	(1)	—	—	—	—	—
		16	4	2	—	—	—	—	—	—

The numbers in parentheses indicate that a score of 1 was achieved for the previous exposure (exp.).

Table 2 Number and percentage of cases with a higher, the same and a lower score from first exposure to second exposure, from second exposure to third exposure etc.

<i>Inclination</i>	<i>Higher score</i>		<i>Same score</i>		<i>Lower score</i>	
	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>
Straight	16	59	9	33	2	7
Buccal	16	64	6	24	3	12
Lingual/palatal	20	69	6	21	3	10
Distal	17	63	9	33	1	4
All	69	64	30	28	9	8

When a score of 1 (perfect image) was obtained, a comparison with the following exposure (if any) was omitted.

access to high-quality intra-oral radiographs. Since implant therapy has become a standard treatment, an oral radiology course should include training in how to record optimal images of dental implants. A rule that facilitates radiation beam alignment for recording intra-oral radiographs with correct projection geometry to ensure sharp rendering of the implant threads has previously been presented in textbooks on implant treatment.^{4,5} The rule is based on the fact that all screw-type implants are inserted by a clockwise turn of the screw; thus, threads which are blurred mostly on the left or right side of the implant indicate that the radiation angle was obtuse or acute in relation to the long axis of the implant. Consequently, in order to obtain sharp threads on both sides of the implant, if the threads are mostly blurred at the right side, the X-ray beam direction must be raised, and if the threads are mostly blurred at the left side, the X-ray beam direction must be lowered. However, the rule is currently not described in oral radiology textbooks used worldwide^{6,7} and therefore is not widely known. Moreover, despite its theoretical simplicity, the rule has never been validated.

We suggest the mnemonic acronym "RB-RB/LB-LB" (right blur-raise beam/left blur-lower beam) for this rule to help memorize it and it was evaluated whether the rule facilitated proper radiation beam alignment for recording optimally projected intra-oral images of dental implants with different inclinations.

The results of our study showed that, based on the RB-RB/LB-LB rule, even inexperienced examiners such as third-year dental students were able to improve the quality of the implant images by changing the vertical projection angle in the correct direction from one exposure to the next in two-thirds of the cases. The results also demonstrated that on average two exposures per implant for all implant sites were needed to obtain a score of 1 or 2, which defined clinically acceptable images. In a parallel study with a similar set-up,⁸ the quality of implant images (in terms of rendering of sharp implant threads) recorded merely using the RB-RB/LB-LB mnemonic rule and a standard film holder was compared with that of images recorded by use of a customized imaging guide. The study demonstrated that the mnemonic rule and film holder method was inferior to the customized imaging guide with regard to the quality of the first exposure, but not when the evaluation also included the second exposure. Learning

and applying the rule may be inexpensive and time saving compared with the efforts needed for constructing the customized imaging guide.

In the present study, only 10 min of theoretical teaching and a standard screw for rehearsing the RB-RB/LB-LB rule were provided. This simple and inexpensive teaching set-up seemed to facilitate inexperienced examiners' understanding and ability to implement the rule. However, variation among the student groups regarding their performance was also observed. One group made eight exposures of one implant without obtaining an acceptable image; the students in this group were allowed to discontinue the recordings owing to subsequent scheduled lectures. It might be reasonable to expect that the RB-RB/LB-LB rule would perform much better in the hands of clinicians or oral radiologists with experience in intraoral radiographic recording; however, this assumption remains to be tested.

A reasonable concern about the applicability of the rule would be with regard to the inclination of the implant within the alveolar process. It could be expected that it would be more difficult to record an implant with a different inclination than that of the alveolar process or the adjacent teeth compared with implants placed straight within the alveolar process and parallel to the neighbouring teeth. However, in general, no major differences in either the quality of the first exposure or improvement between exposures were found among implants placed in a straight position and those placed with an extreme buccal, lingual/palatal or distal inclination. In fact, twice as many images of the buccally inclined implants were judged to be perfect or acceptable (score 1 or 2) at first exposure compared with the other implants; no reasonable explanation for this finding can be given.

It should be considered that the quality of the implant images was assessed subjectively. Nevertheless, the reproducibility test showed an almost perfect agreement⁹ when comparing the first and second scorings.

It is obvious that implementation of the RB-RB/LB-LB mnemonic rule for imaging implants in patients should be evaluated in a future clinical study. In this context, some differences may exist between the present study set-up and the clinical situation. When recording the implants in jaw models in a phantom head, a change in radiation beam angle—if a re-exposure is needed—may be easy to control since the position of the phantom head can be left unchanged during repeated exposures. Therefore, it is reasonable to anticipate that exposures in patients would be more challenging since it may be more difficult to ensure that the patient does not change the position of their head from one exposure to the next.

In conclusion, by applying the principle of the RB-RB/LB-LB mnemonic rule, the quality of implant images was improved in two-thirds of the cases by changing the vertical projection angle in the correct direction from one exposure to the next. Therefore, it

can be concluded that after a short theoretical teaching session and handing out of a standard screw for rehearsing, inexperienced examiners in the majority of

cases were able to successfully implement the simple RB–RB/LB–LB rule for recording optimally projected intra-oral images of dental implants.

References

1. Gröndahl HG. Radiographic examination. In: Lindhe J, Karring T, Lang NP, eds. *Clinical periodontology and implant dentistry*. Copenhagen: Munksgaard; 1997. pp. 873–889.
2. Jacobs R, van Steenberghe D. Radiographic follow-up of endosseous implants. In: Jacobs R, van Steenberghe D, eds. *Radiographic planning and assessment of endosseous oral implants*. Berlin: Springer; 1998. pp. 61–102.
3. Kircos LT, Misch CE. Diagnostic imaging and techniques. In: Misch CE, ed. *Contemporary implant dentistry*. St. Louis, MO: Mosby; 1999. pp. 73–87.
4. Gröndahl K, Ekestubbe A, Gröndahl HG. Postoperative radiographic examinations. In: Gröndahl K, Ekestubbe A, Gröndahl HG, eds. *Radiography in oral endosseous prosthetics*. Göteborg: Nobel Biocare AB; 1996. pp. 111–126.
5. Gröndahl HG, Gröndahl K. High quality radiology—a sine qua non in planning and monitoring of osseointegration-based treatment in the oro-facial area. In: Brånemark P-I, ed. *The osseointegration book: from calvarium to calcaneus*. Berlin/London: Quintessenz; 2005. pp. 177–208.
6. Whaites E. *Essentials of dental radiography and radiology*. Edinburgh, UK: Churchill Livingstone; 2006.
7. White SC. *Oral radiology: principles and interpretation*. St. Louis, MO: Mosby/Elsevier; 2009.
8. Schropp L, Stavropoulos A, Spin-Neto R, Wenzel A. Implant image quality in dental radiographs recorded using a customized imaging guide or a standard film holder. *Clin Oral Implants Res* 2012; **23**: 55–59.
9. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; **33**: 159–174.