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## Clinical Report

# Pre-operative Drilling Simulation Method for Dental Implant Treatment

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## Abstract

The position, depth and direction of implant placement are often planned based on evaluation of radiographs and study casts. Insertion planned in such a manner may not be adequate for precise and safe surgery in some cases due to inadequate working clearance in the oral cavity. In order to obtain high initial stability and ensure osseointegration at the implant-bone interface, careful and precise drilling must be performed at the implant placement site. Therefore, we propose the necessity of evaluating the operability of implant treatment-devices prior to surgery.

The amount of handling space needed during implant placement surgery was determined. The results showed that for implants with a length of 7–18 mm, a vertical distance of as much as 50–60 mm was required, depending on the implant platform. These results suggest the necessity of pre-operative drilling simulation in each individual.

Handling space was measured with angled heads and probes fabricated on a trial basis for pre-surgical drilling simulation in the oral cavity. We believe that these instruments may be clinically useful in estimating the amount of handling space required prior to surgery and ensuring precise implant placement.

Evaluation of the intra-oral environment for handling of treatment devices should be included in the pre-surgical intra-oral evaluation of dental implant cases to avoid changes in treatment planning due to intra-oral interference during the course of surgery.

Key words: Dental implant—Intra-oral examination—Implant placement—  
Handling space—Drilling simulation

## Introduction

In establishing a pre-operative diagnosis in an implant case, it is very important to take

into account the handling characteristics of the tools to be used in the oral cavity to ensure a smooth and accurate course of implant surgery and subsequent related treatment.

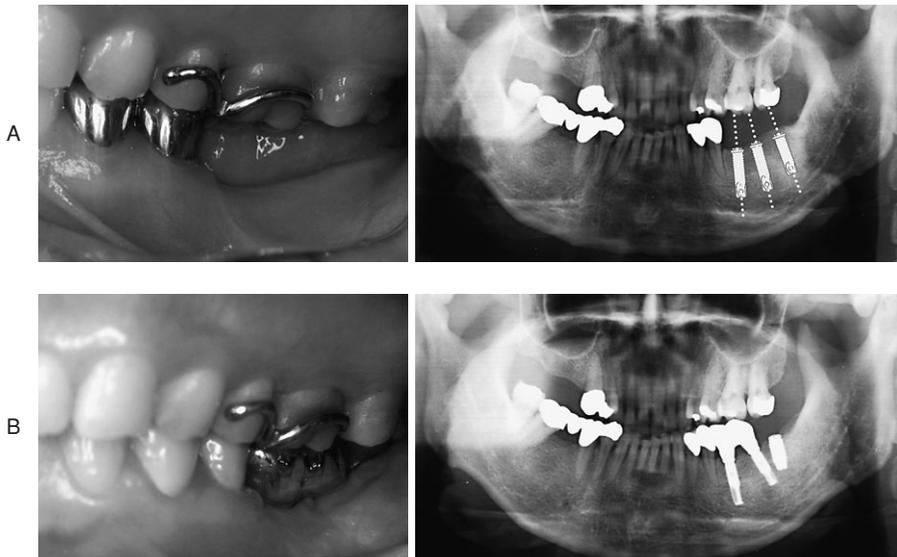


Fig. 1 Case influenced by limited handling space during implant placement

A: Pre-operative intra-oral picture and placement plan on panoramic radiograph.

B: Post-operative intra-oral picture and panoramic radiograph.

Planned insertion position, depth and direction of implant placement established before surgery had to be changed during surgery through lack of handling space.

Although a guidance system has recently been introduced, handling space still needs to be taken into consideration<sup>2,4,7</sup>.

Precise and smooth drilling is indispensable for achieving osseointegration<sup>3,8</sup>. If handling during surgery is not smooth, the high initial stability essential for the success of the implant and acquisition of osseointegration may not be obtained or unexpected complications may arise<sup>5</sup>.

In the case shown in Fig. 1, the initial treatment plan had to be changed because the intra-oral handling environment was inadequate. The planned insertion position, depth and direction of implant placement determined before surgery had to be changed during surgery, owing to lack of handling space, a result, the superstructure design also had to be changed. Similarly, if a patient has antagonist or adjacent teeth near the planned insertion site, or inadequate mouth-opening or high tension in the lips, cheek or tongue, treatment can be difficult. This is because the treatment devices interfere with the residual teeth or soft tissue, forcing changes in the

treatment plan. The Japanese maxillo-facial morphology is quite different from that of Caucasians<sup>6</sup>, and often sufficient mouth-opening cannot be obtained. As a result, the operator is often forced to change the treatment plan during the course of treatment. In addition, the risk of causing accidental injury is also high.

Taking these facts into consideration, we have introduced evaluation of the intra-oral environment for handling of instruments at the pre-surgical intra-oral examination. In this report, we introduce our methods of examining the intra-oral working environment.

## Materials and Methods

### 1. Measurement of handling space required at implant site

First, in order to determine the amount of handling space available for surgery, the dimensions of the instruments were measured.

The minimum vertical distance required for using a twist drill in conjunction with an

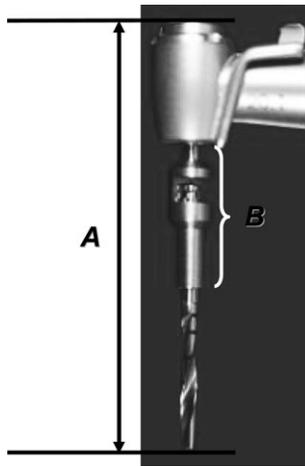


Fig. 2 Measurement of minimum vertical distances required for twist drill in conjunction with angled head

A: Vertical distance. B: Drill extension shaft.

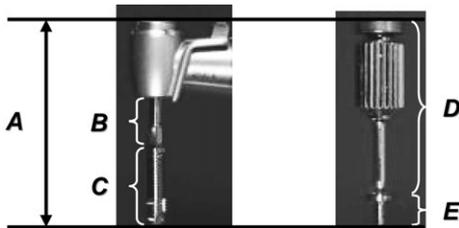


Fig. 3 Measurement of vertical distances required for various combinations of implants and implant drivers

A: Vertical distance. B: Implant driver. C: Implant body. D: Cover screw driver. E: Cover screw.

angled head (Nobel Biocare<sup>®</sup>) was determined (Fig. 2), together with the vertical distance required for using various combinations of Brånemark system implants and implant drivers (Nobel Biocare<sup>®</sup>) (Fig. 3).

## 2. Pre-surgical drilling simulation using trial angled heads and probes

Angled heads and measurement probes were fabricated on a trial basis for measurement of handling space, allowing pre-surgical drilling simulation in the oral cavity. The trial angled heads accurately reproduced the sizes and details of Nobel Biocare<sup>®</sup> angled heads

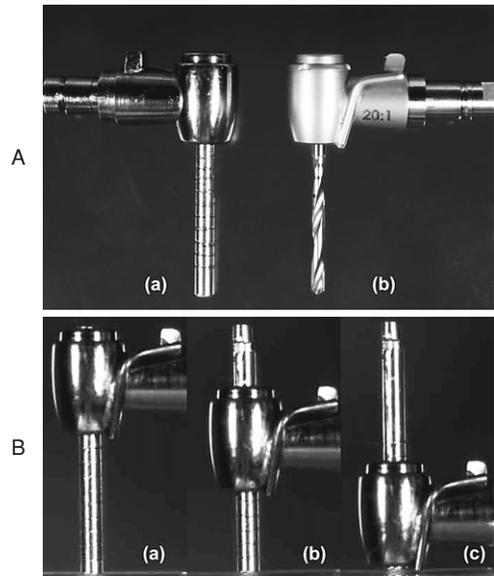


Fig. 4 Angled head and measurement probe for measurement of handling space

A: Trial angled head equipped with trial probe (a) and actually used angled head equipped with twist drill by Nobel Biocare<sup>®</sup> (b).

B: Expansion and contraction of measurement probe as in actual drilling operation.

(a) Trial angle head and probe before commencement of expansion and contraction.

(b) Probe in middle of descent with hand pressure.

(c) Probe expanded to maximum depth.

used for actual surgery, and could be fitted to the hand piece supplied by the company. The trial measurement probes were designed to expand and contract vertically by means of an internal spring, allowing adjustment of length when fitted to the angled head (Fig. 4). The use of these trial angled heads and probes made it possible to simulate drilling of soft tissue prior to surgery, and the operation of similar devices to those used in an actual clinical setting. Figure 5 illustrates the procedure used to examine the intra-oral working environment. First, a wax-up is prepared on the diagnostic cast to allow familiarization with the morphology of the superstructure in contact with the residual ridge before manufacturing of the diagnostic template. Then, using radiographs, the correct insertion position, size and insertion direction of the implant are determined. The diagnostic

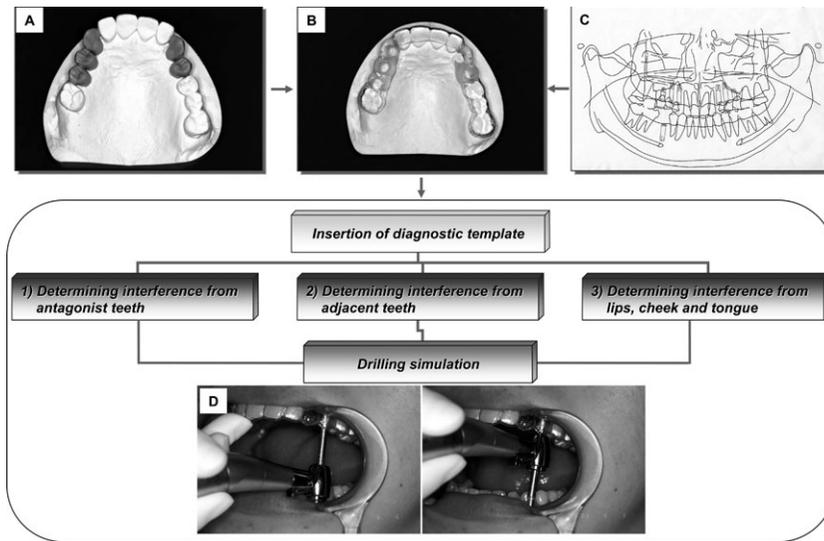


Fig. 5 Procedure for studying intra-oral working environment

A: Wax-up model. B: Diagnostic template. C: Initial placement plan. D: Simulation of drilling of soft tissue at planned implant site.

Diagnostic template loaded into oral cavity, and each interference (1–3) shown in chart is determined during drilling simulation.

Table 1 List of minimum vertical distances required for using twist drill in conjunction with angled head

Length of drill	Without drill extension shaft	With drill extension shaft
7–10mm	29.5	46.0
6–13mm	33.5	50.0
7–15mm	34.5	51.0
13–20mm	39.5	56.0

(mm)

template is then loaded into the oral cavity, and interference from antagonist and adjacent teeth or lips, cheek and tongue at the proposed implant site are determined by simulation of drilling.

## Results

### 1. Measurement of amount of handling space required at implant site

The minimum vertical distances required

for using a twist drill in conjunction with an angled head are listed in Table 1. The vertical distance of the twist drills ranged from 29.5 to 39.5 mm. When using a drill extension shaft, a vertical distance of 46–56 mm was required.

The vertical distances required for using various combinations of implants and implant drivers are listed in Table 2. When implants with lengths of 7–18 mm were inserted using implant drivers of 21, 26 and 34 mm length, minimum vertical distances of 25.5–36.5 mm, 30.5–41.5 mm and 38.5–49.5 mm

Table 2 List of vertical distances required for using various combinations of implants and implant drivers  
(L: length)

Implant length \ Drivers	Implant driver			Cover screw driver
	L:21	L:26	L:34	
7	25.5	30.5	38.5	
8.5	27.0	32.0	40.0	
10	28.5	33.5	41.5	
11.5	30.0	35.0	43.0	19.0
13	31.5	36.5	44.5	
15	33.5	38.5	46.5	
18	36.5	41.5	49.5	

(mm)

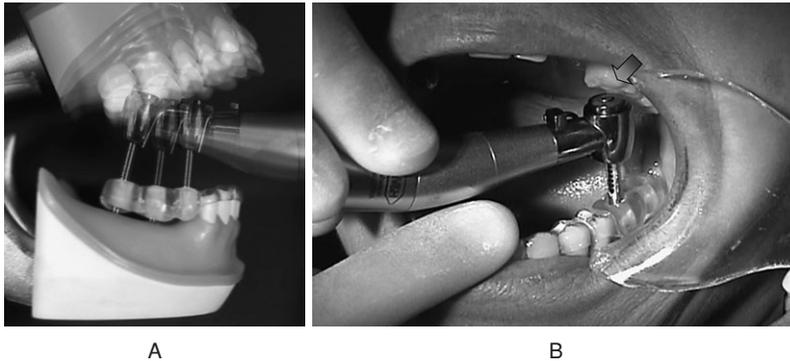


Fig. 6 Determining interference from antagonist teeth  
A: Diagnosis with locked probe; direction governed by template.  
B: Diagnosis. Mark shows interference from antagonist teeth.

were required, respectively.

## 2. Pre-surgical drilling simulation with trial angled heads and measurement probes

As shown below, pre-operative evaluation for implant surgery could be performed safely and precisely with the trial angled heads and measurement probes.

### 1) Determination of interference from antagonist teeth (Fig. 6)

To ascertain whether there was interference from antagonist teeth, first, the maximum mouth-opening at the planned implant site was checked with the probe locked to find out whether the drill could be inserted into the mouth without difficulty. When mouth-

opening was restricted and it was difficult to insert the drill planned to be used, the template was removed, and both the mesio-distal and bucco-lingual angles in the insertion direction toward the optimal implant site were corrected. If the drill could not be inserted into the mouth, even after mesio-distal and bucco-lingual angle correction, or if angle correction was not possible due to the design of the superstructure, shortening of the length of the implant or leveling the antagonist was considered.

### 2) Determination of interference from adjacent teeth (Fig. 7)

A simulation of drilling of soft tissue was performed at the planned implant site to

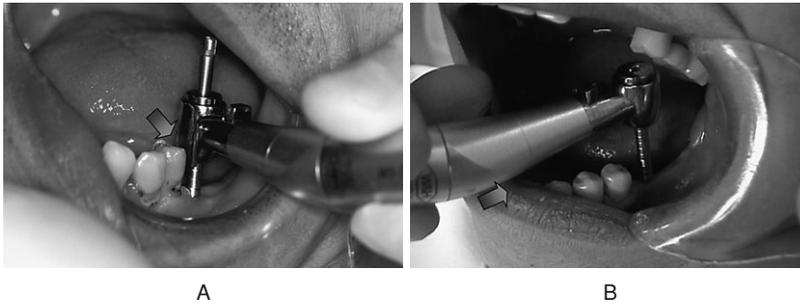


Fig. 7 Determining interference from adjacent teeth  
 A: Interference between angled head and adjacent tooth.  
 B: Interference between shank of contra-angle and anterior teeth.



Fig. 8 Determining interference from lips, cheek and tongue

determine whether it was possible to drill to the target depth. If it is difficult to reach the target depth due to interference between the angled head and an adjacent tooth, a longer drill or an extension shaft must be used. Furthermore, if a residual tooth interferes with the drilling, the drill must be changed or the use of an extension shaft must be considered, after taking into account the insertion direction and position of the hand piece.

### 3) Determination of interference from lips, cheek and tongue (Fig. 8)

During drilling simulation at the planned implant site, the degree of interference from the lips, cheek and tongue was determined. The degree of mouth-opening and hand piece insertion positions that would allow drilling without difficulty were also considered. At the same time, the insertion position of the cheek retractor could be checked.

## Discussion

A general flowchart of the pre-surgical treatment plan for an implant case<sup>1)</sup> is shown in Fig. 9. Insertion position, size and direction of an implant are frequently considered and determined using only a wax-up on a working cast and image simulation on radiographs. This does not adequately reflect the intra-oral working environment for implant treatment devices.

Our procedure for implant surgery has been applied clinically<sup>9)</sup> (Fig. 10). Treatment procedures are well-planned and arranged in a series. In particular, preparation of the implant cavity using a twist drill and insertion of the implant using an implant driver must be carefully performed, only after excluding interference factors and the possibility of an axial run-out, and ensuring a sufficient working environment. As shown in the results,

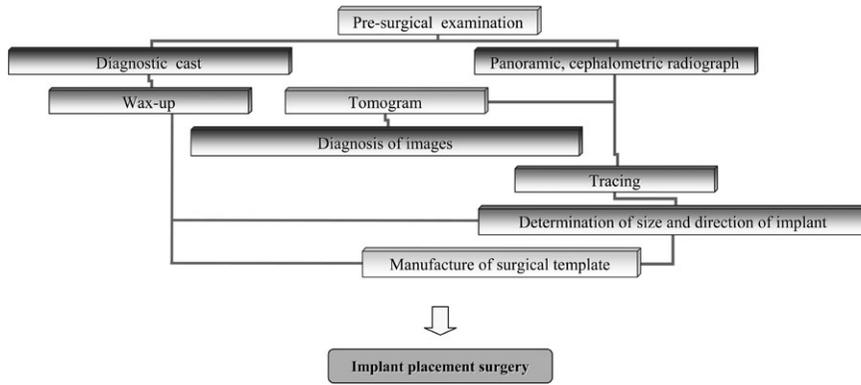


Fig. 9 General flowchart of pre-surgery diagnosis and treatment plan for implant case

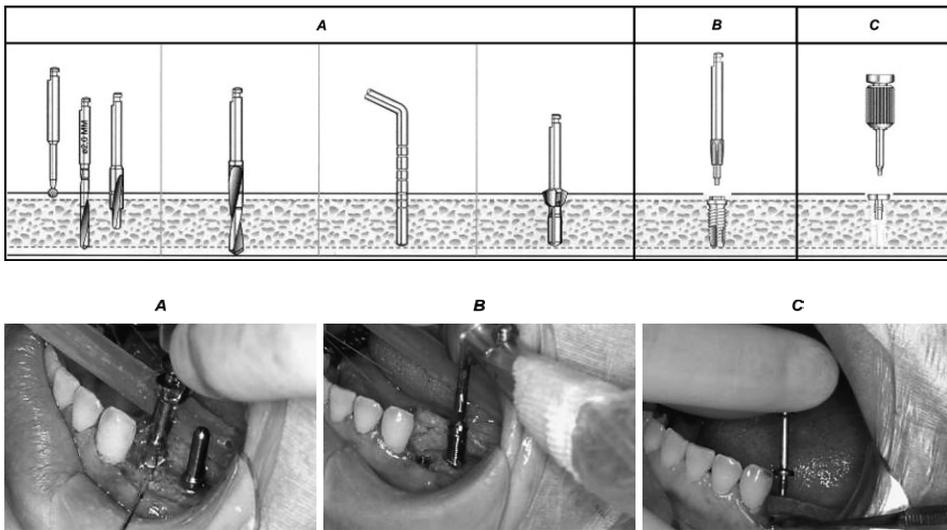


Fig. 10 Stage 1 surgery for two-stage implant systems  
 Operative procedure from Brånemark system® manual and catalog (upper).  
 Implant placement surgery according to procedure (lower).  
 A: Implant cavity formation. B: Implant installation. C: Cover screw fixation.

the vertical distance required for using twist drills ranges from 29.5 mm to 39.5 mm. However, when using a drill extension shaft to prevent interference from an adjacent tooth, a vertical distance of 46–56 mm may be needed. When inserting implants with lengths of 7–18 mm using implant drivers of 21, 26 or 34 mm, minimum vertical distances of 25.5–36.5 mm, 30.5–41.5 mm or 38.5–49.5 mm were required, respectively. However,

a greater minimum vertical distance may be required in an actual clinical setting, depending on the combination of drills and extension shaft used. Therefore, the range of necessary vertical distances will depend on the longest dimension of the implant, taking into consideration the combination of drills and extension shaft used. When inserting implants with lengths of 7–18 mm, a vertical distance of as much as 50–60 mm is required

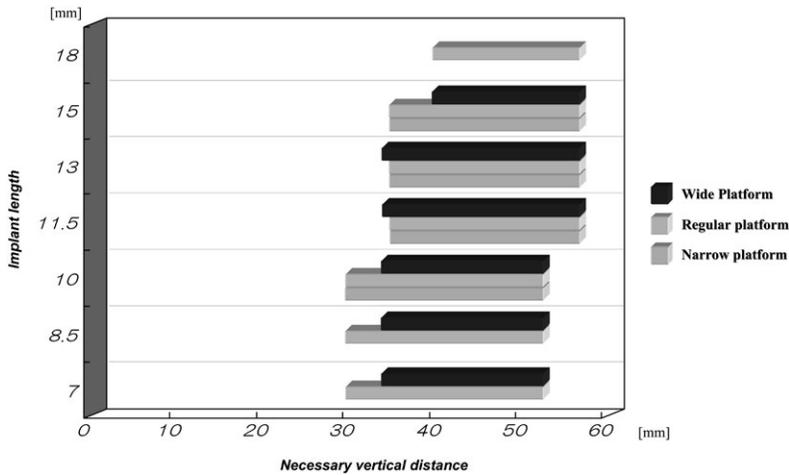


Fig. 11 Range of necessary vertical distances according to length of Brånemark implant Platform in introductory notes shows size of width of implant body.

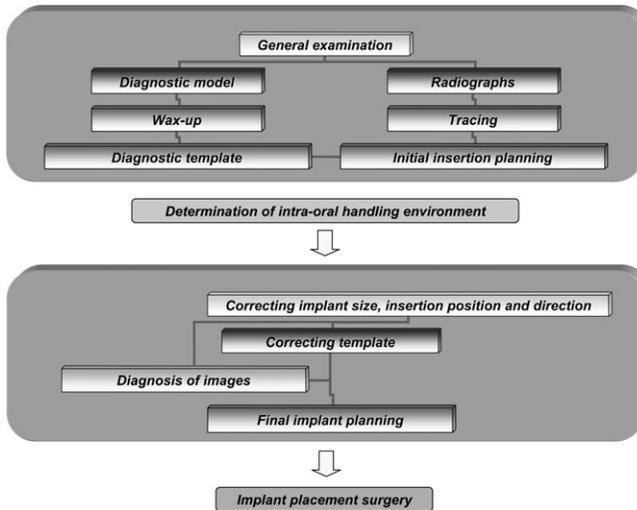


Fig. 12 Flowchart of diagnosis and treatment plan including pre-surgical determination of handling environment

(Fig. 11). Vertical distance will vary, to a large extent, depending on the longest dimension of the twist drills and extension shaft used, and in addition, on the insertion plan and intra-oral handling environment of the individual patient. Therefore, it is important to perform a drilling simulation based on the insertion plan prior to surgery to become thoroughly

acquainted with the actual intra-oral working environment.

A flowchart showing the formulation of the diagnosis and treatment plan in which the treatment-device handling environment was determined pre-surgically using the above procedures is shown in Fig. 12. After reviewing the initial insertion plan, the drilling simula-

tion mentioned above is performed, and the intra-oral working environment is evaluated in each individual. The possible necessity of correcting the implant size and insertion direction is then reviewed. If necessary, a tomograph is taken using a corrected surgical template of the insertion position and direction. After determining the final placement plan, actual implant surgery is performed.

As mentioned above, we believe that it is useful to include a check-up of the intra-oral working environment for treatment devices in pre-surgical evaluation of implant cases. This may help obviate the necessity of changing the treatment plan due to intra-oral working interference during the course of implant surgery.

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