Usefulness of a stool to stabilize dental chairs for cardiopulmonary resuscitation (CPR)

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Abstract

Background: Cardiopulmonary resuscitation (CPR) requires immediate start of manual chest compression (MCC) and defibrillation as soon as possible. During dental surgery, CPR could be started in the dental chair considering difficulty to move the patient from the dental chair to the floor. However, all types of dental chairs are not stable for MCC. We previously developed a procedure to stabilize a dental chair by using a stool. EUROPEAN RESUSCITATION COUNCIL (ERC) guideline 2015 adopted our procedure when cardiac arrest during dental surgery. The objective of this study was to verify the efficacy of a stool as a stabilizer in different types of dental chairs. Methods: Three health care providers participated in this study, and 8 kinds of dental chairs were examined. MCC were performed on a manikin that was laid on the backrest of a dental chair. A stool was placed under the backrest to stabilize the dental chair. The vertical displacement of the backrest by MCC was recorded by a camcorder and measured by millimeter. Next, the vertical displacement of the backrest by MCC were compared between with and without a stool. Results: In all 8 dental chairs, the method by using a stool significantly reduced the vertical displacements of the backrest by during MCC. The reduction ratio (mean [interquartile range]) varied between nearly 27 [20] and 87 [5] %. In the largest stabilization case, the displacement was 3.5 [0.5] mm with a stool versus 26 [5.5] mm without a stool ($p < 0.001$).

Background

Dental office is a special circumstance, and sudden cardiac arrest and asphyxia due to aspiration of dental materials into the trachea are two major life-threatening emergencies. We have already proposed supine abdominal thrust as a relief for asphyxia in the dental chair [1]. When the thrust relief is ineffective, immediate cardiac arrest can occur. Or cardiac arrest might occur alone, as dental surgery is often stressful for patients and dental surgery sometimes worsens basic illness. CPR requires immediate start of external cardiac compression (ECC). The patient must be placed on a hard surface to ensure the effectiveness of ECC. On the other hand, CPR should be started in the dental chair, considering the difficulty of moving the patient to the floor safely. Because, the space around a dental chair is so compact and quite-narrow to do effective treatments between a dentist and staffs. And, there are only a few stuff in many clinics. However, all types of dental chair are not always stable for ECC, because there is no steady support between the backboard of the dental chair and the floor. These condition may alter the effectiveness of ECC.

We previously reported the usefulness to stabilize a dental chair by using a stool for effective chest compression [2]. This procedure was adopted in the ERC guideline 2015 [3]. A stool is placed under the tilted or horizontal backrest, and then the dental chair is lowered so that the backrest come into contact with the stool to support the backrest of the dental chair. To our knowledge, however, there are many kinds of dental chairs, and the shapes of their backrest are different. In addition, the dental chairs have different seat-padding. Therefore, we are afraid whether our procedure is effective in all types of dental chairs or not.

The objective of this study was to evaluate the efficacy of a stool as a stabilizer for effective ECC. We compared the performance of ECC in different types of dental chairs between with and without a stool. We hypothesized that a stool as a stabilizer may reduce the vertical displacement by ECC and increase the efficacy of ECC in dental chairs when the same quality of ECC are provided.

Methods

Study design and setting

Eight different dental chairs were used in this study. #1 (EOM-PLUS SS®; GC, Tokyo, Japan), #2 (EOM ∑®; GC, Tokyo, Japan), #3 (EOMα®; GC, Tokyo, Japan), #4 (Celeb BM Type Clair®; TAKARA, Tokyo, Japan), #5 (SPACELINE EMCIA Type II®; MORITA, Tokyo, Japan), #6 (SPACELINE EMCIA Type III UP®; MORITA, Tokyo, Japan), #7 (NOVA SERIO®; YOSHIDA, Tokyo, Japan), #8 (STAGE II®; YOSHIDA, Tokyo, Japan). Each dental chairs were installed in four private dental offices. Three health care providers, who completed AHA-certified Basic Life Support course, participated in this study; A: 47 years-old man,175cm, 93kg. B: 44 years-old man, 177cm, 60kg. C: 44 years-old woman, 157cm, 50kg.

The CPR manikin (Resusci Anne Torso Basic version 2011; Laerdal Medical AS, Stavanger, Norway) was laid on the horizontal backrest of the dental chair. The upper end of the torso of the manikin was aligned with the top edge of the backrest (Figure.1A, Red line). The surface of the backrest under the lower half of the sternum of the manikin was levelled using a levelling instrument (Z-340; Hozan Co., Osaka, Japan).

The hand position for ECC was the center of the chest (the lower half of the sternum, Figure 1B) as recommended in the European Resuscitation Council Guidelines for Resuscitation [4] and the American Heart Association (AHA) Guidelines [5]. Three health care providers performed ECC on the resuscitation manikin in eight different dental chairs. The displacement of the point P (Figure 2.A) on the lower surface of the backrest (vertically under the area for ECC) was fixed a vertical-measurement instrument (Figure 2.B). The metal indicator (point P) was attached the instrument by using a level gauge (Z-340; Hozan Co., Osaka, Japan) horizontally to the ground. The point P was measured at the same time as ECC-induced vertical movements of the backrest. The depth of ECC was tried to be kept between 5.1 to 6.0 cm in both cases with and without a stool. The actual depth of ECC was evaluated by the skill-reporter® system equipped with the manikin. The green light of the skill-reporter® indicates 3.8 to 5.0 cm of ECC depth, and red light indicates 5.1 to 6.0 cm of ECC depth (Fig.2.C). When the compression depth in the chest of manikin by ECC was 5.1 to 6.0 cm, the vertical displacements of the backrest from its basal position (the width of a starting point to an ending point) were recorded by the camcorder (HC-W580M; Panasonic, Osaka, Japan). Video data were transferred to a computer (Dell; Windows 7, intel: Core i3, Cupertino CA, USA) using a camcorder's dedicated software (HD Writer 3.1; Panasonic, Osaka, Japan). the vertical displacements (degree of instability) of the backrest were measured using the simultaneously captured ruler as a reference.

To compare the eficacy of a stool as a stabilizer on ECC in eight types of dental chair, a round stool with a hard seating surface (45cm in diameter, 46cm in height; FB-01ALLBK, Fuji Boeki Co., Ltd. Fukuoka, Japan) was placed under the backrest of the dental chair. The edge of the seating surface of the round stool was set to (vertically) touch the backrest under the area for ECC (Figure 1A, Green line). ECC was performed with or without the round stool as a stabilizer. The manikin was on a fully reclined chair.

Protocol

Three health care providers individually performed ten rounds of continuous ECC for 20 times each at a pace of 100 compressions per minute by synchronizing to a metronome. Participants used a ECC technique allowing complete chest recoil. The health care providers and the research team were blinded to the information during recording. Therefore, for each participant, 200 records of chest compressions were gotten for each dental chair.

Statistical analysis

The programming language R (version 3.4.3; The Comprehensive R Archive Network, USA) was used for statistical analysis.

Normality Test and Non-parametric Statistical Test

Each combined measurement data set of the chair's reference point displacement during ECC treatment by 3 practitioners were applied to the Shapiro-Wilk test (with the function shapiro.test) to see whether they were sampled from a population with the normal distribution. As all the data sets were found to be with non-normal distribution, they were analyzed using the non-parametric Wilcoxon rank sum test (wilcox.exact: exactRankTests package).

Results

The vertical displacements of the backrest of the dental chair induced by ECC were investigated with or without a round stool as a stabilizer. 4,800 times of ECC was recorded, but 34 of them was excluded as inappropriate compression or unclear recording. The stool which placed under the backrest as a stabilizer significantly reduced the vertical displacements of the backrest in all eight dental chairs (Table 1, Fig. 3). For example, the largest stabilization (85%) was typically observed in Chair #2, where the displacement of the backrest by ECC was 4.1 ± 1.3 mm with the stool, while that was 26.8 ± 4.5 mm without one. Equation 1 defines the reduction ratio.

Due to technical limitations, Equation 1 is only available as a download in the supplemental files section.

The reduction ratios were between nearly 39~85% and different by chairs (Fig. 3). The support efficiency of a stool ware different, maybe as the backrest of some dental chairs has an outer-shell shape with curving line. #2 and #8 dental chairs have a flat outer-shape relatively. therefore, the stool supported the backrest of dental chair firmly (Fig.5A). In this situation, about 85% decrease in the displacement of a backrest against ECC by the stool. In #1 dental chair, the shape has a steep curve. Consequently, the stool contacted to the backrest at a smaller point where the ECC's force concentrates on (Fig.5B). In these situations, the reduction rate is smaller than that of #2 (85%), although, it also significantly decreased the vertical displacement by ECC.

Discussion

The efficacy of a stool as a stabilizer for CPR was investigated in 8 kinds of dental chairs in this study. To our knowledge, this is the first report to compare the stability in many types of dental chairs using our method. This study showed that the stool significantly reduced the vertical displacement of the backrest against ECC. All health care providers could perform stable ECC in all chairs with a stool.

ERC and AHA, current guidelines emphasize the importance of pushing hard and fast, and of minimizing interruptions during compression [4,5]. ECC should be started on the stable surface as soon as possible when cardiac arrest was suspected. During CPR in the dental chair, however, backrest of dental chairs may be not firmly supported for ECC. Previously, we developed a method to stabilize a backrest of a dental chair by using a stool [6]. This method has been adopted in the ERC Guideline 2015 [3]. However, there are many types of dental chairs in the world, and these chairs equip different types of backrest, cushion, pad-softness and a hinge (joint) between the backrest and the seat. It was not clear whether ECC would be performed effectively or not on every types of dental chair. Therefore, we investigated the method of a stool as a stabilizer [2,6]. In CPR, a large vertical displacement of the backrest might decrease efficacy of ECC [7]. In addition, the vertical displacement increases labor efforts as additional power to push down is required. In these situation, ECC may cause more fatigue especially for rescuers in the light body weights group [8,9,10].

In this study, our method [2,6] significantly reduced the displacement of a backrest against ECC in all dental chairs. During ECC in the dental chair, the displacement of the backrest seemed to be mainly caused by stool movements and cushions or seat-pads-softness. A stool moved just a little in every ECC (Figure 4). The support efficiency of a stool ware different, maybe as the backrest of some dental chairs has an outer-shell shape with curving line. #2 and

#8 dental chairs have a flat outer-shape relatively. therefore, the stool supported the backrest of dental chair firmly (Fig.5A). In this situation, about 85% decrease in the displacement of a backrest against ECC by the stool. In #1 dental chair, the shape has a steep curve. Consequently, the stool contacted to the backrest at a smaller point where the ECC's force concentrates on (Fig.5B). In these situations, the reduction rate is smaller than that of #2 (85%), although, it also significantly reduced the vertical displacement by ECC.

Limitations of the study should be mentioned. First, this study includes only 8 kinds of chairs. These are common models in Japan. Although there are a lot of typical chairs in the word. Second, this study was performed on a manikin model, which cannot be extrapolated to a human faithfully. Third, this study did not consider the effect of the cushion-pad of the backrest. Next, the stool was set a particular position where was just under the area for ECC. Further studies should be conducted to evaluate other position of the stabilizer where is more effectively. And, the usefulness of other types of stabilizers remains to be verified. However, no studies to date have demonstrated a significant reduce deflective movements on several types of a dental chair. The technique is very easily and helpful method, and must use at time of CPR on a dental chair.

Conclusion

Our method could significantly reduce the vertical displacement of dental chairs by ECC, and it is convenient and useful when sudden CPR is required. We have only to recline the backrest to horizontal position, place the stool below the back rest and down the chair to contact with the stool firmly.

Declarations

Acknowledgments

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Funding

Not applicable.

Authors' contributions

All authors (NA, TH, YM, YK, TY) made a substantial contribution to the conceptualization, methodology, data collection, formal analysis and writing of this manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

All procedures performed in studies performing on a manikin model. This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study formal consent is not required.We consulted the IRB at Kyushu university, which confirmed that no formal written waiver for ethics approval was required, because of the design of the study. In addition, there was no written consent needed from three health care providers.

Consent for publication

Not applicable.

Competing interests

All authors has no conflict of interest.

Informed consent

For this type of study, formal consent is not required.

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Table 1

Effect of the stool (stabilizer) on the vertical movements of the backrest caused by ECC. Results are expressed as mean ± standard deviation.

Chair	displacement without stool [mm]	displacement with stool [mm]	reduction ratio [%]	p-value
#1	43.7 ± 9.0	9.6 ± 2.1	78 ± 9	< 0.001
#2	26.9 ± 4.3	4.1 ± 1.3	85 ± 7	< 0.001
#3	16.9 ± 1.8	12.0 ± 1.1	29 ± 14	< 0.001
#4	16.8 ± 1.1	2.7 ± 0.3	84 ± 3	< 0.001
#5	12.0 ± 1.2	3.6 ± 0.3	70 ± 6	< 0.001
#6	5.6 ± 0.5	3.4 ± 0.3	40 ± 11	< 0.001
#7	13.2 ± 1.9	5.1 ± 0.6	63 ± 10	< 0.001
#8	16.1 ± 1.4	9.0 ± 0.7	44 ± 9	< 0.001

(#: Number of Dental chair) #1 (EOM-PLUS SS®; GC, Tokyo, Japan), #2 (EOM ∑®; GC, Tokyo, Japan), #3 (EOMα®; GC, Tokyo, Japan), #4 (Celeb BM Type Clair®; TAKARA, Tokyo, Japan), #5 (SPACELINE EMCIA Type II®; MORITA, Tokyo, Japan), #6 (SPACELINE EMCIA Type III UP®; MORITA, Tokyo, Japan), #7 (NOVA SERIO®; YOSHIDA, Tokyo, Japan), #8 (STAGE II®; YOSHIDA, Tokyo, Japan).

Figures

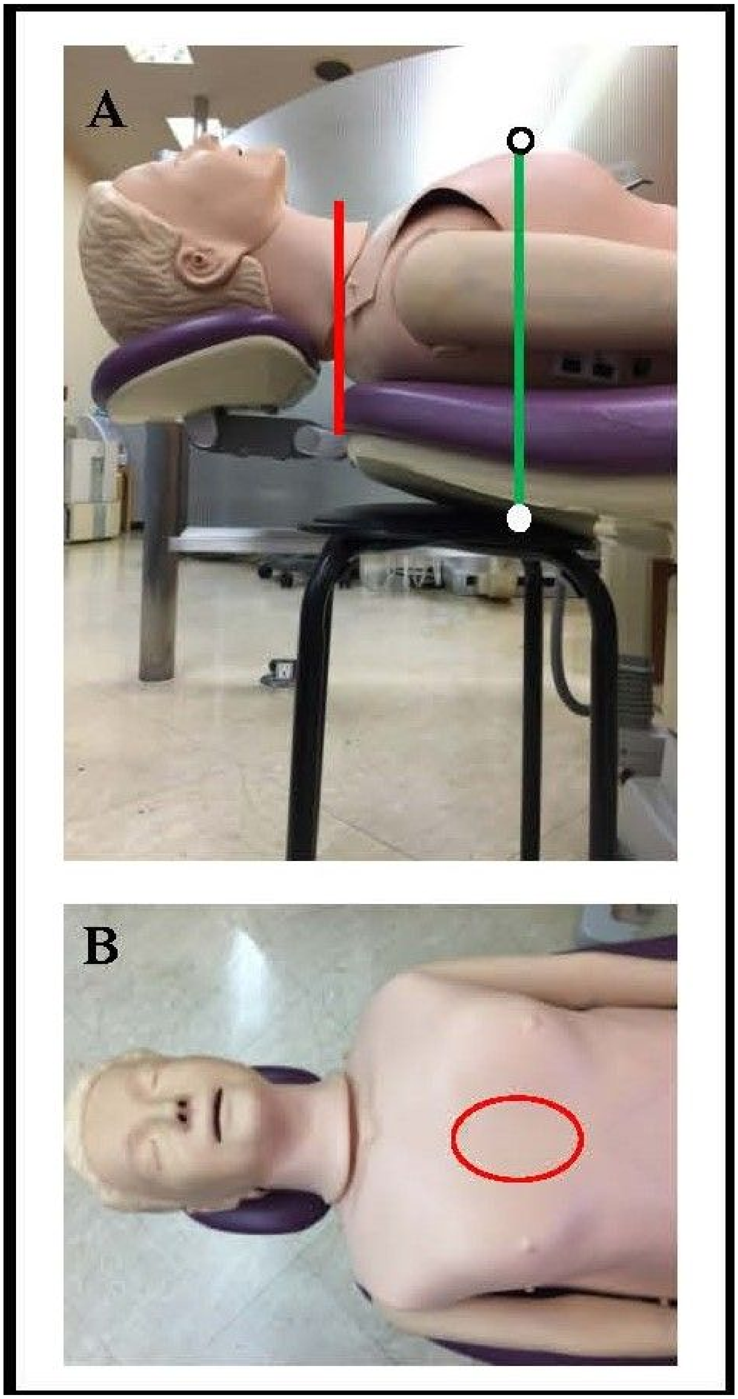

Figure 1

Setup of the manikin for measuring chest compression depth and movement of the backrest. Placement of the round stool as a stabilizer. The edge of the seating surface of the round stool was set to touch the backrest vertically under the area or chest compressions (A). The hand position for the chest compressions was a center of the manikin's chest (B: Red ellipse).

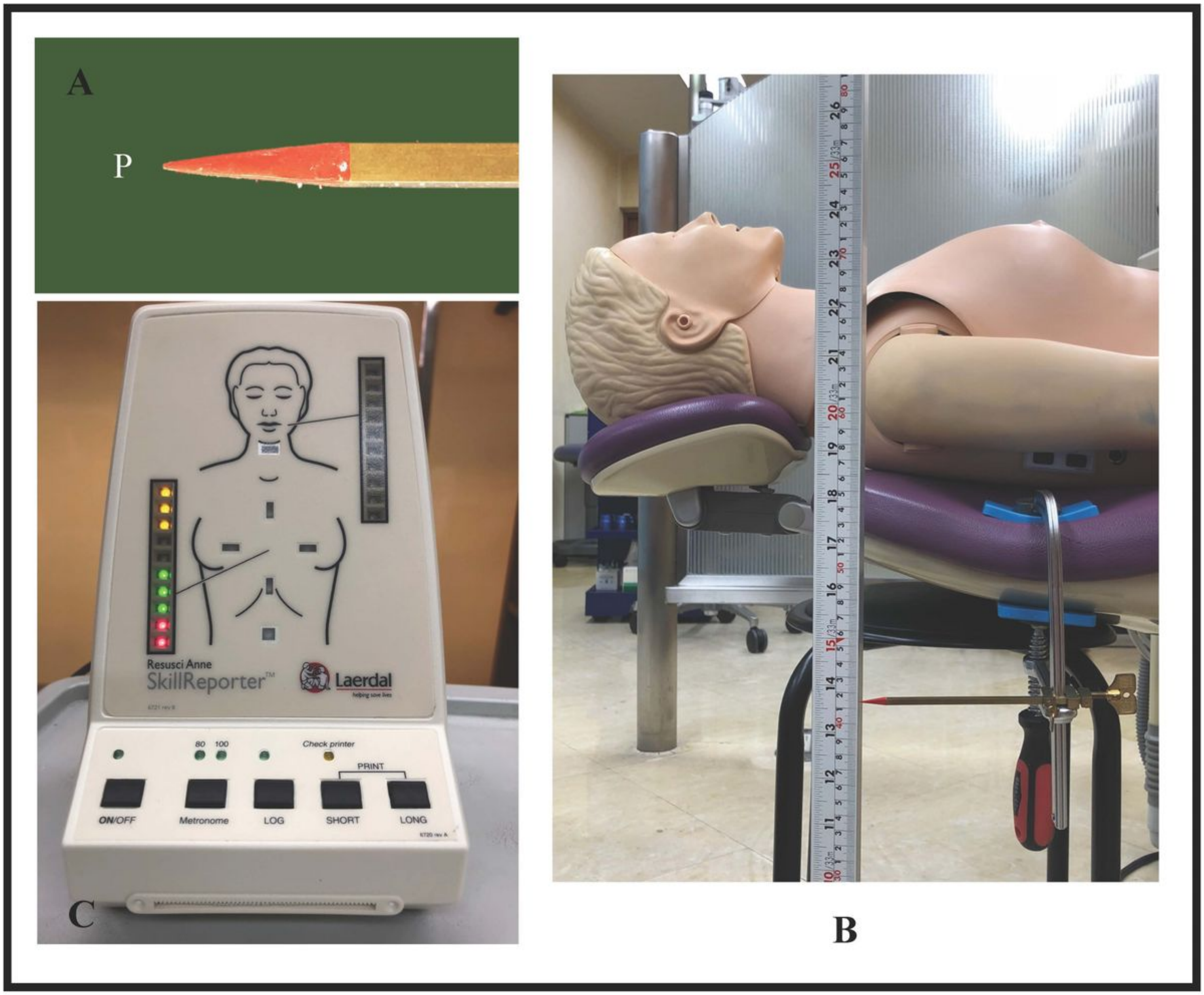

Figure 2

The displacement of the point P on the lower surface of the backrest (vertically under the area for external cardiac compression) was fixed a vertical-measurement instrument. The instrument was attached a metal indicator (A, B). Chest compression depth was measured by the measurement equipment (skill-reporter®). The equipment glow green when chest compression depth was 3.8 to 5.0 cm, and red when 5.1 to 6.0 cm (C).

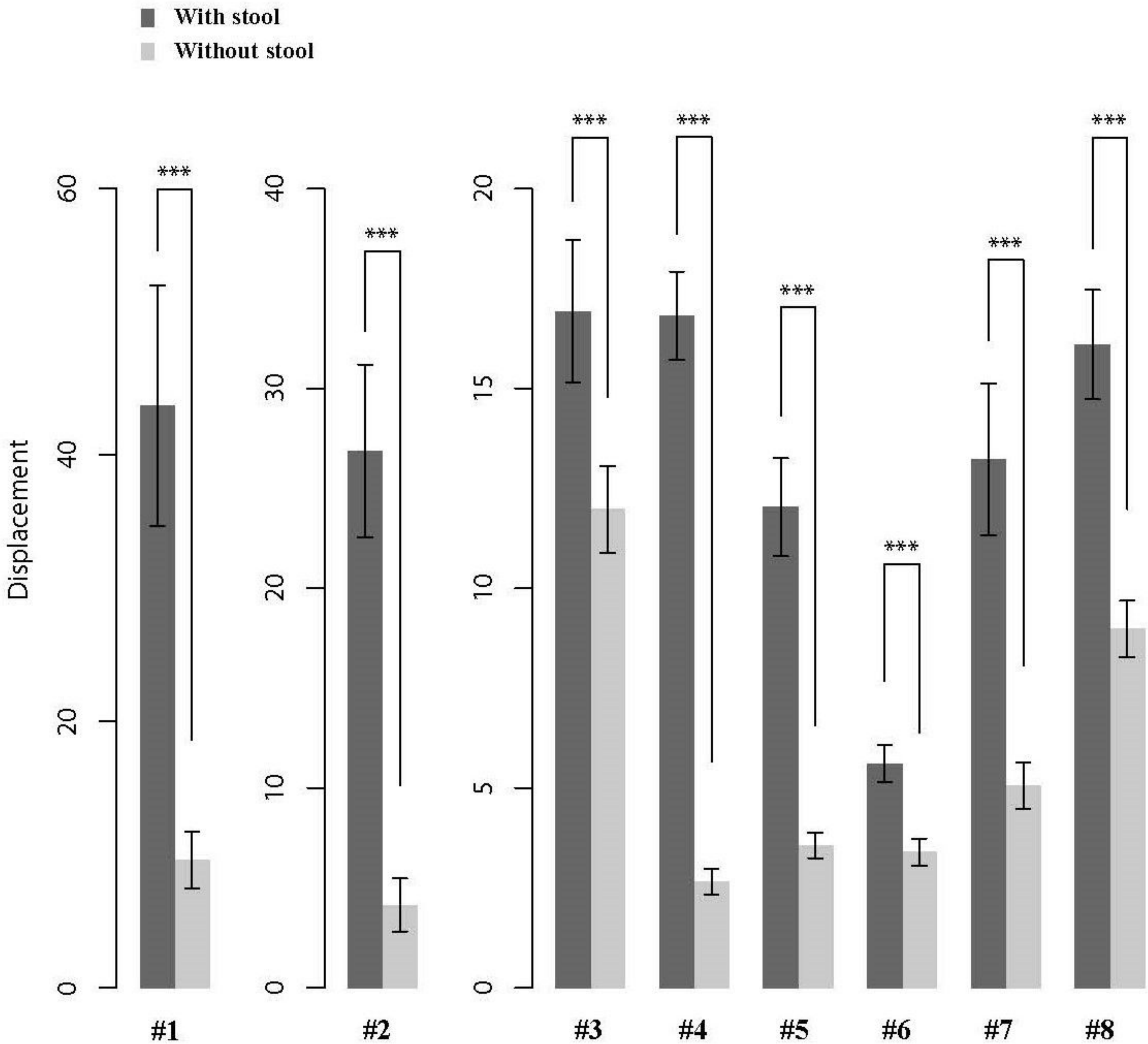

Figure 3

Effect of the stool (stabilizer) on the vertical movements of the backrest caused by external cardiac compression. Results are expressed as mean ± standard deviation. Asterisks represent significant differences (**P<0.001). (#: Number of Dental chair)

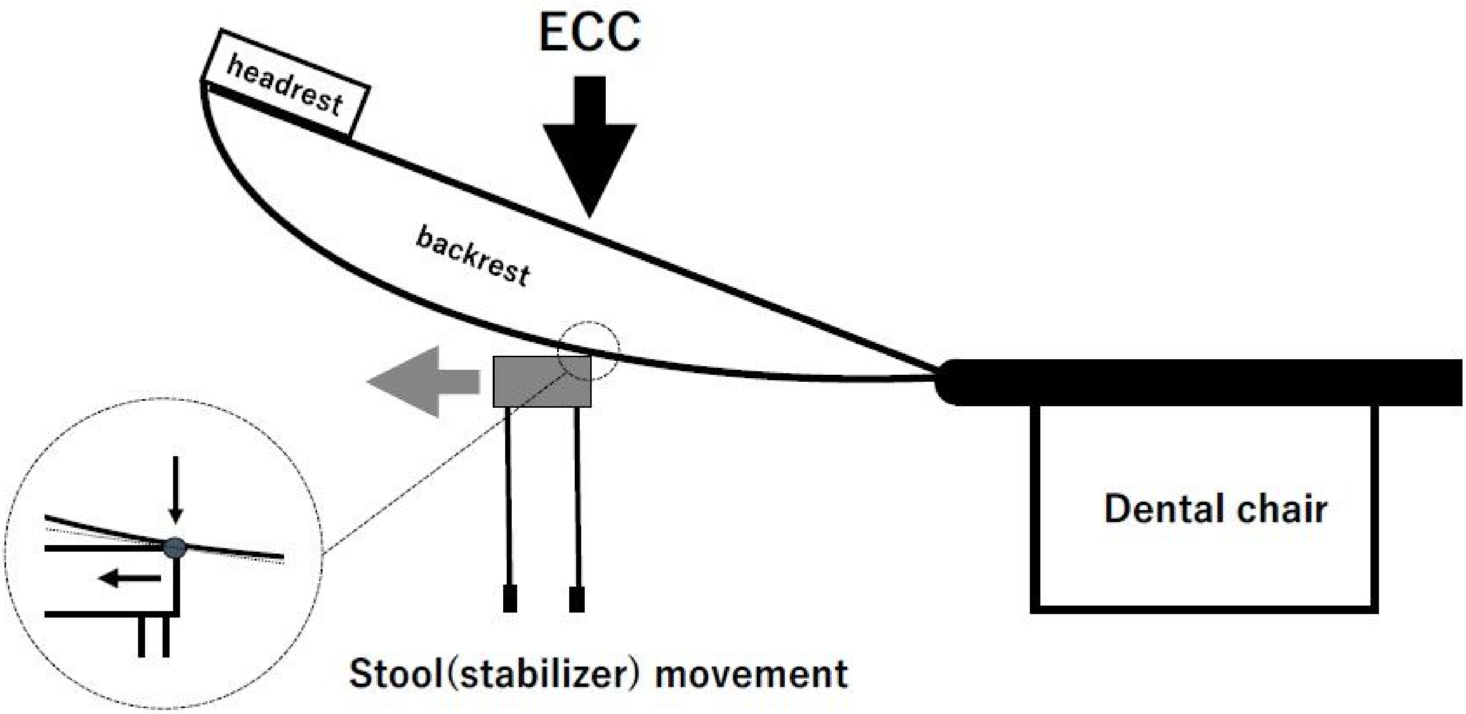

Figure 4

A position of a stool as a stabilizer with a dental chair for ECC.

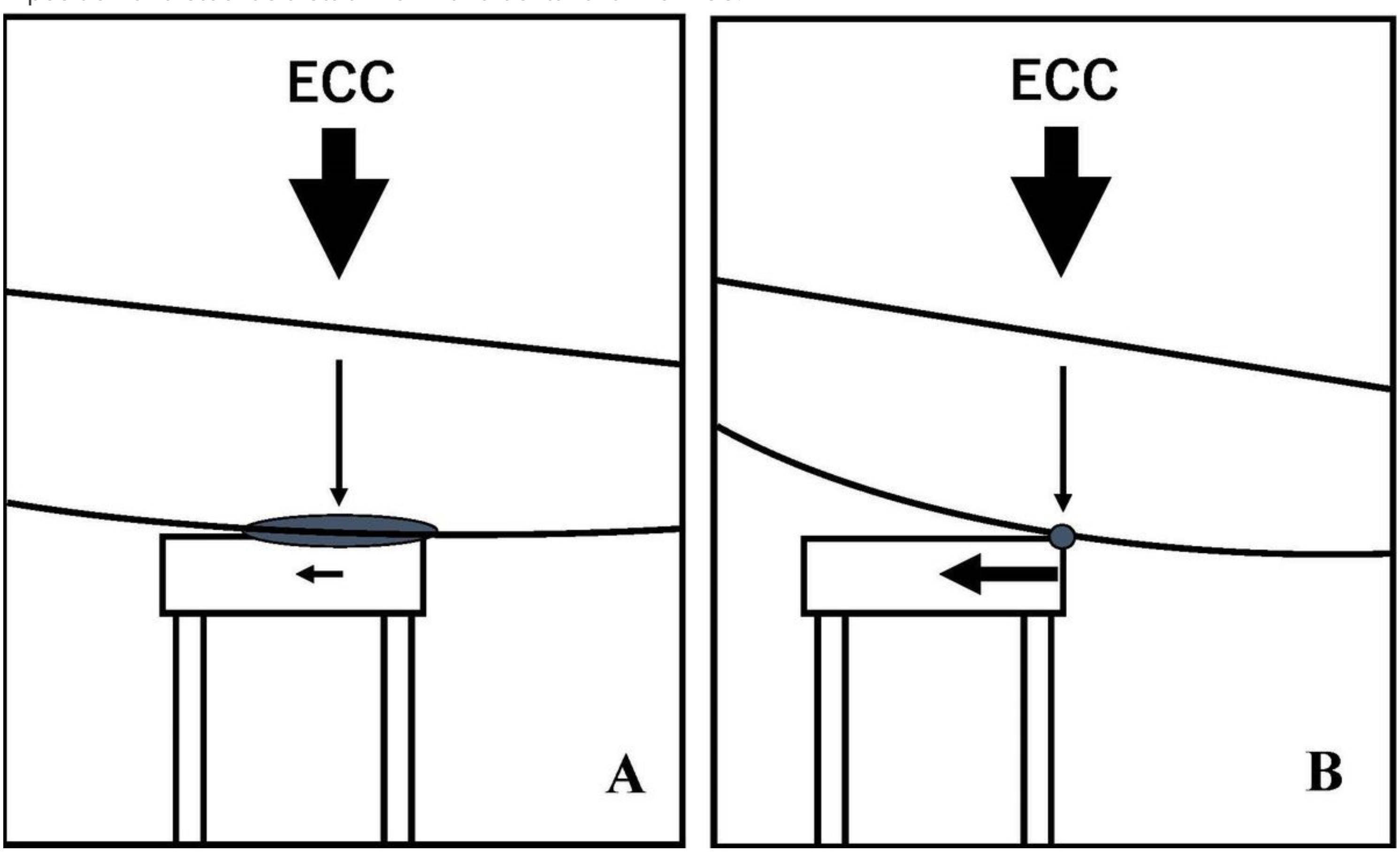

Figure 5

A contact area of a stool with a backrest of a dental chair. An outer-shell shape of backrest has curving line, a contact area gets narrow. Power of ECC concentrate on the area. A stool could not sustain the power and moves laterally.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- supplement1.jpg