



Surgeons' Awareness and Impaction Technique of a Ceramic Liner into a Metal Shell

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Background: In ceramic-on-ceramic total hip arthroplasty, firm locking is necessary between a ceramic liner and an acetabular metal shell to prevent dissociation of the liner from the metal shell. We evaluated surgeons' awareness of the technique for inserting the ceramic liner and measured the impaction force applied by surgeons during the insertion of the ceramic liner.

Methods: To evaluate the awareness, we conducted a survey using a questionnaire including techniques for ceramic liner insertion. The impaction force was measured using an impaction simulator in 224 surgeons.

Results: Most surgeons answered that they cleaned and dried up the inner surface of the metal shell before inserting a ceramic liner (96.4% and 86.2%, respectively), and 74.6% checked the correct seating of the ceramic liner. However, only 23.2% correctly answered that a minimum of 2kN (a light strike) was necessary to obtain a sufficient fit between the metal shell and the ceramic liner. The impaction force was weaker than 2 kN in 9.4% of the surgeons.

Conclusions: Education about the adequate impaction force to obtain a firm fit of the ceramic liner is necessary for surgeons who perform total hip arthroplasty using ceramic-on-ceramic bearings.

Keywords: Impaction technique, Ceramic liner, Total hip arthroplasty, Awareness

Since 1994, contemporary ceramic-on-ceramic bearings have been used for total hip arthroplasty (THA) especially in young active patients because of excellent wear property and almost negligible osteolysis.¹⁻⁴⁾ The new alumina matrix composite ceramic, incorporating zirconia, was introduced in 2003. The composite ceramic has markedly

reduced the incidence of ceramic fractures; however, the incidence of ceramic liner fractures seems to vary geographically.⁵⁻⁹⁾ The variation in the incidence of ceramic fractures could be related to handling.

Insufficient engagement between the ceramic liner and acetabular metal shell can lead to a dissociation of the liner from the metal shell. Liner dissociation has been known as a cause of ceramic liner fractures.^{2,10-12)} A tight concentric fit is necessary between a ceramic liner and a metal shell to avoid the risk of dissociation. Surgeons should clean and dry up the inner surface of the metal shell before inserting the liner. During the insertion, they should check whether the liner has been concentrically and completely seated into the metal shell. Then, surgeons should impact the liner with at least a light strike (> 2 kN) according to the American Society for Testing and Materials (ASTM) guideline.¹³⁻¹⁵⁾

To date, there has been no study about whether sur-

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geons are aware of this guideline. Therefore, in this study, we aimed to evaluate whether surgeons had accurate knowledge on the ASTM guideline and to measure the impaction force of surgeons to fix the ceramic liner into the metal shell.

METHODS

We conducted a survey and an impaction test during 19 orthopedic meetings, which were held from March 2018 to March 2019. Before the survey, we developed a questionnaire to test surgeon's knowledge on how to handle and insert ceramic liners. In the questionnaire, we asked (1) Do you clean inner surfaces of the metal shell before insertion of the liner? (2) Do you dry up inner surfaces of the metal shell before insertion of the liner? (3) Do you perform impaction? (4) How many times do you impact the liner? (5) Are you aware of optimal impaction force to the ceramic liner? (6) Do you check complete and symmetric seating of the ceramic liner? (7) How do you check seating of the liner? (8) How often do you reposition the ceramic liner? (9) How often do you encounter problems during the insertion of the ceramic liner? (10) What are problems during the insertion of the ceramic liner (Supplementary Material 1)?

After filling out the questionnaire, surgeons were asked to impact a ceramic liner (BIOLOX® delta; CeramTec, Plochingen, Germany) into the metal shell according to their usual manner during the operation using an impaction simulator (Fig. 1). A total of 224 arthroplasty surgeons who visited the manufacturer booth during 19 orthopedic congresses throughout the study period (Sup-



Fig. 1. Surgeons were asked to impact a ceramic liner (BIOLOX delta; CeramTec, Plochingen, Germany) into the metal shell using an impaction simulator (CeramTec).

plementary Material 2) answered the questionnaire and performed the impaction test (Table 1).

Ethics Approval

This study, including using the questionnaire, was approved as exempt by the Institutional Review Board of Seoul National University Bundang Hospital (X-1907-552-904).

Table 1. Demographics of 224 Participants

Variable	Number
Age (yr)	
< 40	60
40–50	88
51–60	49
61–70	22
> 70	5
Duration of THA experience (yr)	
< 1	8
1–3	35
3–5	30
5–10	29
> 10	122
Annual number of THAs	
< 10	86
10–20	35
21–50	73
51–100	19
101–200	5
> 200	6
Proportion of use of ceramic-on-ceramic bearings in THAs (%)	
0	11
0–20	79
20–40	35
40–60	19
60–80	18
80–100	62

THA: total hip arthroplasty.

Table 2. Answers from the 224 Participants

Question	Number (%)
Do you clean the inner surface of metal shell before inserting the ceramic liner?	216 (96.4)
Do you dry up the inner surface of metal shell before inserting the ceramic liner?	193 (86.2)
Do you perform impaction?	220 (98.2)
How many times do you impact the liner?	
1	44 (19.6)
2	62 (27.7)
3	77 (34.4)
> 3	37 (16.5)
Awareness on impaction force to ceramic liner (how much impaction force is necessary to securely lock a ceramic liner?)	
Does not need impaction	1 (0.4)
Light strike (> 2 kN)	52 (23.2)
Moderate strike (> 4 kN)	87 (38.8)
Strong strike (> 6 kN)	20 (9.0)
As strong as possible	2 (0.8)
I don't know	62 (27.7)
Do you check complete and symmetric seating of the ceramic liner?	223 (99.6)
How do you check complete and symmetric seating of the ceramic liner?	
Visual	48 (21.4)
Finger	72 (32.1)
Visual and finger	95 (42.4)
Instrument (elevator or freer)	8 (3.6)
Proportion of repositioning of the ceramic liner (%)	
< 1	215 (96.0)
< 5	7 (3.1)
< 10	1 (0.4)
< 50	1 (0.4)
How often do you encounter problem(s) during the insertion of the ceramic liner?	
Never	133 (59.4)
Sometimes	89 (39.7)
Regularly	2 (0.9)
What problem(s) do you encounter during the insertion of the ceramic liner?	
Difficult insertion	44 (19.6)
Malseating	45 (20.1)
Toggling due to a deformation of metal shell	2 (0.9)

RESULTS

Answers to the Questionnaires

Most participants answered that they cleaned (96.4%) and dried up (86.2%) the inner surface of the metal shell before inserting the ceramic liner, checked symmetric complete seating of the ceramic liner (99.6%), and impacted the ceramic liner (98.2%).

However, only 23.2% of the participants correctly answered that a minimum of 2 kN (a light strike) was necessary to obtain a secure fit between the metal shell and the ceramic liner, and only 42.4% checked the liner seating by inspection and finger-palpation. In terms of problems during the insertion, 40.6% answered that they had experienced difficult insertion, malseating, or deformation of the metal shell (Table 2).

Impaction Force

The impaction force ranged from 0.5 kN to 13.3 kN (mean, 4.1 ± 2.1 kN). In 9.4% of the participants, the impaction force was weaker than the minimum requirement of 2 kN. The measured impaction force was 3.2 ± 1.8 kN in 52 participants who answered light strike (> 2 kN) was necessary, 4.5 ± 1.6 kN in 87 who answered moderate strike (> 4 kN) was necessary, 6.4 ± 2.9 kN in 20 who answered a strike (> 6 kN) was necessary, 8.4 ± 6.0 kN in 2 who answered a strike as strong as possible was necessary, and 3.5 ± 1.8 kN in 62 who answered they did not know suitable impaction force (Fig. 2).

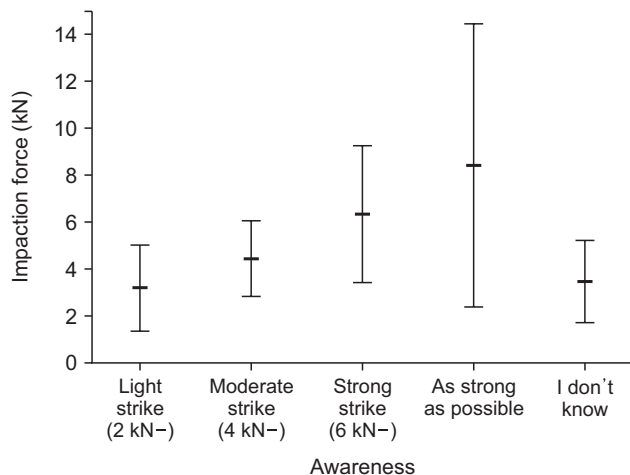


Fig. 2. Impaction force according to the awareness of impaction force.

DISCUSSION

An appropriate technique is necessary in order to properly insert and fit a ceramic liner into the metal shell. The inner surface of the metal shell should be cleaned and dried.^{6,16)} To prevent a fracture of the ceramic liner, the liner should be seated completely and symmetrically.⁶⁾ According to the ASTM guideline, surgeons should impact a ceramic liner with at least a light strike (> 2 kN) to obtain a secure fit between the liner and the metal shell.^{13,15)}

In our study, most surgeons answered that they cleaned and dried up the inner surface of metal shell before inserting the ceramic liner (96.4% and 86.2%, respectively), and 74.6% checked the correct seating of the ceramic liner. However, 76.8% of the surgeons did not know the guideline impact of > 2 kN and 9.4% impacted the liner with a force weaker than 2 kN.

Surgeons may be reluctant to firmly impact the ceramic liner because they may perceive the ceramic material as brittle (i.e., lacking the plastic deformation of metals), despite the very high strength of modern ceramics for THA. This reluctance may increase the risk of incomplete seating of the ceramic liner.¹⁷⁾ The ASTM guideline recommends drying up the metal shell with gauze before inserting the ceramic liner and fitting the liner with strong impact. However, whether these maneuvers are mandatory to prevent malseating of the ceramic liner has not been validated yet.

Our study might be associated with a selection bias. The participants might not represent the general population of arthroplasty surgeons. We did not recruit the participants by random sampling. The participants were surgeons who visited the manufacturer booth due to an interest in ceramic implants. Second, we did not evaluate the correlation between the surgeon's experience and the impaction force. Among the participants, 27% were younger than 40 years and 38% had less than 10 THAs per year. Third, other risk factors for ceramic fractures were not considered. Some liner with lower taper angle might be difficult to insert symmetrically.¹²⁾

Our study showed that an education about the adequate impaction force to obtain a secure fit of the ceramic liner is necessary for surgeons who perform THA using ceramic-on-ceramic bearings. The results of our study might serve as a guide especially for inexperienced arthroplasty surgeons to optimally fix the ceramic liner during ceramic-on-ceramic THA.

CONFLICT OF INTEREST

We declare that one author (AAP) is a paid employee of CeramTec. Otherwise, each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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SUPPLEMENTARY MATERIAL

Supplementary material is available in the electronic version of this paper at the CiOS website, www.ecios.org.

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