The Autoclaving of Autologous Bone is a Risk Factor for Surgical Site Infection After Cranioplasty

Seong-Hyun Wui[1], Kang Min Kim[1], Young-Joon Ryu[2], Inkyeong Kim[1], Seung Jin Lee[1], Jiha Kim[1], Choonghyo Kim[1], Seoungwoo Park[1]

■ BACKGROUND: **This retrospective study was designed to evaluate the effectiveness of autoclaving for the prevention of surgical site infection (SSI) after cranioplasty.**

■ METHODS: **Patients who underwent cranioplasty with autologous bone were enrolled. SSI was defined as an infection requiring bone flap removal. Risk factors of SSI, as reported by other researchers, and microbiologic features of SSI were analyzed. All bone flaps were preserved in a deep freezer (−70°C). Autoclaving of the preserved autologous bone flap before cranioplasty was performed for 5 minutes at 135°C in the 26 patients.**

■ RESULTS: **Eighty patients were enrolled. The mean age was 53.3 years and the male/female ratio was 3:2. Causes of craniectomy included trauma ($n = 37$) and nontrauma ($n = 43$). The mean time interval between craniectomy and cranioplasty was 49.7 days. The SSI rate after cranioplasty with autologous bone was 17.5% ($n = 14$). In univariate analysis, the cranioplasty operation time ($P = 0.09$) and the use of autoclaved bone ($P = 0.00$) were supposed to be risk factors for SSI. The use of autoclaved autologous bone was found to be the only risk factor of SSI ($P = 0.01$; hazard ratio = 8.88) in binary logistic regression analysis. Non–methicillin-resistant *Staphylococcus aureus* (MRSA) causes were more frequent in the autoclaved group (MRSA, 30%; non-MRSA, 70%) compared with the non-autoclaved group (MRSA, 100%) ($P = 0.07$). A microscopic examination showed that autoclaving after long-term cryopreservation may result in a loss of bone viability.**

■ CONCLUSIONS: **Autoclaving of autologous bone causes SSI after cranioplasty and it seems to increase the risk of non-MRSA infection by normal skin flora.**

INTRODUCTION

Cranioplasty is a basic neurosurgical procedure which is performed after craniectomy for various neurosurgical conditions, such as trauma, malignant infarction, and tumors. It is a simple and straightforward procedure. However, complications related to cranioplasty are typically not simple.[1,2] A serious complication is surgical site infection (SSI), because SSI after cranioplasty requires a reoperation to remove the bone flap as well as the long-term use of antibiotics. The SSI rate after cranioplasty with autologous bone has been reported to be approximately 3%–30%.[1-9]

Autoclaving is simple and can be used in most institutions as a disinfection method. The autoclaving of autologous bone has been introduced to decrease the risk of SSI; however, several studies have shown disparate results regarding its effects.[3,5,10] Therefore, we designed a retrospective study to evaluate the effectiveness of autoclaving for SSI after cranioplasty with autologous bone.

METHODS

An inclusion criterion of this study was patients who underwent cranioplasty with autologous bone from January of 2004 to December of 2015 at the authors' institution. Thus, 80 patients were enrolled. Demographic, clinical, and radiologic data were retrospectively reviewed. The mean age of the enrolled patients

Key words
- Autoclave
- Cranioplasty
- Infection

Abbreviations and Acronyms
CT: Computed tomography
MRSA: Methicillin-resistant *Staphylococcus aureus*
NDFC: Newly developed fluid collection
SSI: Surgical site infection

From the Departments of [1]Neurosurgery and [2]Pathology, Kangwon National University Hospital, Chuncheon-si, Gangwon-do, Republic of Korea

To whom correspondence should be addressed: Kang Min Kim, M.D. [E-mail: quintus@hotmail.co.kr]

Citation: World Neurosurg. (2016) 91:43-49.
http://dx.doi.org/10.1016/j.wneu.2016.03.066

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

was 53.3 years (range, 14–82 years), and the male/female ratio was 3:2. The clinical follow-up duration was 25.3 months (range, 1–118 months). The institutional review board approved this retrospective study and patients' informed consent was not required.

Craniectomy causes were classified into trauma ($n = 37$) or nontrauma ($n = 43$) cases. After craniectomy, all autologous bone flaps were immediately preserved in a nitrogen deep freezer at −70°C. The authors' institutional policy pertaining to the maximum preservation time was 6 months. If the bone flap was preserved for more than 6 months after a craniectomy procedure, the bone flap was discarded because of concerns over SSI. Except in 1 case, in which cranioplasty was performed 11 months after the craniectomy procedure, all cranioplasty procedures were performed within 6 months. The mean time interval between the craniectomy and the cranioplasty procedures was 49.6 days.

At the time of each cranioplasty, the autologous bone flap was thawed and washed with betadine and normal saline. Autoclaving of the preserved autologous bone flap before cranioplasty was performed for 5 minutes at 135°C in the 26 patients according to the attending neurosurgeon's preference. Before the cranioplasty procedure, no manipulation of the bone flap by hand with sterile gloves even after hand scrubbing was allowed according to an institutional policy designed to prevent SSI. Cefazolin was used as a prophylactic antibiotic until a subgaleal drainage catheter was removed.

SSI that developed after cranioplasty was defined as an infection that required bone flap removal and the use of antibiotics. Based on previous reports about SSI after cranioplasty, the investigated risk factors of SSI were as follows: age, gender, the cause of the craniectomy, the neurologic status of the patient before cranioplasty, the time interval between craniectomy and cranioplasty procedures, multiple surgeries before cranioplasty, the use of autoclaving, the presence of diabetes mellitus, and the presence of ventricular drainage.[1,3-7,9] Univariate analysis was performed by the Fisher exact test and independent t test. Multivariate analysis was performed by binary logistic regression analysis for risk factors that were well known as risk factors of SSI according to previous reports.[1,3-7,9] Statistical analysis was performed using SPSS software (version 21 [IBM Corp., Armonk, New York, USA]), and statistical significance was defined as a P value of less than 0.05.

For a histologic examination of the bone flap in each condition, the bone flap obtained from the patient who underwent decompressive suboccipital craniectomy was used after informed consent was obtained. The histologic examination was performed under the following conditions: 1) immediately after the craniectomy without any treatment; 2) autoclaving for 5 minutes at 135°C immediately after the craniectomy; 3) after preservation for 3 months in a nitrogen deep freezer at −70°C; and 4) after preservation for 3 months in a nitrogen deep freezer at −70°C followed by autoclaving for 5 minutes at 135°C.

A follow-up brain computed tomography (CT) scan was performed in 59 patients within 2 weeks after cranioplasty. Newly developed fluid collection (NDFC) was defined as newly developed low-density fluid collection on the cranioplasty site, which was not identified on immediate postoperative brain CT scan. The relationship between autoclaving, SSI, and NDFC was analyzed.

RESULTS

The SSI rate after cranioplasty with autologous bone was 17.5% ($n = 14$). Figure 1 shows the annual incidence of SSI. Sixty-five cranioplasty surgeries (81.3%) were performed after 2010, and SSI was identified only between 2010 and 2014. Initial symptoms, such as fever, wound discharge, or fluid collection, which were suspected as a sign of SSI, developed at 35.7 days (range, 3–140 days) on average after cranioplasty. Wound revision for bone flap removal was required in all patients, and the mean time interval between cranioplasty and bone flap removal was 69.9 days (range, 7–409 days).

The results of a microbiologic analysis of 14 cases of SSI are shown in Table 1. Methicillin-resistant *Staphylococcus aureus* (MRSA) was the most common cause of SSI. All instances of SSI in the patients who used nonautoclaved autologous bone were caused by MRSA ($n = 4$); however, non-MRSA causes were more prevalent in patients who used autoclaved autologous bone (MRSA, 3; non-MRSA, 7) ($P = 0.07$). The mean time interval between cranioplasty and the development of the initial symptoms of SSI was 30.9 days (range, 4–140 days) in the MRSA group and 40.6 days (range, 3–85 days) in the non-MRSA group ($P = 0.68$). All instances of SSI were treated with antibiotics for at least 4 weeks. Second wound revision for the removal of a recurrent abscess was required in 3 patients (21.4%) (2 MRSA, 1 *Staphylococcus capitis* + *Propionibacterium acnes*) at 18, 19, and 113 days after the initial revision for bone flap removal.

Tables 2 and 3 show the results of an analysis of risk factors of SSI. The total time of the cranioplasty ($P = 0.09$) and the use of autoclaved bone ($P = 0.00$) were supposed to be risk factors of SSI in univariate analysis (Table 2). However, only use of autoclaved bone ($P = 0.01$; hazard ratio = 8.88) was a statistically significant risk factor according to multivariate analysis (Table 3). Overall, the SSI rate was 38.5% (10/26) in the autoclaved group and 7.4% (4/54) in the nonautoclaved group. When the total time of the cranioplasty was dichotomized as short (≤140 minutes) or long (>140 minutes), it lost its

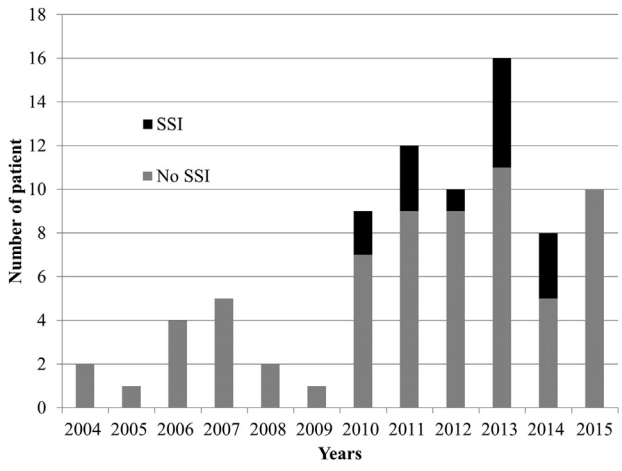

Figure 1. Surgical site infection (SSI) after cranioplasty in the authors' institution.