Neurosurgical "Squeeze Play": Single Incision with Dual Ipsilateral Craniotomies Versus 2 Separate Approaches for Intracranial Aneurysm Treatment

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■ OBJECTIVE: **Patients with bilateral, multiple intracranial aneurysms (IA) can be safely treated using 1 lateral craniotomy. However, in patients with an additional pericallosal artery (PcaA) or distal anterior cerebral artery (ACA) aneurysm, an interhemispheric approach through a bifrontal craniotomy is needed. We investigated the safety of a single incision with dual ipsilateral craniotomies ("squeeze play") and compared results with 2 separate staged surgeries.**

■ METHODS: **Retrospective data collection and analysis was performed of all cases of multiple IAs including a PcaA or complex ACA aneurysm between 1997 and 2016. Univariate statistical analysis was performed to compare radiologic and clinical outcomes.**

■ RESULTS: **Both the squeeze play group (n = 12) and the control group (n = 16) showed similar female gender and mean age distribution, with a higher mean aneurysm number in the squeeze play group. Indication for surgery was mainly subarachnoid hemorrhage (SAH) for the control group (12/16). Mean aneurysm diameter of the largest aneurysm treated with the lateral craniotomy was higher in the squeeze play group (15.8 vs. 4.7 mm, $P = 0.005$), with comparable craniotomy types between both groups. Cumulative estimated blood loss was higher in the control group, with a comparable cumulative operating room time, reoperation rate, and favorable clinical outcome in both groups.**

■ CONCLUSIONS: **Single-staged surgery with a single incision and dual ipsilateral craniotomies is a safe treatment for multiple unruptured aneurysms that include PcaA and distal ACA aneurysms. The squeeze play results in clinical and radiologic outcomes comparable with those in a 2-staged control group. In the setting of SAH, 2-staged surgery with a recovery interval is preferred to prevent bilateral manipulation of the acutely injured brain.**

INTRODUCTION

Multiple intracranial aneurysms have a reported incidence of 14% to 34% and pose a neurosurgical challenge that often requires multiple treatments.[1-3] Multiple intracranial aneurysms have been shown to lead to an increased risk of poor outcomes in the setting of subarachnoid hemorrhage (SAH).[4] The neurosurgical treatment of patients with multiple intracranial aneurysms is complex because of the variability in the anatomic distribution of these lesions, the potential difficulty in identifying the site of rupture in SAH, and the significant anxiety experienced by patients.[5,6] For supratentorial multiple intracranial aneurysms, treatment with a single operation using a lateral craniotomy has been recommended.[3,7] However, for the 20% of multiple, bilateral intracranial aneurysms, a single-stage approach is challenging, and complete treatment may require 2 stages. However, some bilateral intracranial aneurysms may be amenable to a single-stage approach.[7-9] The presence of a pericallosal artery aneurysm (PcaA) or a complex distal anterior cerebral artery (ACA) aneurysm complicates the surgical strategy because an interhemispheric approach through a bifrontal craniotomy typically requires a separate procedure. In this study, we investigated whether a single incision with dual

Key words
- Ipsilateral craniotomies
- Microsurgical aneurysm clipping
- Multiple intracranial aneurysms
- Squeeze play

Abbreviations and Acronyms
ACA: Anterior cerebral artery
EBL: Estimated blood loss
HH: Hunt and Hess grade
mRS: modified Rankin scale
PcaA: Pericallosal artery
SAH: Subarachnoid hemorrhage

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ipsilateral craniotomies would be safe with PcaA or complex ACA aneurysms, and we compared the results from this approach with those from 2 separate staged craniotomies for multiple aneurysms.

METHODS

Inclusion Criteria

This study was approved by the University of California San Francisco Institutional Review Board and performed in compliance with Health Insurance Probability Portability and Accountability Act regulations. Patients operated on with a single incision and dual ipsilateral craniotomies (1 lateral and 1 medial craniotomy, squeeze play) and patients operated on with 2 separate approaches (1 lateral and 1 medial craniotomy, control group) by the senior author (M.T.L.) were identified in a retrospective review of all patients with multiple aneurysms, including pericallosal and distal ACA aneurysms, who underwent microsurgical treatment between January 1998 and September 2016.

Clinical and Radiologic Data

Demographic and clinical data were obtained, including patient age, gender, Hunt Hess (HH) clinical grade, and outcome using the modified Rankin scale (mRS), along with details about the surgery such as estimated blood loss (EBL), time of surgery, and type and side of craniotomy and procedure (bypass, aneurysm clipping). Radiologic data were obtained on aneurysm size, number of aneurysms, location of aneurysm, and postoperative complications including hemorrhage, stroke, or pseudomeningocele.

Definition of Squeeze Play

A squeeze play in baseball is a sacrifice bunt with a runner on third base.[10] In a suicide squeeze, the runner breaks towards home plate as the pitcher releases the ball, relying on the hitter to bunt the ball no matter where it is pitched, while in the safety squeeze the runner waits for the bunt to be laid down. In this report, the term "squeeze play" is used because the surgeon "squeezes" a second craniotomy into the surgical field using a single incision.

Surgical Technique

Patients were positioned supine for the squeeze play, and in patients with restricted neck movement, a small bump was placed under the ipsilateral shoulder. A standard pterional incision within the hair line was extended over the midline. Lateral craniotomies included either a pterional or an orbitozygomatic craniotomy depending on aneurysm location and morphology. The medial craniotomy was a bifrontal craniotomy as a second craniotomy using the same skin incision. After the dura was opened, microsurgical aneurysm treatment (clipping or trapping with bypass) was performed. Except for 2 bypass cases, the lateral approach was performed first, followed by the medial bifrontal craniotomy. After dural closure, both craniotomy flaps were readapted with titanium plates and screws (Figure 1).

For the control group, 2 separate surgeries with 2 different skin incisions were performed. Medial and lateral craniotomies and aneurysm treatment were performed in a similar fashion as described above.

Statistical Testing

Statistical analysis was performed with SPSS 22 (IBM, Chicago, Illinois). Continuous variables are presented as mean with standard error of the mean or range. Comparisons between groups were performed with the Mann-Whitney U test for continuous parameters and the χ^2 test or the Fisher exact test for categoric parameters. Statistical significance was established at the alpha level of $P = 0.05$.

RESULTS

Overall, 28 patients with 106 aneurysms were analyzed in this study, including 12 patients who underwent squeeze play operations with dual ipsilateral craniotomies and 16 patients in the control group who were treated in separate staged surgeries. All aneurysms were successfully clipped (n = 104) or trapped with a bypass procedure (n = 2) as confirmed by postoperative angiography or computed tomographic angiography. Both bypass patients were in the squeeze play group, and the bifrontal craniotomy was used to perform an A3-to-A3 side-to-side anastomosis (n = 1) and an A1-to-A3 anastomosis with a radial artery interposition graft (n = 1).

Mean aneurysm number was 4.8 (1–13) in the squeeze play group, with a total of 58 aneurysms compared with 3 (2–6) in the control group, with a total of 48 aneurysms ($P = 0.06$). In both groups, aneurysms were mainly clipped through a lateral craniotomy (pterional or orbitozygomatic) versus a medial craniotomy (bifrontal). In the squeeze play group, 42 aneurysms (mean 3.5) were clipped through a lateral craniotomy versus 10 aneurysms (mean 0.8) through a bifrontal craniotomy. This was similar to the control group, with 27 aneurysms (mean 1.7) clipped through a lateral craniotomy versus 17 aneurysms (mean 1.1) through a bifrontal craniotomy. The remaining 6 aneurysms from the squeeze play group and 4 aneurysms from the control group had been treated earlier with either microsurgical clipping or endovascular coiling at other centers.

Demographics including gender (female, 10/12 vs. 11/16, $P = 0.66$) and age (mean age 55.2 vs. 52.5 years, $P = 0.84$) were comparable in both groups; however, the indications for surgery differed between groups. Unlike the squeeze play group, SAH was the main treatment indication for the control group (1/12 vs. 12/16, $P = 0.001$) (Table 1). Mean aneurysm diameter of the largest aneurysm treated with the lateral craniotomy was higher in the squeeze play group (15.8 vs. 4.7 mm, $P = 0.005$). There was no significant difference in the type of craniotomy performed between groups (pterional 9/12 vs. 14/16 and orbitozygomatic 3/12 vs. 2/16, $P = 0.62$) or side (left side 7/12 vs. 7/16, $P = 0.70$) (Table 1). Cumulative estimated blood loss was higher in the control group (894 vs. 546 mL, $P < 0.0001$), but cumulative operating room time was comparable between both groups (458 vs. 481 minutes, $P = 0.66$) (Table 1).

Last follow-up time was 33.1 months for all patients and was comparable between groups (25.4 vs. 39 months, $P = 0.42$) (Table 2). There was no difference in postoperative complications between groups ($P = 0.64$). Two patients (1 stroke and 1 infection) in the squeeze play group required additional surgery, compared with 3 patients (1 stroke, 1 chronic subdural hematoma, 1 infection) in the control group