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# Surgical approaches for condylar fractures related to facial nerve injury: deep versus superficial dissection

**T. Imai[1,2], Y. Fujita[3], A. Motoki[4], H. Takaoka[5], T. Kanesaki[2,3], Y. Ota[1,6], S. Iwai[1], H. Chisoku[5], M. Ohmae[4], T. Sumi[3], M. Nakazawa[1], N. Uzawa[1]**

[1]Department of Oral and Maxillofacial Surgery II, Osaka University Graduate School of Dentistry, Suita, Osaka, Japan; [2]Department of Oral and Maxillofacial Surgery, Saiseikai Senri Hospital, Suita, Osaka, Japan; [3]Department of Oral and Maxillofacial Surgery, Toyonaka Municipal Hospital, Toyonaka, Osaka, Japan; [4]Department of Oral and Maxillofacial Surgery, Rinku General Medical Centre, Izumisano, Osaka, Japan; [5]Department of Oral and Maxillofacial Surgery, Higashiosaka City Medical Centre, Higashiosaka, Osaka, Japan; [6]Department of Oral and Maxillofacial Surgery, Itami City Hospital, Itami, Hyogo, Japan

*T. Imai, Y. Fujita, A. Motoki, H. Takaoka, T. Kanesaki, Y. Ota, S. Iwai, H. Chisoku, M. Ohmae, T. Sumi, M. Nakazawa, N. Uzawa: Surgical approaches for condylar fractures related to facial nerve injury: deep versus superficial dissection. Int. J. Oral Maxillofac. Surg. 2019; 48: 1227–1234.* 

*Abstract.* The aim of this study was to investigate the probability of facial nerve injury (FNI) in the treatment of condylar neck and subcondylar fractures (CN/SCFs) with percutaneous approaches and to identify factors predicting FNI. The data of 80 patients with 87 CN/SCFs were evaluated retrospectively. The primary outcome was FNI occurrence. The predictor variables were age, sex, aetiology, alcohol consumption, fracture site and pattern (dislocation or not), concomitant fractures, time interval to surgery, surgeon experience, plate type, and the dual classification of percutaneous approaches. The approaches were classified based on whether subcutaneous dissection traversed the marginal mandibular branch (MMB) deeply (deep group: submandibular and retroparotid approaches) or superficially (superficial group: transparotid, transmasseteric anteroparotid (TMAP), and high cervical-TMAP approaches). Twenty-two patients (27.5%) suffered FNI, of whom two in the deep group had permanent paralysis of the MMB. In the multivariate logistic regression model, deeply traversing surgery approaches (odds ratio 12.4, $P = 0.025$) and the presence of a dislocated fracture (odds ratio 6.66, $P = 0.012$) were associated with an increased risk of FNI. These results suggest that percutaneous approaches in the superficial group should be recommended for the treatment of CN/SCFs to reduce the risk of FNI.

Key words: facial nerve paralysis; transmasseteric anteroparotid approach; condylar neck fractures; subcondylar fractures; new classification.

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Successful open treatment of mandibular condyle fractures depends on accurate diagnostic imaging, an appropriate surgical procedure, anatomical reduction of the fractured condyle, rigid osteosynthesis, and careful postoperative management[1]. The selection of surgical approaches for condylar neck and subcondylar fractures (CN/SCFs) is still highly debated; percutaneous approaches are still performed in most procedures[2,3].

With the advent of approaches purported to minimize associated morbidities, such as facial nerve injury (FNI), the different routes of subcutaneous dissection with similar incisions often confuse both surgeons and trainees[4,5]. Representative examples include approaches via retromandibular and submandibular incision. The former includes three main methods differing by their relationship

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to the parotid: transparotid[6], retroparotid[7,8], and transmasseteric anteroparotid (TMAP)[9,10] approaches, while the latter includes approaches via a low submandibular incision with sub-platysmal dissection (traditional submandibular approach, i.e., Risdon approach) and a high submandibular incision with superplatysmal dissection (high cervical-TMAP (HC-TMAP) approach[11] or high submandibular transmasseteric approach[12], i.e., modified Risdon approach).

Few studies have compared the rate of FNI among multiple percutaneous approaches using statistical methods[13]. Recently published systematic reviews have suggested that the routes are more closely associated with the probability of such injury than the incision site[2,3]. However, the surgical pathway has not been evaluated as a risk factor for FNI with potential variables, such as patient background characteristics or the site and pattern of the fractures.

This study investigated the risk of FNI in patients undergoing extraoral surgeries for CN/SCFs and explored factors predicting FNI. Focusing on the marginal mandibular branch (MMB) as a critical branch in FNI, a simplified dual classification of percutaneous approaches according to the anatomical relationship between the subcutaneous dissection route and the MMB was employed.

## Patients and methods

### Study design and samples

This retrospective cohort study was approved by the internal review boards of the authors' institutions. Data for cases of surgical CN/SCFs repair were acquired from the electronic charts of patients treated between January 2010 and August 2018 at Osaka University Dental Hospital, Saiseikai Senri Hospital, Toyonaka Municipal Hospital, Rinku General Medical Centre, Higashiosaka City Medical Centre, and Itami City Hospital. Data that included paper-based records were also obtained as far back as September 2006 at Osaka University Dental Hospital and Saiseikai Senri Hospital. The five general hospitals listed are affiliated with Osaka University and have adopted policies of mutual exchange of surgeons.

The selection criteria were patients over the age of 15 years with CN/SCFs[14], who had undergone surgical treatment with rigid internal fixation by percutaneous approach, who had pre- and postoperative panoramic radiographs or computed tomography (CT) images available, who were mentally capable of undergoing a neuromotor examination, and who had postoperative clinical follow-up data covering at least 3 months[10,15,16].

### Study variables

Documented variables were age, sex, cause of trauma, consumption of alcoholic beverages before the accident, fracture location (condylar neck or subcondylar)[14] and pattern (non-displaced/deviated, displaced, or dislocated)[17], concomitant mandibular and midfacial fractures, interval from trauma to the operation (days), experience of the operator (a certified specialist or not certified), surgical approach, and type of miniplate for fixation.

The primary outcome was the occurrence of FNI, and the patients were divided into groups according to FNI presence or absence at 1 week after surgery. This outcome was also checked at the postoperative 1-, 3-, and 6-month follow-ups. The motor response of the major branches was visually checked[18], including the ability to wrinkle the forehead (temporal branch), to completely close the eyes (zygomatic branches), to puff the cheeks (buccal branch), and to symmetrically show a smile (marginal mandibular branch).

Other clinical evaluations included the inter-incisal distance, malocclusion, and postoperative surgical complications. An inter-incisal distance of less than 35 mm was defined as restricted mouth opening[19]. Malocclusion was categorized into three grades[20]: recovery to pre-injury occlusion with intercuspation of teeth (grade I), mild malocclusion requiring prosthetic reconstruction or orthodontic therapy (grade II), and severe malocclusion requiring reoperation (grade III). Postoperative surgical complications included surgical site infection, parotid-associated complications (sialocele, salivary fistula, and Frey syndrome), and hypertrophic scar[21]. Abnormal findings on postoperative radiography, such as plate breakage, were also evaluated using panoramic radiographs or CT images.

### Surgical management

At the study institutions, the following CN/SCFs have generally been referred for open treatment: (1) unilateral displaced or dislocated fractures with malocclusion; (2) bilateral displaced fractures associated with a symphyseal fracture of the mandible or midface fractures. The authors occasionally referred non-displaced forms for open treatment in cases with concomitant fractures of the mandibular body that were managed surgically. Surgeries were performed by specialists certified in oral and maxillofacial surgery or under the instruction of a specialist if not certified. All surgeons served their apprenticeship at Osaka University. The percutaneous approaches applied included the traditional submandibular (Risdon) approach and others described below.

In the transparotid approach, an incision approximately parallel to the posterior border of the mandibular ramus was used[6,19,22,23]. The superficial musculoaponeurotic system (SMAS) and parotid capsule were incised anteriorly. The parotid was bluntly dissected towards the ramus with no attempt to visualize the facial nerve branches.

In the retroparotid approach, an incision was initiated just below the earlobe and continued obliquely and inferiorly towards the mandibular angle[7,8]. The subcutaneous tissue was dissected posteriorly around the surface of the parotid capsule, followed by superoanterior retraction of the parotid and surrounding soft tissues for the posterior border of the ramus.

The TMAP approach[9] can be performed via only a retromandibular incision (modified form)[15,24] or with pretragal extension (original form)[9,10]. The original procedure was employed at the study hospitals. Dissection proceeded anteriorly on the SMAS, and the anterior edge of the parotid was carefully separated with protection of the buccal branches. Retracting the parotid posteriorly and the posterior edge of the masseter muscle anteriorly, the periosteum was dissected to the ramus.

In the HC-TMAP approach, the skin was incised for a 5-cm length from 0.5 to 1 cm below the lower border of the mandible[11,25]. Subcutaneous dissection was performed on the platysma, which was then transected and retracted to expose the masseter muscle. The masseter muscle was cut superior to the MMB and anterior to the parotid, following which sub-periosteal access to the ramus was achieved.

With these approaches, the condyle was reduced under digital compression on the occlusal aspect of the ipsilateral lower dentition or by inferior traction using a twisted wire around the screw that was temporarily inserted into the ramus[19], if necessary. In principle, two miniplates were set in a triangular fashion with one below the sigmoid notch and the other along the posterior edge of the ramus. The plates were predominantly locking miniplates (AO LOCK Mandible 2.0 or

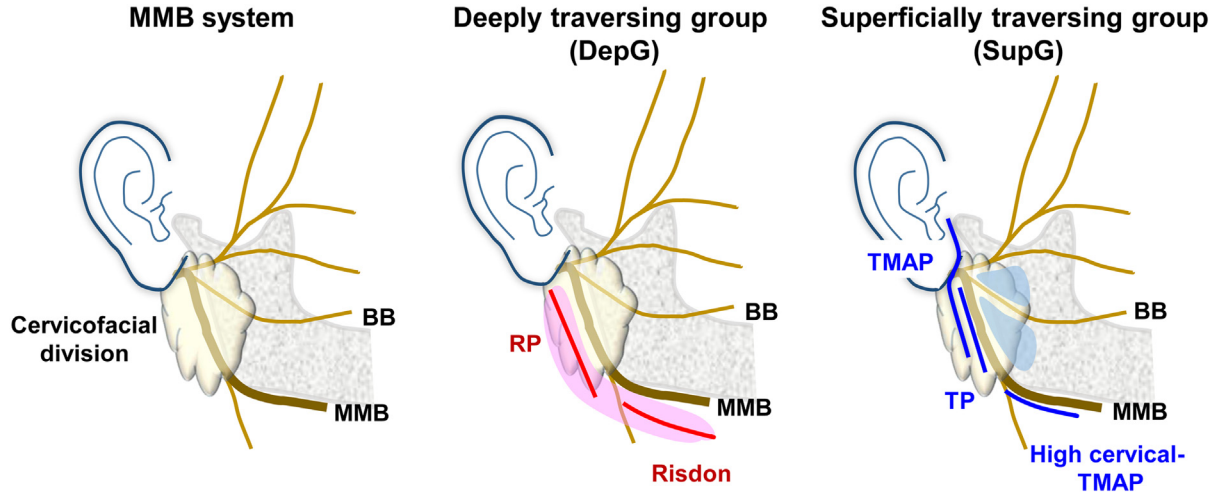


*Fig. 1.* Dual classification of percutaneous approaches for condylar neck and subcondylar fractures. The cervicofacial division of the facial nerve contains nerve fibres for the marginal mandibular branch (MMB). In this study, the MMB system was defined as the segment shown with a bold line (left panel). The skin incisions are generally located inferoposterior to the MMB system. The point of focus is whether the route of subcutaneous dissection traverses the MMB system deeply or superficially. The coloured shapes indicate the main dissection area under the superficial musculoaponeurotic system/platysma. The middle panel shows the deeply traversing group (DepG). The surgical path begins with dissection in the deep direction, remaining inferoposterior to the MMB, followed by traversing under the MMB. The right panel shows the superficially traversing group (SupG). The dissection route superficially traverses the MMB system and then deeply proceeds to the ramus superoanteriorly to the MMB through the interspace between the facial nerve branches, with penetration through (i.e., TP) or travelling anterior to the parotid (i.e., TMAP and high cervical-TMAP). BB, buccal branch; MMB, marginal mandibular branch; RP, retroparotid; TMAP, transmasseteric anteroparotid; TP, transparotid.

MatrixMANDIBLE 2.0, Synthes, Paoli, PA, USA; or Lorenz Plating System Mandible, Biomet Inc., Jacksonville, FL, USA). Alternatively, a single heavier plate was placed along the ramus. A specialized osteosynthesis system of three-dimensional subcondylar miniplates (MatrixMANDIBLE Subcondylar Plate, Synthes, Paoli, PA, USA) has been used more recently. For some subcondylar fractures, bioabsorbable plate systems were also used (GrandFix; Johnson and Johnson, Tokyo, Japan). A suction drain was placed in contact with the lateral aspect of the ramus and was removed within a few days postoperative.

A liquid diet was started in principle the day after the operation, followed by a soft diet for approximately 1 month. Jaw exercises with or without functional mouth-opener activator was provided at the outpatient clinic, and self-rehabilitation was encouraged.

### Dual classification of percutaneous approaches

The inter-branch space of the facial nerve through which the surgeon performs the condyle dissection is important. In order to treat the various percutaneous approaches as dual variables, the MMB and its central side (the cervicofacial division of the facial nerve) were defined as 'the MMB system' and five percutaneous approaches were classified into two groups depending on whether the subcutaneous dissection traversed the MMB system deeply (deep group) or superficially (superficial group) (Fig. 1).

Based on this classification, the traditional submandibular (Risdon) and retroparotid approaches were categorized into the deep group, whereas transparotid, TMAP, and HC-TMAP were categorized into the superficial group. In other words, approaches via a retromandibular incision were divided into two groups (retroparotid approach into the deep group, and transparotid and TMAP into the superficial

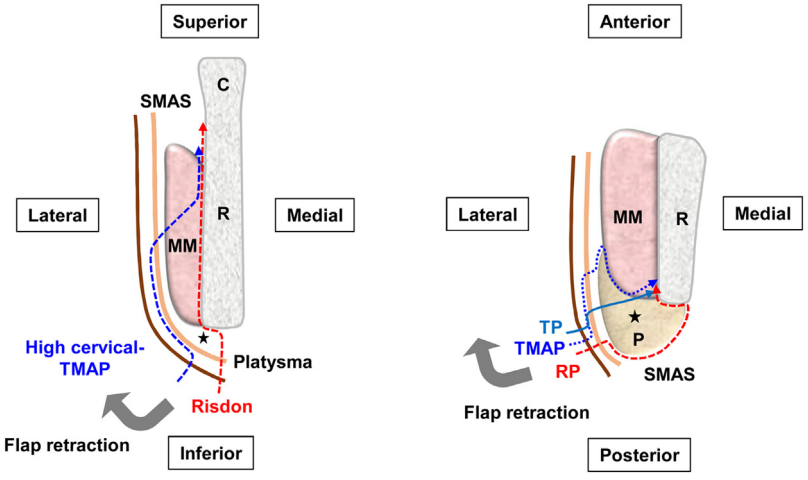


*Fig. 2.* Sectional models of percutaneous approaches for condylar neck and subcondylar fractures. The arrows indicate the dissection routes with the skin incision-to-ramus approach on the right side of the coronal (left panel) and horizontal sections (right panel). The marginal mandibular branch (MMB) system (stars) is located within the retracted flap in the deep group approaches (Risdon and RP approaches), but not in the superficial group approaches (TP, TMAP, and high cervical-TMAP). C, condyle; MM, masseter muscle; P, parotid; R, ramus; RP, retroparotid; SMAS, superficial musculoaponeurotic system; TMAP, transmasseteric anteroparotid; TP, transparotid.

group), as were those via a submandibular incision (Risdon into the deep group and HC-TMAP into the superficial group) (Fig. 2).

### Statistical analyses

Categorical and continuous variables were presented as the frequency (percentage) and as the mean and standard deviation (or median (interquartile range)), respectively. To assess the association with FNI, Fisher's exact test was applied for categorical variables and the Wilcoxon rank-sum test for continuous variables. Univariate and multivariate logistic regression models were utilized to obtain the odds ratios (OR) and 95% confidence intervals (CI) of FNI occurring and to assess the effects of study variables. Additional logistic regression analyses allowing duplication of cases with bilateral surgeries were performed as sensitivity analyses[19]. Statistical significance was considered as a *P*-value of less than 0.05. Statistical analyses were conducted using R 3.4.1 software program (R Foundation for Statistical Computing, Vienna, Austria).

## Results

A total of 80 patients with 87 fracture sides were eligible for the analysis; 73 patients (91.2%) underwent unilateral surgery and seven patients (8.8%) underwent bilateral surgery. The mean age of the patients was 46.3 years. The cause of the trauma was predominantly falling (34 patients, 42.5%), followed by motor vehicle accidents (19 patients, 23.8%). The median interval between the trauma and the surgery was 6.0 days. Regarding the fracture site, 25 fractures (28.7%) were located in the condylar neck and 62 (71.3%) in the subcondylar areas. The fracture pattern included dislocation in 13 sides (15.0%), displacement in 37 (42.5%), and deviation/non-displacement in 37 (42.5%). Concomitantly with the CN/SCFs, 48/80 patients (60.0%) had extra-condylar fractures in the mandible and eight (10.0%) had midfacial fractures.

Surgeries in 63 patients (78.8%) were performed by specialists certified in oral and maxillofacial surgery. In the dual classification of the approaches, 61 patients (76.2%) with 66 fractures (75.9%) underwent procedures of the deep group and 19 patients (23.8%) with 21 fractures (24.1%) underwent procedures of the superficial group. Osteosynthesis was mainly achieved using miniplates: 62 patients (77.5%) with 68 fractures (78.2%). Bioabsorbable plates were used in five patients (6.2%) with six fractures (6.9%).

*Table 1.* Bivariate analysis of variables grouped by patients with and without facial nerve injury.

| Study variables | Facial nerve injury, *n* (%) | | *P*-value |
|---|---|---|---|
| | Present | Absent | |
| Sample size | | | |
| Patients, *n* = 80 | 22 (27.5) | 58 (72.5) | |
| Fractures, *n* = 87 | 22 (25.3) | 65 (74.7) | |
| Patient demographics | | | |
| Age (years), mean ± SD | 40.3 ± 18.7 | 48.5 ± 20.7 | 0.082 |
| Sex | | | 0.441 |
| Male | 12 (54.5) | 38 (65.5) | |
| Female | 10 (45.5) | 20 (34.5) | |
| Aetiology | | | 0.100 |
| Falling | 7 (31.8) | 27 (46.6) | |
| Motor vehicle accident | 9 (40.9) | 10 (17.2) | |
| Assault | 1 (4.5) | 12 (20.7) | |
| Bicycle accident | 2 (9.1) | 4 (6.9) | |
| Sports | 2 (9.1) | 2 (3.4) | |
| Falling from a height | 1 (4.5) | 3 (5.2) | |
| Alcohol consumption | 3 (13.6) | 19 (32.8) | 0.101 |
| Condylar fracture | | | |
| Fracture site[a] | | | 0.279 |
| Condylar neck | 8 (36.4) | 14 (24.1) | |
| Subcondylar | 14 (63.6) | 44 (75.9) | |
| Fracture pattern[a] | | | 0.015 |
| Dislocated | 7 (31.8) | 5 (8.6) | |
| Non-dislocated | 15 (68.2) | 53 (91.4) | |
| Concomitant facial fractures | | | |
| Mandible | 12 (60.0) | 36 (67.9) | 0.585 |
| Midface | 2 (9.0) | 6 (10.3) | 1.000 |
| Operation | | | |
| Interval to surgery (days), median (IQR) | 5.0 (3.25–8.75) | 6.5 (4.25–10.0) | 0.236 |
| Experience of surgeons | | | 1.000 |
| Certified in OMS | 17 (77.3) | 46 (79.3) | |
| Not certified in OMS | 5 (22.7) | 12 (20.7) | |
| Percutaneous approach[a] | | | 0.017 |
| Deeply traversing | 21 (95.5) | 40 (69.0) | |
| Superficially traversing | 1 (4.5) | 18 (31.0) | |
| Plates for fixation[a] | | | |
| Miniplate | 16 (72.7) | 46 (79.3) | 0.690 |
| 3D subcondylar plate | 3 (13.6) | 8 (13.8) | |
| Combination of those above | 1 (4.5) | 1 (1.7) | |
| Bioabsorbable plate | 2 (9.1) | 3 (5.2) | |

3D, three-dimensional; IQR, interquartile range; OMS, oral and maxillofacial surgery. SD, standard deviation

[a] Target fracture per case to avoid analyzing duplicate cases with bilateral surgeries.

The primary outcome of FNI was observed in 22 (27.5%) of 80 patients who underwent surgery for 87 CN/SCFs. This complication was unilaterally observed even in patients with bilateral surgeries. A statistical comparison between patients with and without the outcome indicated that the dual classification ($P = 0.017$) and fractures with dislocation ($P = 0.015$) were associated with an increased risk of FNI (Table 1). No statistically significant differences were detected among the other variables examined.

Logistic regression analyses were performed at the patient level and at the fracture level (Table 2). The univariate model showed that deep group surgery (OR 9.45, 95% CI 1.18–75.80; $P = 0.035$ (patient level) and OR 9.33, 95% CI 1.17–74.30; $P = 0.035$ (fracture level)) and fractures with dislocation (OR 4.95, 95% CI 1.37–17.80; $P = 0.015$ (patient level) and OR 4.59, 95% CI 1.34–15.70; $P = 0.015$ (fracture level)) were associated with the probability of FNI. In the multivariate model, backward-selection stepwise regression identified the following as significant factors: deep group surgery (OR 12.40, 95% CI 1.38–112.00; $P = 0.025$ (patient level) and OR 14.10, 95% CI 1.53–130.00; $P = 0.020$ (fracture level)) and fractures with dislocation (OR 6.66, 95% CI 1.52–29.10; $P = 0.012$ (patient level) and OR 7.17, 95% CI 1.66–30.90; $P = 0.008$ (fracture level)).

*Table 2*. Logistic regression model to determine the association between facial nerve injury and study variables.

| | Univariate model | | Multivariate model | |
|---|---|---|---|---|
| | OR (95% CI) | *P*-value | OR (95% CI) | *P*-value |
| Variable ($n$ = 80 patients) | | | | |
| Age | 0.98 (0.95–1.00) | 0.110 | | |
| Sex | | 0.367 | | |
| Male | Ref. | | | |
| Female | 1.58 (0.58–4.30) | | | |
| Fracture site | | 0.277 | | |
| Subcondylar | Ref. | | | |
| Condylar neck | 1.80 (0.62–5.17) | | | |
| Fracture pattern | | 0.015 | | 0.012 |
| Non-dislocated | Ref. | | Ref. | |
| Dislocated | 4.95 (1.37–17.80) | | 6.66 (1.52–29.10) | |
| Experience of surgeons | | 0.842 | | |
| Not certified in OMS | Ref. | | | |
| Certified in OMS | 0.88 (0.27–2.89) | | | |
| Approach applied | | 0.035 | | 0.025 |
| Superficially traversing | Ref. | | Ref. | |
| Deeply traversing | 9.45 (1.18–75.80) | | 12.40 (1.38–112.00) | |
| Plates for fixation | | 0.816 | | |
| Miniplates | Ref. | | | |
| 3D subcondylar plate | 1.08 (0.25–4.57) | 0.919 | | |
| Combination of those above | 2.87 (0.17–48.70) | 0.464 | | |
| Bioabsorbable plate | 1.92 (0.29–12.50) | 0.497 | | |
| Variable ($n$ = 87 fractures)[a] | | | | |
| Fracture site | | 0.363 | | |
| Subcondylar | Ref. | | | |
| Condylar neck | 1.61 (0.58–4.52) | | | |
| Fracture pattern | | 0.015 | | 0.008 |
| Non-dislocated | Ref. | | Ref. | |
| Dislocated | 4.59 (1.34–15.70) | | 7.17 (1.66–30.90) | |
| Approach applied | | 0.035 | | 0.020 |
| Superficially traversing | Ref. | | Ref. | |
| Deeply traversing | 9.33 (1.17–74.30) | | 14.10 (1.53–130.00) | |
| Plates for fixation | | 0.820 | | |
| Miniplates | Ref. | | | |
| 3D subcondylar plate | 1.22 (0.29–5.15) | 0.788 | | |
| Combination of those above | 3.25 (0.19–55.00) | 0.414 | | |
| Bioabsorbable plate | 1.62 (0.27–9.71) | 0.594 | | |

3D, three-dimensional; CI, confidence interval; OMS, oral and maxillofacial surgery; OR, odds ratio; Ref., reference.

[a] Allowing duplicate cases.

The relationships between dislocated fracture and FNI with stratification by percutaneous approach applied are summarized in Table 3. No case of FNI was encountered in patients who underwent the TMAP or HC-TMAP approach. Of the 22 patients (27.5%) with FNI, seven (31.8%, or 8.8% of the total study patients) had prolonged paralysis for more than 3 months. Of the prolonged paralysis cases, two (28.6%, or 2.5% of the total study patients) treated using the traditional submandibular approach (i.e., deep group) also had paralysis of the MMB at their 6-month visit. Regarding the distribution of branches with impaired function, 20 patients showed FNI only in the MMB and the remaining two patients showed FNI in multiple branches, one with hemifacial dysfunction (Fig. 3) and the other with an injury of the MMB and buccal branch.

No surgical site infection was evident postoperatively. No patients suffered any salivary complications that required additional intervention or had limited mouth opening at the 3-month follow-up. Three patients (3.8%) with concomitant mandibular body fractures underwent prosthodontic occlusal reconstruction (grade II malocclusion). Plate breakage occurred in one case with a displaced condylar neck fracture. No patients had hypertrophic skin scarring.

## Discussion

Among the diverse postoperative complications associated with percutaneous approaches for CN/SCFs[21], FNI is probably the largest concern for both the patient and the surgeon[2,3]. The few studies comparing the clinical outcomes among multiple percutaneous approaches have not conducted multivariate analyses for factors related to FNI[13]. Furthermore, studies on surgery for CN/SCFs using these analyses have only focused on a single approach[18,19]. In the present study, univariate and multivariate logistic analyses revealed that the dual classification of deep group surgery and the presence of a dislocated fracture were significantly associated with the risk of FNI.

Of the deep group surgeries, the traditional submandibular approach is the preferred extraoral choice for the repair of mandibular body or angle fractures. However, for the treatment of CN/SCFs, the superior traction of the flap often causes an injury to the MMB because this branch, which is located at the inferior end of the

*Table 3*. Relationship between the approaches applied and fracture components.

| Approach | Deeply traversing group | | | | Superficially traversing group | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Traditional submandibular | | Retroparotid | | Transparotid | | TMAP | | High cervical-TMAP | |
| Fracture site | CN | SC | CN | SC | CN | SC | CN | SC | CN | SC |
| | 4/8 | 13/46 | 4/7 | 0/5 | 0/3 | 1/5 | 0/5 | 0/3 | 0/2 | 0/3 |
| Fracture pattern | | | | | | | | | | |
| Dislocated | 1/1 | 3/4 | 3/4 | | | 0/2 | | | 0/2 | |
| Non-dislocated | 3/7 | 10/42 | 1/3 | 0/5 | 0/3 | 1/3 | 0/5 | 0/3 | | 0/3 |
| Facial nerve injury sides/total sides, $n$ (%) | 17/54 (31.5) | | 4/12 (33.3) | | 1/8 (12.5) | | 0/8 (0) | | 0/5 (0) | |

CN, condylar neck; SC, subcondylar; TMAP, transmasseteric anteroparotid.

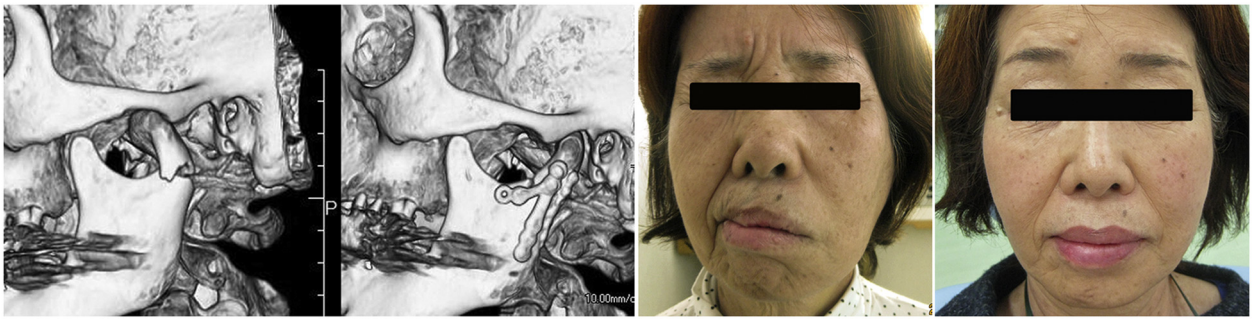

*Fig. 3.* Severe postoperative facial nerve weakness. A patient with a dislocated condylar neck fracture (first (left) panel) underwent open treatment with reduction and internal fixation using the retroparotid approach (second panel). The patient displayed a unilateral severely imbalanced facial appearance (third panel) with almost normalized features at the 3-month follow-up (last panel) and complete recovery of the nerve function at the 6-month follow-up.

flap, thus becomes directly loaded[26,27]. In the retroparotid approach, also in the deep group, oblique manipulation of the CN/SCFs with superoanterior traction of the bulky flap that includes the whole parotid may be unavoidable for accurate reduction and stable fixation. For the patient with whole FNI on the affected side in the present study (Fig. 3), this may have been due to the traction force applied to the facial nerve trunk, as described above.

Compared with the deep group surgeries, the superficial group surgeries provide more perpendicular access to the condyle, which facilitates efficient handling and helps reduce the fracture fragment and stable fixation with plates and thereby decreases the incidence of FNI. A cadaver study demonstrated that the traction force on the soft tissues in the HC-TMAP approach (i.e., superficial group) was significantly lower than that in the Risdon approach (i.e., deep group)[28].

Interconnections occur between the zygomatic and buccal branches in more than 70% of subjects[29]. Such features are predominantly anterior to the masseter muscle. However, the MMB is vulnerable to surgical injuries due to the low rate of interconnections, which generally occur in no more than 17% of subjects, leading to the occurrence of visible postoperative complications[29]. A comparative study on approaches for CN/SCFs showed that permanent paralysis was more frequent with the traditional submandibular approach (11%) than with the transparotid approach (3.6%)[13]. In the present study, the traditional submandibular approach was the only procedure that provoked permanent damage (two of 54 fracture sites treated with this approach, 3.7%).

FNI was unlikely to occur using the dissection routes in the superficial group, particularly TMAP and HC-TMAP, because these routes pass through the 'anatomical nerve-free window' located superior to the MMB[10,30]. Although flap retraction at the superior level of the MMB can stretch the buccal branch, possibly leading to an asymmetric upper lip, the abundant interconnections may allow for the preservation of the nerve function in cases treated with TMAP and HC-TMAP, as no FNI was noted with these approaches in this study. A systematic review showed that TMAP and HC-TMAP were more suitable than the transparotid approach for condylar neck fractures[2]; however, no statistical comparison of the rate of FNI among the superficial group approaches was performed in the present study because of the small number of cases treated with each approach.

Another independent factor related to FNI was fracture with dislocation, although with a lower OR than for the dual classification. Previous studies on the transparotid approach have also reported dislocated fractures as a predictor of FNI in multivariate models[18,19]. This may reflect the difficulty in reduction of the dislocated condyle, which requires a strong traction force over a long manipulation time.

In the present study, the overall incidence of FNI was high (27.5%, patient-level; 25.3%, fracture-level). This is ascribed to the high rate of adopting the deep group approaches (traditional submandibular and retroparotid approaches) among the total approaches; the deep group approaches were performed for 66 of 87 fracture sides, with a high incidence of FNI (21/66 sides, 31.8%), as shown in Table 3. Each of the five approaches in this study showed an incidence of FNI within the range of those reported previously in the literature (Table 4): traditional submandibular (incidence of FNI in this study, 31.5%; incidence in previous studies, 5.3%[27]–48.1%[26]), retroparotid (33.3%; 10.5%[7]–40%[8]), transparotid (12.5%; 3.2%[23]–30%[22]), TMAP (0%; 0%[10]–7.7%[24]), and HC-TMAP (0%; 0%[25]–0.6%[30]) approaches. However, the relatively elevated incidence in the retroparotid approach (33.3%) may be due to its high rate of application for condylar neck fractures with dislocation. The incidence of FNI in the traditional submandibular approach (31.5%) is considered to reflect the intrinsic disadvantage of the high chance of FNI due to the necessity of heavy superior traction of the flap. In contrast, the superficial group approaches showed reasonable outcomes with a low incidence of FNI (1/21 sides, 4.8%), although the sample size was small. The investigation of additional cases in the future will help to determine the reliability of this result, showing a low incidence of FNI in the superficial group approaches.

Salivary gland-associated complications are more likely in approaches through the parotid than in those circumventing the parotid. To avoid these problems with transparotid approaches, gentle blunt dissection and tight closure of the parotid fascia is crucial[19]. With the TMAP and HC-TMAP approaches, dissection into the masseter muscle but not into the parotid can reduce the risk of salivary complications, as shown in the present study. Of note, complications have also been reported for the modified TMAP approach[16]. Dissection through a narrow manipulating space via a small 2.5- to 3-cm retromandibular incision, unlike the regular incision employed by the present authors, might cause an unexpected injury to the parotid.

A limitation of this study is the retrospective collection of data for patients who underwent surgery performed by different surgeons at any of six institutions. Although a multicentre approach in obser-

*Table 4.* Profiles of the dual classification and major percutaneous approaches for condylar neck and subcondylar fractures.

| | Deeply traversing group | | Superficially traversing group | |
|---|---|---|---|---|
| Dissection area in the deep direction to the mandible | Inferoposterior to the MMB system | | Superoanterior to the MMB system | |
| Volume of the retracted soft tissues | Larger | | Smaller | |
| Location of MMB | Within the retracted flap | | Outside the retracted flap | |
| Surgical manipulation of the fractured condyle | Tendency from the inferoposterior direction | | Easier accessibility from the perpendicular direction | |
| | Submandibular | Retroparotid | Transparotid | TMAP |
| Application to displaced condylar neck/subcondylar fractures | Difficult/possible | Slightly difficult/possible | Possible/possible | Possible/possible |
| Procedure technique | Popular and simple | Relatively long distance of dissection | Simple and short distance | Stepwise dissection |
| Awareness in maxillofacial surgeons | Well-known | Known | Known | Developing |
| Skin incision | Submandibular | Retromandibular | Retromandibular | Retromandibular ± pretragal extension |
| | | | | High cervical, high submandibular |
| Relationship to the parotid | Out of the field | Posteriorly circumnavigating | Penetrating | Anteriorly circumnavigating |
| Salivary complications | None | Rare | Low | Rare |
| Possible main exposed FN branches in the surgical field | MMB | MMB (with inferiorly extended incision) | MMB, BB | BB |
| Prevalence of FN injuries | 5.3%[27]–48.1%[26] | 10.5%[7]–40%[8] | 3.2%[23]–30%[22] | 0%[10]–7.7%[24] |
| | | | | 0%[25]–0.6%[30] |

BB, buccal branch; FN, facial nerve; MMB, marginal mandibular branch; TMAP, transmasseteric anteroparotid; ZMB, zygomatic branch.

vational clinical research, unlike a small study at a single centre, allows for an increased number of patients and enhanced generalizability of the results, leading to improved efficiency[31], the clinical outcomes associated with surgical interventions can be biased by a larger number of surgeons performing various surgical approaches using diverse techniques. However, the five collaborative hospitals involved in this study are all affiliated with Osaka University and have adopted policies of mutual exchange of surgeons who have received postgraduate training in oral and maxillofacial surgery at Osaka University. Therefore, it is believed that the outcomes of this study were based on treatment by surgeons with a common background and that the outcomes were relatively reliable compared with those of samples collected from completely independent institutions. Another limitation is that individual variations, such as the anatomical distribution of nerve branches or the extensibility and thickness of the retracted flap, are likely to affect the probability of FNI but have yet to be evaluated. In addition, a statistical analysis of prolonged FNI was not performed due to the small number of samples.

Knepil et al.[4] and the present authors' group[5] have proposed a model to facilitate the recognition of the anatomical relationships of the nerve branches and parotid through the dissection course that should be applied before selecting a percutaneous approach for CN/SCFs. The dual classification employed in this study may be a framework reflecting the risk of FNI and indicating the importance of the relationship between the subcutaneous route and the MMB systems.

In conclusion, when selecting a percutaneous approach for CN/SCFs, procedures with superficial dissection traversing the MMB system are recommended because of the significantly lower probability of FNI than with approaches via deeply traversing routes. Surgeons treating maxillofacial fractures should be aware of the different subcutaneous dissection routes to the condyle and choose the most appropriate approach based on the profile.

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Address:
*Tomoaki Imai*
*Department of Oral and Maxillofacial Surgery II*
*Osaka University Graduate School of Dentistry*
*1–8Yamadaoka*
*Suita*
*Osaka 565-0871*
*Japan*
*Tel.: +81 6 6879 2941; Fax: +81 6 6879 2170*
*E-mail: tomoimai@dent.osaka-u.ac.jp*