Comparison of Three Techniques for Swine Temporomandibular Joint Space Injection

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Aims: To compare the feasibility and accuracy of three injection techniques for entering the superior joint space of the swine temporomandibular joint (TMJ). **Methods:** Nine swine were used for this study, in which 500 µL of colored dye was injected into both TMJs of each swine. Three injection techniques were used: the posterior injection (PI), the anterosuperior injection (ASI), and the lateral injection (LI) techniques. Each injection technique was performed on six TMJs. Swine were sacrificed immediately after injection and the swine head was dissected in order to observe the dye distribution. Injection was considered successful if no dye could be observed outside the superior joint space. **Results:** The PI technique was successful in all six TMJs (success rate: 100%), the LI technique in three out of six TMJs (success rate: 50%), and the ASI technique in two out of six TMJs (success rate: 33%); the differences were statistically significant (chi-square test, $P < .05$). **Conclusion:** The PI technique was more accurate than the LI or ASI techniques in accessing the swine superior TMJ space. *J Oral Facial Pain Headache 2016;30:165–170. doi: 10.11607/ofph.1469*

Keywords: *animal model, injection techniques, joint space, swine, temporomandibular joint*

Animal models have been used extensively for studying joint diseases, for developing treatment methods, and for evaluating treatment effects.[1,2] These studies have most often used rat, rabbit, or dog temporomandibular joints (TMJs), but their anatomy and function differ considerably from that of the human TMJ, thus decreasing the possibility of making inferences that are valid for the human TMJ.[3,4] However, the swine TMJ has been reported to have a greater similarity to the human TMJ.[5–7]

In clinical and animal studies, a lateral injection (LI) technique is most commonly used to inject into the TMJ cavity,[8,9] and an anterosuperior injection (ASI) technique has been used for the rat TMJ for reasons relating to the rat's unique anatomy.[10] However, there have been no reports on the ideal injection technique for the swine TMJ. Therefore, the aim of this study was to compare the feasibility and accuracy of three injection techniques for entering the superior joint space of the swine TMJ. These techniques were the LI technique, which is commonly used to inject into many animal TMJs and also the human TMJ[11-15]; the ASI technique, which is used for the rat TMJ; and the posterior injection (PI) technique, which has been developed according to the anatomy of the swine TMJ.

Materials and Methods

Nine Yorkshire swine aged 6 months were used in this study. By means of permutation without repetition, the swine were divided into three groups of three animals each: the ASI group, the LI group, and the PI group. Swine were housed under conventional conditions and provided with water and food. The study was approved by the Institutional Animal Care and Use Committee (IACUC) of the National Yang-Ming University and performed according to their guidelines.

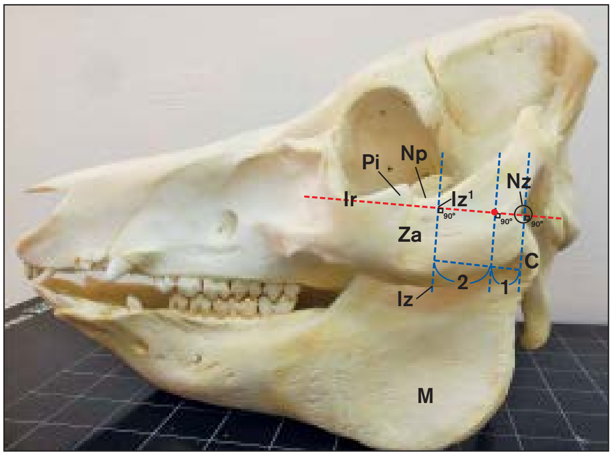

Fig 1 Sagittal view of the skull with the anatomical landmarks. Ir = inferior border of infraorbital rim; Pi = protuberance of infraorbital rim; Np = notch of zygomatic process; Za = zygomatic arch; Iz = inferior border of zygomatic arch; Iz^1 = a point at the intersection between the Iz line and the Ir-Nz line; Nz = notch of zygomatic arch; C = condyle; M = mandible.

Each swine was anesthetized with an intramuscular injection of zolazepam and tiletamine (Zoletil, 4 to 6 mg/kg, Virbac) and anesthesia was maintained with inhalation of 1.5% isoflurane (Isoflurane, Panion & BF Biotech). The swine was ventilated with tidal volume (10 mL/kg) to maintain the respiratory rate at 15 breaths/minute. A glycopyrrolate intramuscular injection (0.01 mg/kg, Glycopyrrolate, United Biomedical Asia) was used to reduce saliva. Body temperature was maintained at 38.0°C to 39.0°C.

Injection into the TMJ of 500 µL of colored dye (Stamp Ink, Liberty) was performed by means of a 21-gauge needle (Disposable syringe, Perfect Medical) under aseptic operating conditions. Both TMJs were injected in each swine.

To perform the injection, five anatomical landmarks were identified (Fig 1): the inferior border of the infraorbital rim (Ir); the protuberance of the infraorbital rim (Pi; determined by palpating the base of the temporal process of the zygomatic bone); the notch of the zygomatic process (Np; located on the upper border of the zygomatic process just distal from Pi); the notch of the zygomatic arch (Nz; located on the posterior border of the zygomatic process); and the inferior border of the zygomatic arch (Iz).

To perform the TMJ injection, the Ir and Nz points were palpated and connected by a line. Thereafter, at the intersection between this Ir-Nz line and the line perpendicular to it going through Iz, the point Iz^1 was marked (Fig 1). The distance between Iz^1 and the Nz point can be divided into three equal portions. The TMJ is located medial to the point that is two-thirds of the distance from Iz^1 to Nz (Fig 1). The insertion angulation was described in relation to the Ir-Nz line. As the injection was performed without the assistance of imaging, aspiration of synovial fluid was recognized as an indicator that the needle tip was in the superior joint space—once the needle was inserted into the joint space, joint fluid could be aspirated, thus confirming the needle position in the target joint space. Needle penetration was stopped at this point. The insertion angulation was expressed in relation to the sagittal, coronal, and frontal planes defined by the Ir-Nz line. An insertion direction from cranial to caudal or from ventral to dorsal was expressed as a positive angle and an insertion in the opposite directions as a negative angle. Before insertion of the needle (21-gauge), the skin was disinfected with a povidone-iodine solution (Y F Chemical).

Injection Techniques

Anterosuperior injection (ASI) technique. The TMJ position was identified by the point on the Iz^1-Nz line at two-thirds of the distance from Iz^1 to Nz. After the point Np was identified by palpation along the zygomatic process, the needle was inserted at Np in a dorsomedial direction with an angulation of 10 degrees in an anteroposterior direction and 60 degrees in a lateromedial direction with respect to the Ir-Nz line (Fig 2).

Lateral injection (LI) technique. The point at two-thirds of the distance from Iz^1 to Nz was marked. The needle was inserted through this point in a craniomedial direction with an angulation of 90 degrees in an anteroposterior direction and 80 degrees in a lateromedial direction with respect to the line Ir-Nz (Fig 3).

Posterior injection (PI) technique. After locating Nz as the injection point, the needle was inserted in an anteromedial direction with an angulation of –10 degrees in a posteroanterior direction from the lateral view (Fig 4a) and –80 degrees in a lateromedial direction from the bottom view (Fig 4b) with respect to the Ir-Nz line (Fig 4).

After injection, the mandible was secured to the head by means of straps to prevent any mandibular movement, which would have led to spread of the colored dye. The swine was then sacrificed by an anesthetic overdose injection and its head was cut off at the height of the first cervical vertebra and divided into two halves. Subsequently, the TMJ was exposed in order to check the dye location by trimming off the skin, cutting the anterior side of the zygomatic arch, part of the masseter muscle, the condyle neck, and the lateral pterygoid muscle. The injection was

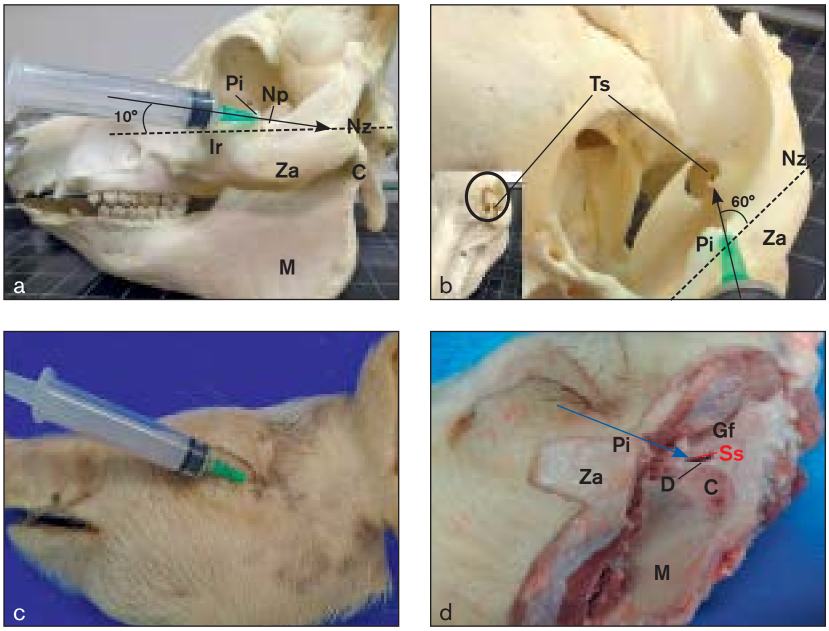

Fig 2 Anterosuperior injection technique. **(a)** Sagittal view of the skull. **(b)** Cranial enlarged view of the TMJ marked by a circle showing the TMJ space. The insertion angulation of the needle in relation to the Ir-Nz line is visible from the skull views. **(c)** Simulation of the injection. **(d)** Dissection of the swine head. The TMJ and its superior joint space become clearly visible after removal of the notch of the zygomatic arch (Nz) and the lateral part of the condyle. The blue arrow shows the injection path of ASI. Ts = TMJ space; Gf = glenoid fossa; D = disc; C = condyle; M = mandible; Ss = superior joint space.

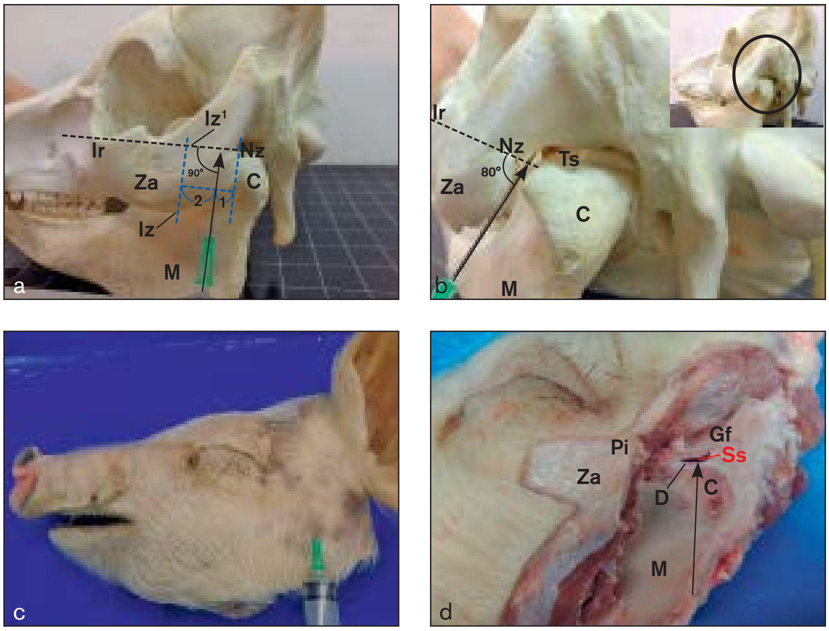

Fig 3 Lateral injection technique. The insertion angulation of the needle in relation to the Ir-Nz line is visible in **(a)** and **(b,** where circled area in inset indicates area shown in full image**)**. **(c)** Simulation of the injection. **(d)** Dissection of the swine head. Ts = TMJ space; Gf = glenoid fossa; D = disc; C = condyle; M = mandible; Ss = superior joint space.

considered successful if all the dye was confined to the superior joint space; eg, if it did not spread out into the surrounding tissues.

Statistical Analysis

Chi-square test was used to compare the success rates of the ASI, LI, and PI techniques by means of SPSS 13. The level of statistical significance was $P < .05$.

Results

The PI technique was successful in all six TMJs (success rate: 100%), the LI technique in three out of six TMJs (success rate: 50%), and the ASI technique in two out of six TMJs (success rate: 33%). The success rate was significantly higher with the PI technique than with the two other techniques (Table 1, $P < .05$).

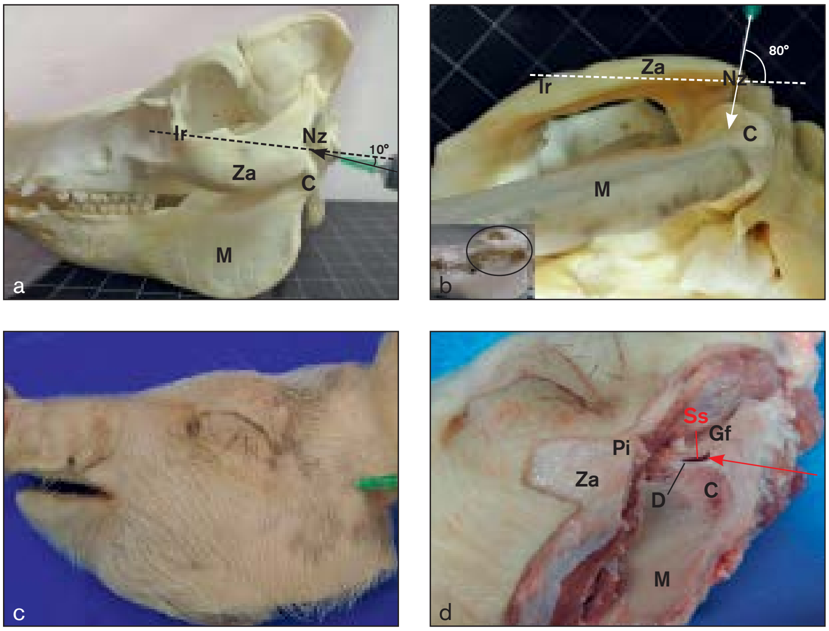

Fig 4 Posterior injection technique. The insertion angulation of the needle in relation to the Ir-Nz line is visible in **(a)** and **(b,** where circled area in inset indicates the area of bottom view shown in full image**)**. **(c)** Simulation of the injection. **(d)** Dissection of the swine head. Gf = glenoid fossa, D = disc; C = condyle; M = mandible; Ss = superior joint space.

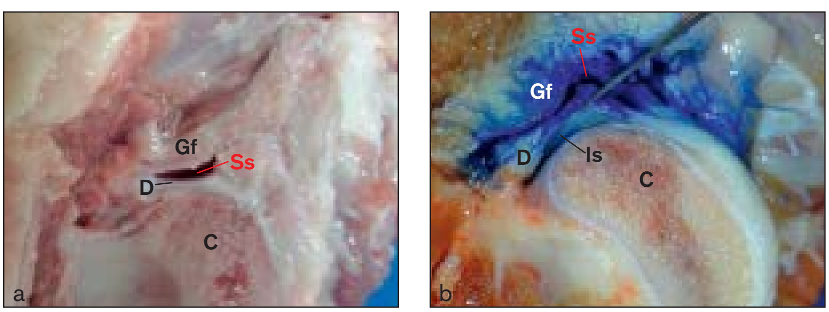

Fig 5 Sagittal view of the swine TMJ from **(a)** noninjected joint and **(b)** injected joint. Gf = glenoid fossa; Ss = superior joint space; D = disc; C = condyle; IS = inferior joint space.

Table 1 Number of Successful and Failed TMJ Injections for Each Technique

Injection technique	Number of joints	Success	Failure	Success rate
Posterior injection (PI)	6	6	0	100%
Anterosuperior injection (ASI)	6	2	4	33%
Lateral injection (LI)	6	3	3	50%

Figure 5 shows the sagittal views of swine TMJs obtained from a noninjected and an injected animal. Figure 6 shows the caudal view of dye distribution in a successful PI injection. The dye was confined to the superior joint space with a low degree of distribution in the surrounding soft and hard tissues. Figure 7 shows an example of a failed ASI. Figure 8 shows an example of a failed LI. The dye was not in the joint space, but in the temporalis muscle and surrounding tissues.

Discussion

Animal models have been widely used for inducing TMJ arthritis to assess a treatment effect. There is a recent tendency to use the swine TMJ because, when compared with other animals, this joint is more similar to the human TMJ as far as disc biochemical properties, joint morphology, and function, thus making it a better animal model for TMJ studies.[6,7]

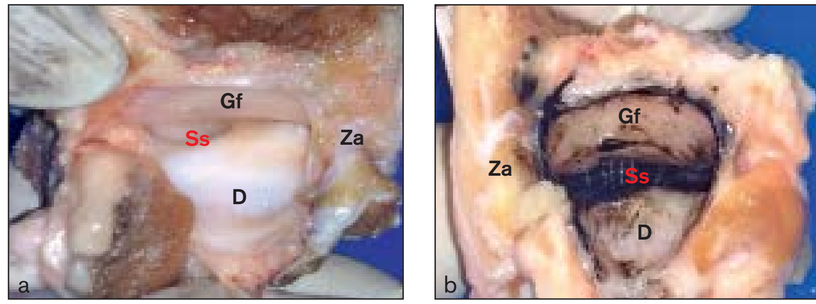

Fig 6 Caudal view of the swine TMJ showing dye distribution in a successful posterior injection. **(a)** Noninjected joint; **(b)** injected joint. Notice the dye located in the joint space and surrounding soft and hard tissues. Gf = glenoid fossa; Ss = superior joint space; D = disc; C = condyle; Za = zygomatic arch.

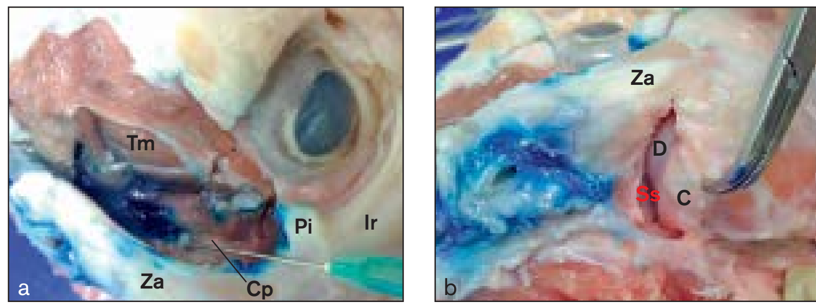

Fig 7 Dye distribution in an unsuccessful anterosuperior injection. The dye is located in the temporal muscle and surrounding tissues. **(a)** Anterior lateral view; **(b)** caudal view. D = disc; C = condyle; Tm = temporalis muscle; Cp = coronoid process; Pi = protuberance of infraorbital rim; Ir = inferior border of infraorbital rim; Za = zygomatic arch.

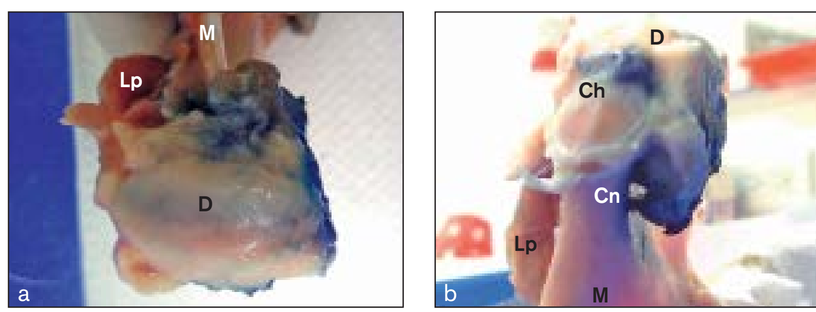

Fig 8 Dye distribution in an unsuccessful lateral injection. The dye is located in the temporalis muscle and surrounding tissues. **(a)** Cranial view; **(b)** dorsal view. D = disc; M = mandible; Ch = condylar head; Cn = condylar neck; Lp = lateral pterygoid muscle.

For a successful injection, the needle tip must be inserted into the superior joint space. There are reports on how to inject into the TMJ of large animals,[12–15] and previous studies have suggested that the ASI technique may be adequate to inject the rat TMJ.[10] However, in the swine model, this technique may adversely affect blood vessels and nerves around the eyes and induce unnecessary tissue damage. In addition, the TMJ disc may also be damaged by the inserted needle when using the ASI technique. The LI technique, normally used to access the human TMJ, is difficult in the swine because the swine TMJ is completely covered by the zygomatic bone laterally. Therefore, it is necessary to evaluate and validate the most appropriate technique to inject the swine TMJ. The present study has shown that the PI technique allowed the superior joint space to be consistently entered, thus reducing the need to perform repeated injections, which would lead to greater stress to the swine. To the best of the authors' knowledge, this is the first time that the most appropriate technique to inject the superior joint space of the swine TMJ has been determined.

Conclusions

Under the limitations of this experiment, the PI technique was successful in all cases in entering the swine superior TMJ space and was significantly more accurate than the ASI and LI techniques.

Acknowledgments

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