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# Standardized surgical approaches to ear surgery in rats

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**Abstract**

*Objective*: To describe several approaches of ear surgeries for experimental studies in rats.
*Methods*: Anesthetized rats were prepared for demonstration of various ear surgery approaches designed to optimize experimental outcomes in studies with specific goals and exposure requirements. The surgical approaches included the posterior tympanum, superior tympanum, inferior tympanum and occipital approaches.
*Results*: The middle ear cavity and inner ear were successfully exposed from different angles via the mentioned surgical approaches. For example, electrode placement for recording of cochlear bioelectric responses was easily achieved through the posterior tympanum or inferior tympanum approach. Alternatively, drug delivery or gene transfection via round window membrane was most easily accomplished using the posterior tympanum approach. Cochlear perfusion of protective or ototoxic drugs was best performed using the inferior tympanum approach. Ossicular chain interruption to induce a prolonged conductive hearing loss was readily achieved using a superior tympanum approach. Lastly, surgical destruction of the endolymphatic sac to induce experimental endolymphatic hydrops was readily performed via an occipital surgical approach.
*Conclusion*: These standardized surgical approaches can be applied in scientific studies of the ear with different purposes covering electrophysiology, conductive hearing loss, intra-cochlear drug perfusion and experimental studies relevant to Meniere's disease.


*Keywords:* Rat; Middle ear; Inner ear; Surgical approach

## 1. Introduction

As the understanding of the rat auditory system and knowledge of the rat genome increase, the use of rats in experimental studies involving the middle and inner ears has also been growing (Liu et al., 2011; Ding et al., 2011a; Wu et al., 2011; Ding et al., 2013, 2014a, 2014b; Yu et al., 2014; Fu et al., 2012; Fu et al., 2013; Ding et al., 2011b, 2012a). Experimental ear studies with rats involve placement of electrodes for recording cochlear bioelectric responses via the posterior and inferior tympanum approaches, local perfusion for inner ear gene transfection or drug delivery via the cochlea or vestibular semicircular canals, interruption of the ossicular chain via a superior tympanum approach to simulate middle ear anomalies, and endolymphatic sac ablation via an occipital approach for hydrops modeling. Knowledge of anatomy of rat temporal bone and neighboring structures is required to performed middle and inner ear surgeries in rats for these studies. This current paper provides a complete description of standardized middle and inner ear surgical techniques in rats to help researchers involved in experimental ear studies using rats.

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## 2. Anesthesia and pre-operative preparation

Health SD rats weighing about 250 g were selected and anesthetized with intraperitoneal ketamine (100 mg/kg) and chlorpromazine (5 mg/kg). The skin around the ear, neck or occipital area was prepared using iodine and alcohol, respectively, depending on the intended surgical approach. The rat was placed on a heating pad with its head secured in an adjustable frame for appropriate head positions.

## 3. Posterior tympanum approach via a retroauricular incision

### 3.1. Purpose of the approach

Along this approach, the following structures can be visualized: the posterior wall of the ear canal, extra-temporal segment of facial nerve, the tympanic bulla, the medial wall of posterior tympanum, round window and cochlear basal turn (Fig. 1). The approach therefore can be used to insert silver wire electrode into the facial canal up to the geniculate ganglion level for recording of cochlear bioelectric activities including cochlear microphonic (CM), auditory nerve compound action potential (CAP) and summit potential (SP) without opening the middle ear (Yu et al., 2014; Ding et al., 2011b, 2012a, 1993a, 1996; Ding and Jin, 1998; Wang et al., 1999a, 1996; Shi et al., 1994; Ding and Zhang, 1995; Qi and Ding, 1997). Upon opening the posterior wall of ear canal, the round wind is visible, where electrodes can be inserted for recording cochlear auditory potentials and drugs can be placed in the round window niche. The approach also allows drilling into the vestibular or tympanic scala at the basal cochlear turn for perilymphatic perfusion. Anatomy of this approach is relatively simple, and the middle ear cavity can be easily closed when needed using the nearby readily available and abundant temporalis flap. For its relative simplicity, minimal invasiveness and satisfactory exposure, this approach is frequently used in experimental animal studies.

### 3.2. Surgical procedure

The rat was placed in a lateral position on a heating pad and a 2 cm long incision was made along the retroauricular groove. Soft tissues were separated by the layer to expose the muscles. A triangular depression became visible upon pulling the pinna anteriorly and superiorly, which borders the sternomastoid and temporalis muscles and the posterior wall of ear canal (Fig. 1A). Between the temporalis and sternomastoid muscles is the extra-temporal segment of facial nerve, which extends laterally on the surface of bony posterior wall of ear canal until dividing into several branches to supply facial muscles. The shiny tendon of the sternomastoid muscle can be used to guide identification of the facial nerve (Fig. 1B). By following the facial nerve, the opening of facial canal can be exposed behind the tendon. After removing the facial nerve from the canal, a silver wire electrode can be inserted into the canal up to its horizontal segment which is separated from the cochlea by only a very thin bony wall, allowing acquisition of cochlear bioelectric signals in response to acoustic stimulation with

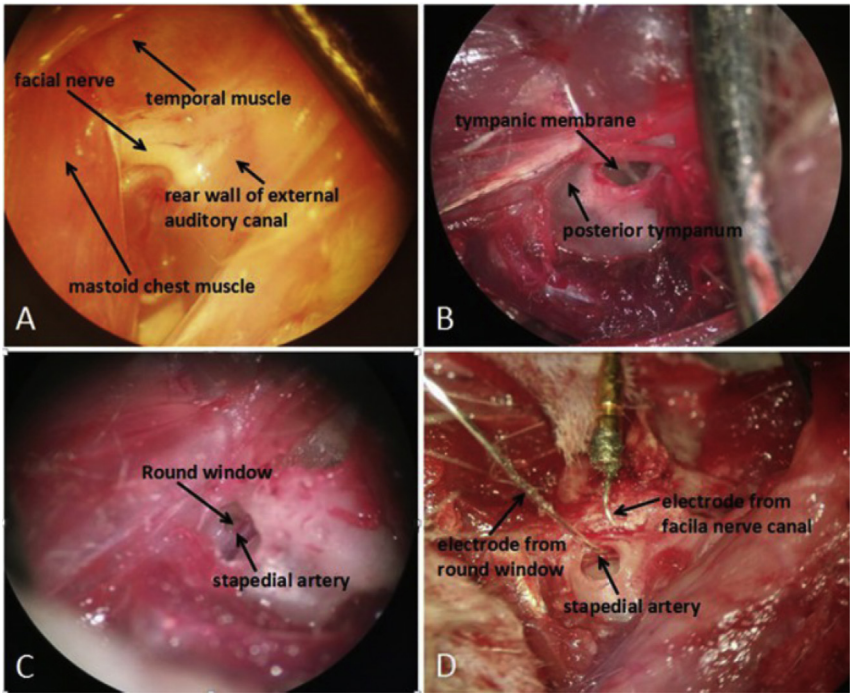


Fig. 1. Posterior tympanum approach via a retro-auricular incision. A. Subcutaneous tissue, muscles and facial nerve exposed via the retro-auricular incision. B. Lateral wall of posterior tympanum exposed following separation of muscles. C. Round window niche visible after opening the lateral wall of posterior tympanum. D. A silver wire electrode inserted into the facial canal and a silver ball electrode placed in the round window niche.