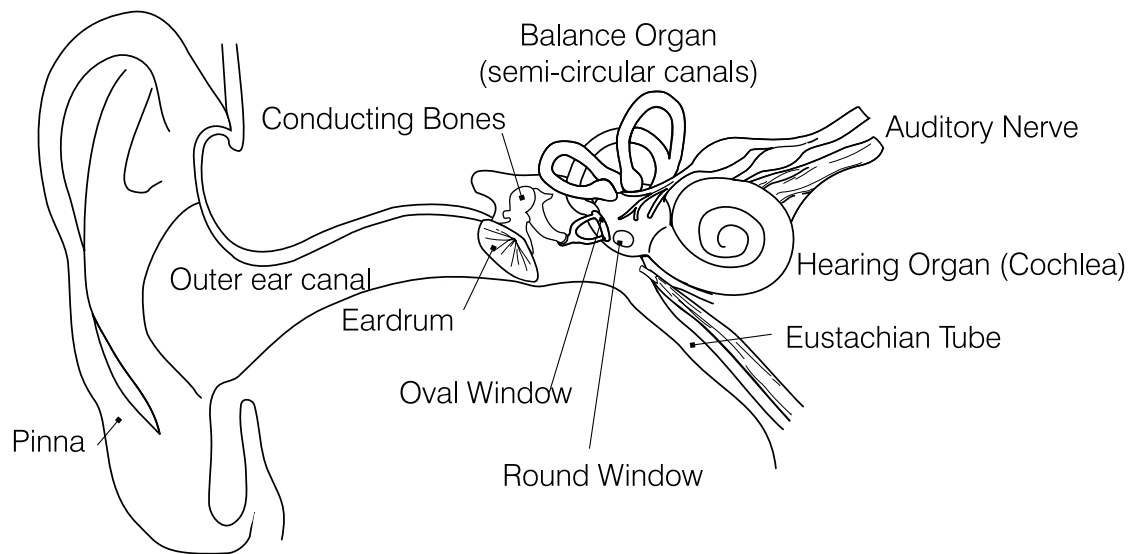


## 8 Avoiding ear injuries

Of all the diving injuries a diving doctor sees, the most common are ear injuries. An understanding of the ear will help prevent these injuries, which have the potential to delay scuba training, prevent the enjoyment of a dive and can lead to long-term damage.



*Anatomy of the ear*

### Anatomy

The ear consists of three major components, the outer ear, middle ear and inner ear. The outer ear, consisting of the external ear (*pinna*) and the outer ear canal, is separated from the middle ear by the eardrum (*tympanic membrane*). The gas-filled middle ear contains the conducting bones (*ossicles*) and is connected to the back of the throat via the Eustachian Tube. The Eustachian Tube allows movement of air into and out of the middle ear so the gas-filled middle ear to be equalised during descent and ascent. The fluid-filled inner ear contains the hearing organ

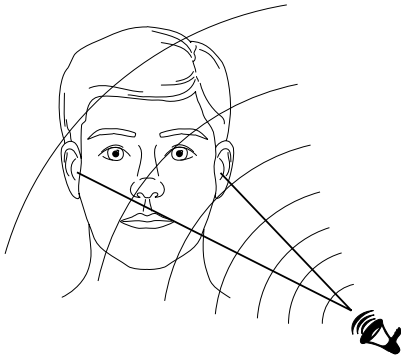
(*cochlea*) and balance organ (*semi-circular canals*).

Sound waves generated by the source of a sound are collected by the external ear and directed down the outer ear canal causing the eardrum to vibrate. The vibrations are then transmitted to the inner ear via the conducting bones, where they are converted into nerve impulses by the hearing organ. The auditory nerve then sends the nerve impulses to the hearing centre of the brain.

The oval and round windows are membranes that separate the inner and middle ear. The round window compensates for pressure fluctuations in the inner ear as a result of generated sound waves.

## Function

Both ears act together to determine the direction of the source of a sound. On land, a sound wave will hit one ear slightly before the other and our brain is able to calculate the time lag and hence determine the direction of the sound. This is known as the *binaural effect*. Underwater, however, sound travels four times faster than in air and the brain cannot distinguish the time lag between the left and right ear therefore the ability to determine the direction of sound is lost. For example, if a diver hears a boat, the exact direction of the boat cannot be determined but the changing intensity of the sound will give the diver an idea of whether the boat is approaching or not.



*The Binaural Effect*

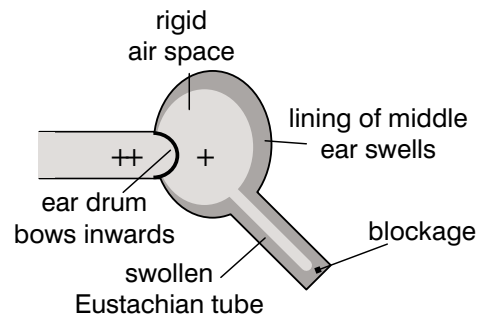
The ears are also responsible for determining balance and position in space. The fluid-filled balance organ consists of three fluid-filled tubes lined with tiny hairs (*cilia*). When a person rotates to the left and stops, the inertia of the fluid will cause the hairs to bend with the current resulting in a nerve impulse telling the person they have spun to the left. The tubes act in all three dimensions. Pressure on the feet and vertical lines determined by the eyes also contribute to our balance.

Underwater, there is a potential for loss of balance, because of the loss of the effect of gravity and the loss of vertical lines as a result of decreasing light with depth.

Balance also requires equal stimulation in both ears or rotational dizziness (vertigo) can occur causing disorientation. Different pressures in each ear can be a result of inadequate equalisation and different temperatures in each ear can result from a ruptured eardrum, allowing colder water to enter one ear and not the other, which may result in vertigo.

## Equalisation

The key to preventing an ear injury is equalising the gas space in the middle ear.



*A middle ear squeeze on descent*

During descent, if equalisation does not occur, the pressure in the middle ear becomes less than the pressure in the outer ear and the surrounding tissues. Initially, the eardrum will bow inwards and stretch to compensate the reducing gas volume. If descent is continued the soft tissue lining the middle ear (mucous membrane) will swell and can rupture, resulting in bleeding into the middle ear. This is usually evidenced by a feeling of fullness, like water in the ear, or blood in the mask at the conclusion of the dive, as blood travels

down the Eustachian Tube. This injury is known as Middle Ear Squeeze.

With further descent, failure to equalise can result in an eardrum rupture that could allow water to enter the middle ear, resulting in vertigo.

It is important to note that if not achieved immediately, equalisation will become more difficult as the Eustachian Tube is blocked by swollen mucous membranes.

There are various methods of achieving equalisation during descent (see table below) and when a suitable method is successful it should be practised regularly. Divers who have difficulty equalising their ears should regularly practise the technique that works best, or consult a diving doctor.

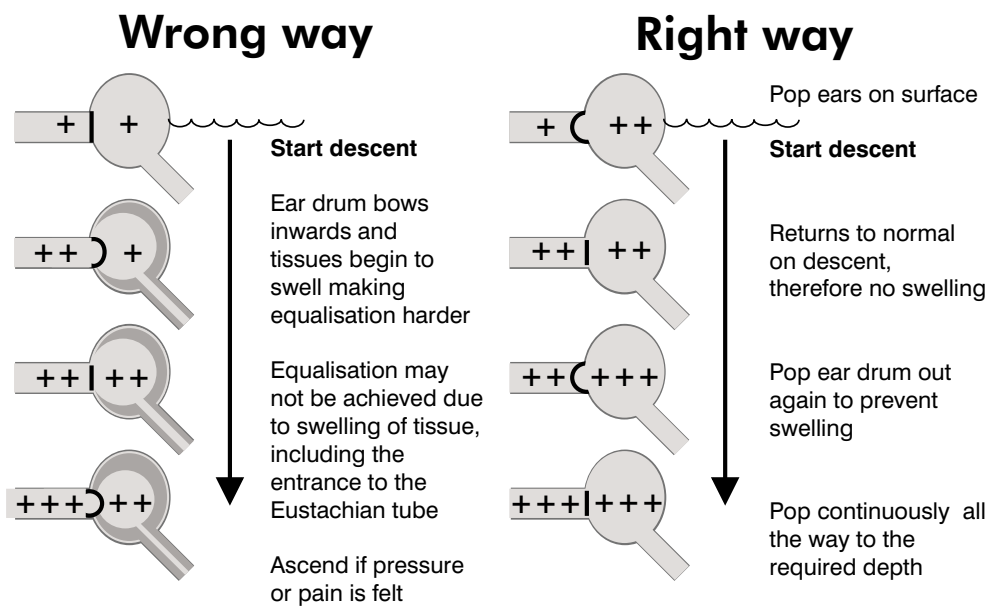
When equalisation is achieved the ears will usually *pop* or *squeak*. If one of the methods listed in the table below does not work, a diving doctor should be consulted to remedy the situation, if possible.

#### Methods for popping ears

- |          |   |
|----------|---|
| Method 1 | Pinch nostrils and <b>gently</b> blow through nose to increase pressure   |
| Method 2 | Pinch nostrils and <b>gently</b> blow through nose, wiggling jaw and/or stretching neck may help                  |
| Method 3 | Place bottom teeth in front of upper teeth, pinch nostrils, <b>gently</b> blow, and as pressure builds up swallow |
| Other    | If the above methods don't work, <b>consult</b> your instructor or diving   |

To achieve successful equalisation on descent a diver must increase the pressure in the middle ear on the surface by *popping the ears* before commencing the descent. This will cause the eardrum to bow out and as the diver descends it will return to normal, minimising the chances of the mucous membrane swelling.

If this procedure is repeated every half metre (2 ft) until the desired depth is reached then the chances of an ear injury will be greatly reduced.



*Equalising ears correctly on descent to prevent ear injury*

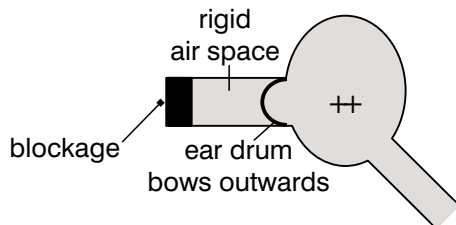
If equalisation is not achieved during descent, which is usually indicated by pain in the ear, then ascend slightly and try again. If equalisation does not occur then the dive must be aborted.

The middle ear will normally automatically equalise on ascent unless the Eustachian Tube becomes blocked as a result of diving with a cold or if any decongestants being used wear off during the dive.

Equalisation may not be achieved if a diver is a heavy smoker, is suffering from asthma, hay fever, cold, flu or any other upper respiratory infection or allergy.

### Reverse Ear Squeeze

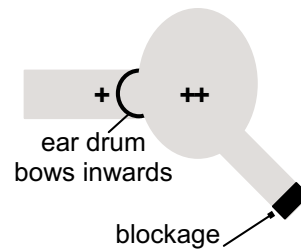
Injury to the ear can also result from a blocked outer ear because of a tight fitting wetsuit hood, earplugs or growths in the outer ear canal (*exostoses*), which create an air space in the outer ear canal that cannot be equalised. This is known as a Reverse Ear Squeeze (Page 114).



*A reverse ear squeeze of descent*

Reverse ear squeeze can also be caused on ascent when the Eustachian tube becomes blocked, preventing air escaping from the middle ear. The Eustachian tube can

become blocked during a dive as a result of a movement of mucous, difficulty equalising on descent, or a decongestant wearing off.



*Reverse ear squeeze on ascent*

### Avoiding inner ear injury

When a diver equalises it is important not to overly force equalisation as this can result in damage to the inner ear if the round window ruptures. Damage to the inner ear is recognised by ringing in the ear (*tinnitus*) and/or deafness. Suspected damage to the inner ear requires urgent medical treatment from a diving doctor to prevent permanent ringing or hearing loss.

### Avoiding outer ear infection

Outer ear infections can result from diving in pool water, freshwater, or constant exposure to seawater. These painful afflictions need to be treated promptly and a diving doctor consulted. Prevention is best achieved by using a drying agent such as *aqua-ear*<sup>™</sup> after each dive.

**Review questions**

- 1 Name the three major components of the ear.
- 2 What is the function of the Eustachian Tube?
- 3 What are the two functions of the ear?
- 4 How is hearing affected underwater?
- 5 What can cause dizziness or disorientation when underwater?
- 6 When should a diver equalise their ears?
- 7 If equalisation is not achieved during descent what action should a diver take?
- 8 List three factors, which may prevent equalisation.
- 9 What can ringing in the ears indicate and what action should be taken?
- 10 What can cause Reverse Ear Squeeze?