THE DISTRIBUTION OF HUMAN TRACHEAL CARTILAGE CHONDROCYTES

N. E. McCallion and Ruth St. C. Gilmore
Department of Physiology, The Queen's University of Belfast.

Summary

The distribution of chondrocytes in human tracheal cartilage has been examined at various ages. The cell density of the tissue declined with increasing age and at each age examined declined with increasing distance from the perichondrium, to reach a minimum in the central region of the cartilage. The minimum cell density as measured along the vertical axis of longitudinal sections from the superior to the inferior border of each ring was found at 50% of the height of the ring in a neonate, at 30% in prepubertal children and at 20% in an adult. These results suggest that tracheal cartilage is actively undergoing remodelling during growth, with the chondrocytes becoming rearranged in response to metabolic gradients and changing mechanical stresses upon the tissue.

Introduction

The stiffness of human tracheal cartilage serves to maintain tracheal patency. This mechanical property of the cartilage is a consequence of the physicochemical organisation of the matrix which makes up the bulk of the tissue. However it is not the matrix but the chondrocytes lying within it which are responsible for the growth and maintenance of the tissue.

Previous workers have studied the number and distribution of chondrocytes in non-articular cartilage from various species and sites in order to determine the relationship between these cells and the matrix surrounding them. Several variables have been found to affect cell distribution — distance from the tissue boundary is associated with variation in cell density in neonatal costal cartilage and in horse nasal cartilage. A decline in cell density with increasing age has been demonstrated in human costal and tracheal cartilage.

In this study, two methods have been used to examine cell distribution in human tracheal cartilage, while changes in cell number with age and with distance from the tissue boundary have been measured.

Materials and Methods

Specimens were obtained at autopsy from a fetus of 34 weeks gestation and from 5 cadavers aged 1 day, 9, 16, 17 and 27 years. All except the 27 year-old were male. Endotracheal intubation had not been used in the treatment of these individuals and there was no history of recent respiratory disease or local trauma. Pieces of trachea incorporating several rings above the carina were fixed in neutral formal saline, after which each specimen was divided longitudinally down the midline. The resulting pieces were processed routinely and 10 µm longitudinal sections from as near the midline as possible were stained with haematoxylin and eosin. The histological appearance of the cartilage from each specimen was noted and the vertical height of each ring measured.

Two methods were used to examine cell distribution:

Grid method: Slices of sectioned cartilage rings were mounted in a Leitz (Prado) projector with a Leitz (x 10) microscope adaptor. The sections were projected at a magnification of x 250 on to a screen which had a series of square grids of side 50 mm. The number of cells per grid square was counted using sample areas taken at 0.1 or 0.2 mm intervals along the length of the vertical axis bisecting the cartilage section (Fig. 1). As grid size and projector magnification were known, the area of matrix per cell (the reciprocal of the cell density) was calculated for each sample area. The log₁₀ values of area of matrix per cell were plotted firstly against the absolute position of each sample area along the vertical axis and then against the position of the sample area expressed as a percentage of

![Diagram](image-url)
Fig. 2—Diagram showing the matrix domain around cell X.

the total height of the ring. The latter enabled area values at different ages to be compared directly, despite the differences in absolute size of the rings.

**Planimetry method:** Similar sections were projected on to a plain screen. Chondrocytes were selected at intervals of from 0.5 mm to 0.2 mm, depending on the size of the section, along the vertical axis bisecting the specimen and the area of matrix in the immediate vicinity of a cell (X) was mapped out (Fig. 2) by cells (A-E). A line joining the positions of the nearest neighbours delineated the 'domain' of matrix surrounding the chondrocyte in question. [For a cell such as X (Fig. 2), the cell A₁ was included as a nearest neighbour when AB was greater than the mean of AA₁ and A₁B]. The area of each domain was measured using a planimeter and domain area was plotted against position as for the grid method.

**Correlation Analysis**

The data obtained by both methods were analysed further by expressing each area or domain value as a percentage of the maximum area or domain measured in that specimen. These values were plotted against the position of the cells along the vertical axis, expressed as a percentage of the total vertical height of the ring. Lines of best fit were drawn for the two sides of each graph and the slope of each line together with its correlation coefficient obtained. Appropriate 't' values were calculated and probability values deduced.

**Observations**

Upon preliminary microscopic examination the tracheal rings were seen to be ovoid at 34 weeks gestation and at 1 day of age. The sections were more elongated in the vertical axis in all the older specimens, with the internal (luminal) surface being more convex than the external one.

Chondrocytes were distributed fairly uniformly throughout the sections in all specimens. Chondro-