In Vivo Oxygen Tension in Human Septal Cartilage Increases with Age

Reuther MS, Briggs KK, Schumacher BL, Masuda K, Sah RL, Watson D
1Division of Otolaryngology – Head and Neck Surgery, Departments of 2Bioengineering and 3Orthopaedics, University of California - San Diego, La Jolla, CA

ABSTRACT

Objectives/Hypothesis:
Tissue engineered septal cartilage is expected to provide a source of autologous cartilage for repair of nasal framework defects. The production of clinically useful neocartilage involves multiple steps that include manipulating the tissue culture environment. The partial pressure of oxygen (ppO₂) is a property that has been shown to influence cartilage development. Specifically, studies suggest that low ppO₂, such as pgO₂, may influence articular cartilage development. This study described the oxygen levels in septal cartilage relative to the inferior turbinate.

Methods:
The ppO₂ was measured in 14 patients (mean±SD age, 35±1.45 years; range, 18-63 years) during routine septoplasty or septorhinoplasty using the OxyLab pO₂ monitor (Oxford Optronix Ltd, Oxford, UK). Measurements were taken from the septum and inferior turbinate as a control. Each patient’s age and sex were recorded.

Results:
The average ppO₂ measured at the septum and inferior turbinate was 10.5±0.1 mmHg (1±3.3 %) and 27.6±2.4 mmHg (3.6±6.8 %), respectively. The ppO₂ of these locations was significantly different (P <.005). Advancing age was positively correlated with septal ppO₂ (R² = .42; P <.05). Septal ppO₂ showed no significant sex variation.

Conclusions:
This is the first report of in vivo measurement of ppO₂ in septal cartilage. The data demonstrated reduced oxygenation of septal cartilage relative to the inferior turbinate. This elucidates an important characteristic of the in vivo milieu that can be applied to septal cartilage tissue engineering.

INTRODUCTION

• Cartilaginous defects created by trauma, tumor resection, and congenital deformities must be repaired with analogous material
• Autologous grafts are favored over synthetic and allogenic structures due to the risk of extrusion and immune rejection/disease transmission, respectively

OBJECTIVES

• To measure the oxygen tension of septal cartilage in vivo using the OxyLab pO₂ monitor
• To determine age- or sex-related variation in ppO₂

METHODS

• ppO₂ measured in 14 pts during routine septoplasty or SRP under IRB approval
• OxyLab probe inserted into inferior septal cartilage adjacent to maxillary crest (Fig.1)
• Inferior turbinate ppO₂ measured as a control
• Patient age and sex recorded along with ppO₂
• Paired t-test used to compared ppO₂ of septum and inferior turbinate
• Relationship between ppO₂ and age analyzed by linear regression; ANOVA used to determine the effect of age and sex on ppO₂

RESULTS

• 14 patients (7 male, 7 female)
• Mean age 35±1.45 years (range 18-63 years)
• The average ppO₂ measured at the septum and inferior turbinate was 10.5±0.1 mmHg (1±3.3 %) and 27.6±2.4 mmHg (3.6±6.8 %), respectively (P = .002)
• Septal ppO₂ significantly varied with age
  - 5.1±1.1 mmHg (0.7±0.7 %) in patients <40 years and 20.2±9.7 mmHg (2.6±1.2 %) in patients >40 years (P = .006)
  - The correlation between age and septal ppO₂ was statistically significant (Fig.2)

REFERENCES


DISCUSSION

• The oxygen concentration in human septal cartilage is relatively hypoxic when compared with the inferior turbinate and ambient oxygen levels
  - cartilage receives oxygen through diffusion from adjacent perichondrium, while the inferior turbinate is supplied by arterial arcades
• As patient age increases, the measured oxygen level also increases; however, there is no correlation between oxygen level and sex
• This age-related increase in ppO₂ is supported by the decreased cellularity found in human septal cartilage with increasing age (decreased # of cells = decreased oxygen consumption and increased levels of measured oxygen)
• This is the first report of in vivo ppO₂ measurements in human septal cartilage
  - The culture of human septal chondrocytes in a hypoxic environment will better mimic the native septal environment and may result in the production of clinically useful neocartilage constructs

ACKNOWLEDGEMENTS

This project was supported by a Veterans Administration Merit Award (D.W.) and NIH R01 AR044058 (R.L.S.)