Regen Med. 2009 Jul;4(4):539-48.

Effect of oxygen concentration, culture format and donor variability on in vitro chondrogenesis of human adipose tissue-derived stem cells.

Pilgaard L, Lund P, Duroux M, Fink T, Ulrich-Vinther M, Søballe K, Zachar V.

Laboratory for Stem Cell Research, Aalborg University, Fredrik Bajers Vej 3B, 9220 Aalborg, Denmark. vlaz@hst.aau.dk.

BACKGROUND: The chondrogenic differentiation potential of the easily accessible adipose tissue-derived stem cells (ASCs) is of particular interest within the field of tissue engineering for treating cartilage defects. However, no consensus has been reached as to which oxygen tension is more beneficial for the differentiation process. MATERIALS & METHODS: In this investigation, the impact of available oxygen was investigated to identify optimal conditions for human ASC chondrogenesis in vitro. Four physiologically relevant oxygen concentrations of 15, 10, 5 and 1% were compared with ambient air condition, and the ASCs originating from six unrelated donors were subjected to chondrogenic induction in high-density pellet cultures. RESULTS: The qualitative and quantitative assessment of accumulated extracellular matrix and the gene-expression analysis revealed marked interindividual differences, nevertheless the chondrogenic process was optimally supported in high-density pellet setup at ambient or 15% oxygen concentrations, irrespective of the origin of cells. The histochemical analysis based on alcian blue staining demonstrated that the differentiation took place in a gradient-like fashion, displaying highest levels in restricted regions, most often adjacent to the periphery. The two lowest hypoxic conditions, at 5 and 1% oxygen, seemed to have an inhibitory effect. CONCLUSION: The micropellet cultures at ambient or 15% oxygen concentration provided the most suitable environment for inducing chondrogenesis in ASCs. Furthermore, in light of the fact that the induction appeared in a zone-dependent manner, this format lends itself as a suitable model for further analysis of the relationship between chondrogenic differentiation and the gradient of nutrients.