THE ENHANCEMENT OF PERIOSTEAL CHONDROGENESIS BY DYNAMIC FLUID PRESSURE

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Introduction: Cartilage repair by autologous periosteal arthroplasty is enhanced by continuous passive motion (CPM) of the joint after transplantation of the periosteal graft in periosteal arthroplasty (1). However, the mechanisms by which CPM stimulate chondrogenesis are unknown. Based on the observation that an oscillating intra-synovial pressure fluctuation has been reported to occur during CPM (0.6-10 kPa) (2), it was hypothesized that the oscillating pressure experienced by the periosteal graft as a result of CPM has a beneficial effect on the chondrogenic response of the graft. We have developed an in vitro model within which dynamic fluid pressures (DFP) that mimic those during CPM can be applied to periosteal explants while they are cultured in agarose gel suspension (3).

Materials and Methods: In this study periosteal explants were treated with or without DFP during suspension culture in agarose, which is conducive to chondrogenesis. Different DFP application times (30 min, 4 hrs, 24 hrs/day) and pressure magnitudes (13 kPa, 103 kPa or step-wise 13 to 54 to 103 kPa) were compared for their effects on periosteal chondrogenesis (Fig. 1). All work in this study was conducted with the approval of the Mayo Clinic Institutional Animal Care and Use Committee.

Results: Low levels of DFP (13 kPa @ 0.3 Hz) significantly enhanced chondrogenesis over controls (34 ± 7% vs. 14 ± 5%; p<0.05, Fig. 2a), while higher pressures (103 kPa @ 0.3 Hz) completely inhibited chondrogenesis, as determined from the percentage of tissue that was determined to be cartilage by histomorphometry. Application of low levels of DFP to periosteal explants also resulted in significantly increased concentrations of Collagen Type II protein (43 ± 8% vs. 10 ± 5%; p<0.05, Figure 2b).

Discussion: These observations may partially explain the beneficial effect on cartilage repair by CPM. They also validate an in vitro model permitting studies aimed at elucidating the mechanisms of action of mechanical factors regulating chondrogenesis. The fact that these tissues were successfully cultured in a mechanical environment for six weeks makes it possible to study the actions of mechanical factors on the entire chondrogenic pathway, from induction to maturation. Finally, these data support the theoretical predictions regarding the role of hydrostatic compression in fracture healing.


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