Clin Orthop Relat Res (2008) 466:2015–2016 / DOI 10.1007/s11999-008-0321-5

Published online: 3 June 2008

50 Years Ago in CORR

Physiologic Basis of Bone-Graft Surgery

Marshall R. Urist MD CORR 1953;1:207–216

Bone graft surgery has a long and at times controversial history. According to Bick [1] bone grafts were vaguely noted in early Hindu, Egyptian, and Greek sources, but the first clear description was from 1682, when Jobi Meekren replaced a skull defect in a soldier with pieces of a dog's skull. John Hunter experimented with various sorts of grafts, but the major debates began in the late 1800s with the experiments of Ollier, Duhamel, and others [4]. Lexer, in this month's republished Classic from 1908 [5], reported success in a number of patients using fresh allografts; he took grafts mostly from elderly patients undergoing amputations for dry gangrene from vascular disease (evidently quite common at the time). However, Bick suggests most clinical cases were unsuccessful until about 1910 [1]. Most of the subsequent successes appear to have been autografts taken from the same patient.

Marshall Urist, the second Editor-in-Chief of Clinical Orthopaedics and Related Research (1966–1993), had a particular life-long interest in bone grafting. In the article we highlight this month [8] he reviewed the experimental evidence on the various mechanisms influencing success and failure of autografts, allografts (homografts), and zenografts (heterografts or grafts from other species). Urist noted "at least 9 different types of bone-graft materials…in clinical use…(1) osteoperiosteal bone, (2) autogenous cancellous bone, (3) autogenous cortical bone, (4) boiled autogenous cancellous or cortical bone, (5) homogenous fresh cancellous or compact bone, (6) frozen or lyophilized (frozen-drive) homogenous cancellous or cortical bone, (7) fresh or frozen heterogenous (calf) bone, (8) chemically preserved homogenous cancellous or cortical bone, and (9) homogenous or heterogenous embryonic bone" [8]. In our symposium this month, one can find an array of studies on several of these sorts of grafts, most of which are still in use or at least studied in various places in the world.

Urist [8] emphasized the importance of "induction": "the physical-chemical effect which one tissue exerts upon another in contact with it." The literature he cited (including some of his own) strongly supported such a concept, but he noted, "Induction…appears to be a more complex mechanism than a direct humoral effect of a diffusible chemical substance…Isolation or characterization of 'inductor substances' from extracts has not been satisfactorily accomplished…and may not be possible until further knowledge of the process of endochondral ossification…and endosteal bone formation…has been gained from experiments…" However, through a variety of experiments [2, 3, 7, 9, 12, 14–16], Dr. Urist eventually did exactly that: isolate and characterize the inductor substance in bone graft [6, 10, 11, 13, 14, 17]. What all of these grafts appear to have in common is this inducing protein—"bone morphogenetic protein" or BMP—one which is remarkably conserved across species.

There is a vast literature on bone grafting: using the search term "graft[ti] AND bone[ti]" in PubMed yielded 3580 articles, and these are obviously do not reflect the entire literature. While this month's symposium reflects crucial ongoing research to identify the best ways to use bone grafts, autografts and allografts are remarkably safe and effective for many applications, thanks to the efforts of hundreds of individuals exploring the techniques of procuring, processing, and applying these grafts.

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50 Years Ago in CORR

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