Fifteen Years of Clinical Experience with Hydroxyapatite Coatings in Joint Arthroplasty
Jean-Alain Epinette, MD
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Preface by Rudolph G.T. Geesink, MD, PhD
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Foreword

Ronald J. Furlong of the United Kingdom performed the first clinical implantation of a hydroxyapatite-coated (HA) hip implant in 1985, about 18 years ago. This was followed in 1986 by other HA clinical implantations conducted by the ARTRO Group in France and Rudolf Geesink in the Netherlands. Following these pioneers, many thousands of HA-coated hip implants of various designs, from various implant manufacturers, have been implanted worldwide, by many surgeons at many institutions. The coating technology has expanded to include the revision setting in the hip, as well as unicompartmental knees, total knees, shoulders, and an assortment of minor joint implants.

In the early 1990s, we were both involved in the compilation of texts summarizing the application and function of hydroxyapatite coatings, together with the findings of favorable bone adaptation and favorable biological response to the material achieved in vivo. These volumes, Hydroxyapatite Coatings in Orthopaedic Surgery, Rudolph G.T. Geesink and Michael T. Manley eds. Raven Press Ltd 1993, together with Hydroxyapatite Coated Hip and Knee Arthroplasty, Jean-Alain Epinette and Rudolph G.T. Geesink eds. the French Orthopaedic Society 1995, included the early clinical results with hydroxyapatite-coated hip implants that were the results available at the time of writing. Since the publication of these volumes, many reports of clinical results with HA-coated hip implants and HA-coated knee implants have appeared in the orthopaedic literature. Clinical follow-up of about fifteen years is available now in the hip, and ten years follow-up is available in the knee. With host response data of fifteen years now available, we felt that the time was right to ask various investigators worldwide to report the current clinical results with their HA-coated implants of choice, and then to collect these manuscripts into a single volume. We trust that this compilation of results will answer the question of whether the favorable results achieved in the short term with this method of biologic fixation of total joint implants has withstood the test of time.

Our thanks are due to the authors of chapters in this volume for the effort they made to write and submit their work to us in a timely fashion. These authors, working in Europe, the United States, Japan, and Australia, do not all use English as their first language. Many made great efforts to provide us with English language documents. Where we felt the language was unclear, we made only those minor changes needed to facilitate understanding. For manuscripts submitted in a language other than English, we employed professional interpretation, and then made editorial changes if the content was unclear to us. We trust our editorial efforts have not changed the intent of the authors. In addition, each member of our Scientific Committee used their expertise to give further feedback to us. We wish to congratulate and thank each of them for this effort on our behalf. We also wish to thank Kate Sutton, MA, for her many hours of work in editing the copy of our volume. Without her help, we would never have finished this task.

Finally, we should state that results with implants manufactured by many companies are included in this volume. Our intent was simply to determine if the use of hydroxyapatite coatings for the fixation of orthopaedic implants to bone, so fascinating to us in the late 1980s, has been proven by the survivorship and satisfaction of those patients receiving hip and knee implants of the various designs described herein. We trust this monograph will be of value to researchers and to orthopaedic surgeons interested in joint replacement, and will allow them to form their own educated opinion about the utility of hydroxyapatite coatings for implant fixation.

Jean-Alain Epinette, MD
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By the authors' request, all royalties will be given to "Médecins Sans Frontières-Doctors Without Borders".
Preface

Total hip arthroplasty has been with us now for more than forty years. Since the pioneering years of Sir John Charnley, significant improvements have been achieved through better understanding of the inter-relationship between biomaterials, biomechanics, and biology. For example, structural improvements in the cement mantle were derived as cementing technique evolved from first generation to third generation methods. Modern cemented total hip arthroplasty now gives us excellent clinical results and long term implant survival, especially in elderly people. For younger patients, improvement in implant longevity was more difficult to achieve. Demands from ever younger and more active patients tended to exceed the limited mechanical properties and lifetime of acrylic bone cement. This limitation stimulated the development of alternative cementless techniques of implant fixation.

The first generation of cementless fixation included plain press-fit type implants. Without sufficient biological anchoring in bone to counteract the load-bearing forces imposed by patient activity, micro-motion between implant and bone caused bone resorption which contributed to complete implant loosening. However important the geometrical design of the implant may be for the initial mechanical stability of the implant in the bone, some type of stable implant-bone interface was necessary to prevent implant-bone micro-motion.

Fixation by bone ingrowth into porous-metal coatings was a development of the 1980s. Theoretical and experimental foundations were very promising. Pioneering work by Pilliar and Engh in the United States as well as Boutin, Judet and Lord in Europe contributed much to the development of cementless implants. These authors reported successful applications in many patient populations, but emphasized the need for accurate instrumentation and surgical technique. Generally, clinical results using porous-metal coatings were however rather variable and sometimes disappointing because of bead shedding, thigh-pain and unacceptable loosening rates. The causes of loosening were to be found in the inadequate biological profile of the materials involved, although this has improved considerably in the last decade. Bone ingrowth using porous-metal coatings takes a long time period for implant stabilization. Accuracy of bone preparation and immobilization of the implant in the bone during the ingrowth period was critical to success. Improved biological surface characteristics were needed to overcome these problems.

About twenty years ago, the interesting biological profile of calcium-phosphate ceramics and its potential for implant fixation became evident, at first in dental implants, later on in orthopaedics. Through the pioneering work of Klaas de Groot of the Leiden Biomaterials Research Group, the hydroxyapatite coating technique was adapted for orthopaedic applications. Experimental studies were conducted by the author proving the excellent capability of calcium-phosphate coatings to provide a stable bony interface even under less than optimal conditions. Within the large group of calcium-phosphate materials, hydroxyapatite was and still is the most attractive choice because of its natural occurrence in bone, its well-documented biocompatibility and its reliability in establishing a stable bony interface in vivo. First human applications of HA-coatings in orthopaedics were reported both by Furlong and by me in 1986. Since 1987 I have enjoyed a close collaboration with Jean-Alain Epinette, one of the pioneers of HA-coatings in France. Other study teams originated in France, such as the ARTRO and ABG groups, also made significant contributions to the use of HA-coatings in orthopaedic surgery as did Michael Manley in the US. Current follow-up data suggest that HA-coatings can indeed retain reliable long term implant stability and function. The clinical results remain excellent up to current 15 year follow-up and pain rates remain very low.

Over the past two decades, numerous studies have provided an almost exponential increase in knowledge on HA-coatings in orthopaedics. This book is a welcome summary of the work so far. Some controversies still remain. Should coatings be easily resorbable or more permanent, should they be thick or thin, single phase or multiphase calcium phosphates? Today we know that HA-coatings will be transformed by osteoclastic activity and actively take part in the bone remodelling process of the bone around the implant. We know that thin (50-60 micron) HA coatings are very gradually degraded over a long period of time and the body can easily cope with the physiolo-
gical material released without any tissue overload by debris and risk of osteolysis. We know that thicker coatings may suffer mechanical delamination from the implant in a short time period. We do not know if the clearance mechanisms are able to remove this debris or whether (as animal data suggests) the debris simply becomes encapsulated by bone. Some of these answers only may become apparent after many years of clinical follow-up with proper documentation of results. We know now that with the thin HA coatings, clinical results, bone adaptation and implant survivorship remain excellent at twelve to fifteen year follow-up. Only time can tell us whether this favorable trend will continue into longer term (twenty plus years) results. May this book provide a moment of contemplation on current knowledge before we continue our journey to further perfection of artificial joint reconstructions.

Rudolph GT Geesink MD, PhD
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