Total joint replacement : on innovation, ambition, courage, irony and morsellized bone, of course

TOTAL JOINT REPLACEMENT:
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"Skepticism is the first step on the road to philosophy" - Denis Diderot.
A sensible Russian expression reads "If you're unhappy, reduce your wishes, and you're happy again." Try it; it always works. Unless, of course, ones bread and butter is the innovation of, say, Total Joint Replacement. There is a revealing anecdote afloat in orthopaedic circles, allegedly created by Shelley Simon (an American Orthopod) when asking Peter Walker (an English professor of Bioengineering) one day what occupied his mind at the time. Truthfully, Peter answered he worked on a new knee prosthesis. "A new knee prosthesis?" Shelley replied in astonishment, "But why? The problem is solved; you solved it yourself!" This assessment of the state-of-the-art in TKR might have left Peter unhappy for a while, an issue the anecdote does not reveal. In any case, innovators, in contrast to the Russian wisdom, rather tend to increase their wishes in order to find happiness. The question is, is there still room for such ambitions in TJR?

The doubt whether the problems of knee - and hip - replacement are now basically solved is very relevant today. There is a general awareness among Orthopods that cemented joint replacement provides reproducible results and acceptable failure rates - based on good reasons. Despite the hype in noncemented innovations during the last decade, the motion pro cement would, if put to a vote, find a large majority. In fact, the recent decade has witnessed the downfall of the innovative process regarding prosthetic development, as a number of experts, including myself, have argued in recent years. There might be a truly perfect jewel among all the junk created, but if that is the case, there is no real opportunity to establish its identity objectively at the present time. Isn't it a matter of supreme irony, that after all the money, time and creative activity spent, the vintage Charley prosthesis is still documented as the most successful hip replacement, and the Total Condylar as the best knee?

The failure of the innovation process and its consequences for the patients involved also introduced the decay of the 'cowboy' era in orthopaedic technology, when patients were considered as the experimental animals of choice. We all know now that the archaic 'trial-and-error' innovation procedures became extinct, are no longer ethically justifiable. Every new prosthetic feature must be pre-clinically tested for safety and efficacy before used in a patient. If its unworthiness is not exposed by stern computer-simulations or laboratory bench tests, it may be

verified in limited clinical trials, using RSA to detect even the smallest motions which, once established, will cause the innovative prosthesis to subside into the drawer; for good. In the unlikely event that it stays put, it's time to find out whether the orthopaedic community at large is apt to handle it, in well-documented prospective, paired, multi-center clinical trials. The investor is about to receive the first returns on a fortune spent. When all goes well, we're not there, yet, though. What follows is post-marketing surveillance in the Swedish Register. The orthopaedic community outside Sweden is recommended not to acquire the new design until it has proven to endure, relative to the golden Charnley standard, for some ten years. Such is the strategy for a responsible, scientifically accountable, step-wise introductory procedure of innovative TJR.

Are you still there, reader? Yes, indeed, my own eyelids were getting heavier, too. Who wants to innovate on these terms? And then, oh irony, the chances of getting better survival rates than the Charnley are so slim, that if it does, it'll be nearly impossible too proof with statistic significance within a period of 10 years, as Peter Herberts led us to believe, after doing his sums. The best an author can realistically hope for is that his product will not be provable worse. It may not be worth our while to improve upon a proven concept.

"The very substance of the ambitious is merely the shadow of a dream" - Shakespeare.

Shouldn't we, innovators, just quit? Call it a day, turn our collars to the wind and wander out towards new horizons? But that would mean defeat, wouldn't it? Because, despite the lack of significant clinical improvements, cemented TJR is all but perfect. Think of the archaic process of cementing, the tampering with the slimy stuff in the operating room; imagine the carpentry of the bone itself, joyfully shaking with the motions of the rasp; envision the placement and cement-curing phases, the sense of timidity it creates, a feeling not dissimilar to what most golfers experience when approaching the green. Artistic, surely, but perfect? While working on our Acta Supplement "Quality Assurance of Joint Replacement" Lauri Faro once suggested we might rather regulate the surgeons, instead of the prostheses, in order to ensure safety and efficacy of TJR. That should not be necessary. There are no fools in Orthopaedics, naturally, but TJR should be fool-proof nonetheless. How to do that? Well, that's the challenge, isn't it? Robotic-enhanced surgery? The shadow of a dream.

Think of the cement itself, a material appropriate for filling holes in the walls of a garden shed, but basically too weak to endure the joint forces of daily living for an adequately prolonged period of time. It produces heat, shrinks, debonds, abrades, degrades and accumulates micro-cracks, in that sequence, and finally gives way. Its eventual doom can only be deterred through a timely death of the patient. It should be our ambition to replace it with something better. That this is

not a trivial matter was illustrated by the many who tried in vain. But still, a goal it must be. Biological coatings, morsellized bone? Who knows; but the ultimate future of TJR will be one without cement; it's inevitable.

Think of the polyethylene, how nicely it shines, how effective it is for making little bags in which to carry our sandwiches to work. Imagine how convivially they litter the forests after the Sunday picnic; they last forever, indestructable. But for a load carrying joint implant to endure for, say, 20 years? Safety belts should be enforced when running on such a material. No, I don't know anything better, either, but that's not the issue. The point is that contemporary TJR is far from perfect, despite our gloating over Swedish survival rates.

"Writing free verse is like playing tennis with the net down" - Robert Frost.
On travels I tend to meet Orthopods and Bioengineers, innovators by nature, scheming for hours, in pairs, red ears and excited voices, involved in the details of their new designs. Interesting people; creative, resourceful, responsible, visible, eloquent, socially engaged in the field; I enjoy their company. The question why this new prosthesis is being developed, however, what problem it is meant to solve, usually brings nothing but oblivious glassy-eyed stares. Innovators, it seems, are much like mountain climbers; any variety feasible must be tried, any invention applied. Where climbers tend to be restrained in their enterprises at least by the limited availability of funds, the orthopaedic industry is not reluctant to gamble in the orthopaedic roulette called 'Chasing the Charnley'.

The truth is that most of the innovations introduced in the last decade are incremental adaptations, variations on a theme. A way to brighten up your day is to ask a sales-person concerned what these variations are for; they don't know, basically. It's not that they're dense or inarticulate, they just haven't been informed. The problem is, no one knows. In the industrious, convivial, unregulated game of TJR innovation the players produce one solution after another, but the code which ties these to the problems we all know seems to have gone astray. A game without rules, hence with no winners.

Let's leave this stage for a moment, reader, and sit down to think. If we worship new solutions, the first priority is the identification of problems deserving our attention. I mean, if we want to be heroes, we need heroic goals; saving the ants in the garden may be commendable, but it won't do much for fame. If the Charnley is perceived by the masses as the solution of its typical problems, so be it. Let's leave this alone then, for the time being, and concentrate on alternative issues like, for example, its untypical problems. There are two of those in this field, actually, the very young patient and the revision. That these are indeed problematic is illustrated by the fact that many Orthopods will simply ignore them, pretending they don't exist, or hoping the ill-fated concerned will move elsewhere. But let's forget about the meek and rather talk about heroes, for a while.

"There is no darkness, but ignorance" - Shakespeare.

Revision surgery is a problem from several perspectives. Where many Orthopods ignore its existence, as said, health-insurance organizations refuse to fund it. Which is cause and which effect in this matter I can't say, but true it is. So their treatment is left to the altruistic, of which the orthopaedic field probably has as few as any other one, or the truly ambitious.

The second problem, partly an effect of the first, naturally, is its common postponement, not in the least because of the hesitation ruling both surgeon and patient. Known socially as a lay - hence approachable - person with orthopaedic connections, I'm frequently asked for advise concerning the wisdom of particular treatment modalities suggested to patients by their surgeons. My ground rule for such unbillable consultancies is that the ailed should postpone elective surgery as long as humanly possible - people tend to like that recommendation, by the way; it's obviously the easiest one to follow, it establishes my independence from the medical community, hence also their own shrewdness in asking me, and exposes the shameless advancement of the surgeon's own business interests which, completely undeserved of course, confirms their own perception of this professional field. Anyway, revision surgery is the exception to my rule. Revision surgery is like the enjoyment of wealth, there's really only one sensible moment to do it: now.

But, like I said, it's usually done too late, so the bone has withered, which introduces the third problem. As any carpenter knows, one can't have ones wood eaten by wood-worms and have it, too. In restorations of antique furniture the replacement of bad wood is commendable, be it only to prevent grandma rolling in the fireplace at the next Christmas reunion. The same principles rule revision surgery. Revision surgery can be considered as the "continuation of joint replacement with other means", paraphrasing von Clausewitz on a statement he never made, or rather never meant, as I heard recently. Anyway, our problem here is "what other means?". Food for real innovators.

"Heroism feels and never reasons and therefore is always right" - Ralph Waldo Emerson.

In the late Seventies, Tom Slooff, whom you all know, decided to try a solution to this problem. Forcefully, he crumbled excised trabecular bone - the word morsellized had not been coined as yet; in fact it's still not carried by Webster (1996) - obtaining a biological analog of 'yoghurt with muesli', and used it to repair a leaking acetabular roof, blended it with cement - as some people foolishly put whipped cream over their yoghurt - pressed the acetabular component in and let the cement cure. Miraculously, the patient survived and marked the onset of an exceptional success story, referred too, no doubt, many times in this same book. Conceived some 19 years ago, revision surgery with cement-blended morsellized

bone grafts is now the talk of the town in orthopaedic circles. Tom Slooff invented it, and anyone suggesting otherwise may be kicked in the butt on my behalf.

Courageous, certainly. I didn't believe in it at all, at the time. I can bring up my relative youth and lack of biological background in defense, but the truth is that I was notably shortsighted in this matter. I couldn't fathom this muddy substance to withstand the forces. But it did. The clinical results were promising and Tom considered to use it for femoral revisions as well. Sleepless nights is what it gave me. I convinced him to try it out in goats first, poor animals. Unfortunately he consented; good for my faith, valuable scientific data and those sorts of things, and a laudable PhD thesis for Wim Schreurs, his successor; all benefits, granted, but had he not consented, he would have been at it much earlier than the Exeter group, and the method might have been known under another name. I still blame myself for scorning the enchantment of adventure. But then, of course, Tom's the surgeon, I the scientist; engineers and poets, innovators and contemplators. There's a lesson here, no doubt.

There was another lesson in this experience for me, and I will come back to both below. Let me first say that the behavior of the graft material in all kinds of animal experiments was amazing. Revascularization occurred quickly, throughout its volume, followed by remodeling and graft incorporation. Although some failures were seen in animal hip replacement, by-and-large secure fixation was obtained. It seemed, however, that the initial stabilization of the morsellized-bone substance with cement was important; noncemented prosthetic components tended to loosen in an early stage. So there we were, the biology *can* put it right, if only the proper conditions are created.

Morsellized grafts became a focus of clinical and scientific attention in our department. Its applicability for knee revisions and the restoration of bone loss in avascular necrosis are investigated, and its behavior under the influence of variable forces and morphogenetic agents is studied in animal models. The main targets now, of course, are to know how it works, to specify the optimal conditions for the graft, and to unravel the factors that can make it fail. This information could engender better reproducibility and promote applications for other purposes. What a happy ending to an heroic enterprise.

"Rules and models destroy genius and art" - William Hazlitt.

So what about ethical considerations? What about pre-clinical testing and step-wise introduction of TJR innovations? Aren't we doing things in a reversed order? Weren't the patients the first experimental animals? Reluctantly, I can only admit it, but I have two arguments for our defense. First, there was no reliable treatment for revision patients. Just as there was no effective treatment for coxarthrosis and the like in Charnley's time. So experimentation with revision patients was ethically defendable. Second, and I hate to admit it, this is probably the only realistic route

towards real innovation; I'm talking about significant novelty, of course, not about an alternative bend in a hip stem or a fold in a cup. You see, if it had not been established clinically that this method might work, it would probably never have emerged. In the reversed order, the ethically 'correct' one, we would still be researching the method, ever coming up with more questions. Such is the role of the natural sciences, of course, to unravel the workings of nature in ever refining detail. It is the function of technology to innovate. It takes an engineer, such as an orthopaedic surgeon. Science is useful when it comes to explaining why things do or do not work, or for providing the information required to carry a new method towards perfection. Scientists are no inventors by trade, they provide knowledge, useful or not.

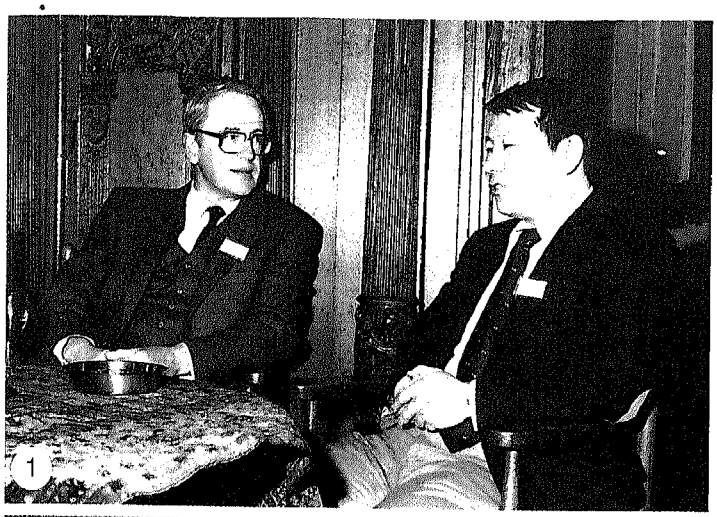
I still stand by all I've written about pre-clinical testing and step-wise introduction of innovative TJR, unabridged. It's an excellent framework for protecting patients, and the orthopaedic community at large, against commercia and its innovative allies. But regulation and innovation are adversaries by nature. To really get ahead in surgery it still takes 'cowboys', despite the change in culture. Whether their actions are justifiable is appraised only by success or failure.

"Science is the knowledge of consequences, and dependence of one fact upon the other" - Thomas Hobbes.

Orthopaedic surgery implies "...providing the mechanical and biological conditions to the tissues which allow them to heal, adapt and maintain themselves..." has become one of my favorite statements. Morsellized bone grafts fit very well in this concept. In fact, the conception of the notion itself was very much inspired by the experience with these grafts in our research program. Biology *can* put it right, if only provided with the proper stimuli; what a challenge for an orthopaedic scientist. What a contest to unravel these stimuli, define them, measure them, model them, and then apply the information in what is now called the science of 'Tissue Engineering'. The science which provides the knowledge for having cells produce and maintain musculoskeletal tissues with just the right mechanical properties their functions require. 'Mechano-biology' we've re-baptized our research program, precisely to emphasize that excitement. Who knows, we may be able to solve the problems of the young patient as well, in the future, and rid the orthopaedic community of cement.

Tom Slooff will leave us with a method that seems to revolutionize TJR revision surgery, and maybe has solved its problems for good. But he also leaves interesting questions behind. To a philosopher, this appears even more important.

Nijmegen, 22 december 1996



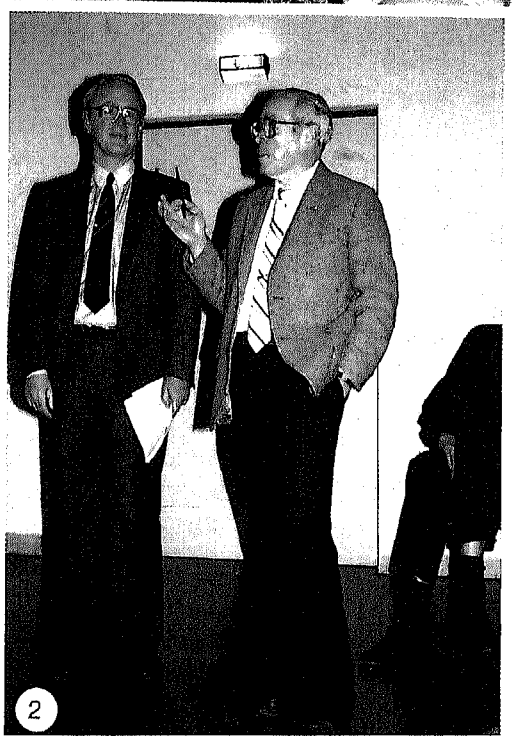


Fig. 1: In 1982, with Ed Chao, during the Conference Banquet, 3rd Congress of the European Society of Biomechanics. First reports on morcellized grafts?

Fig. 2: In 1984, with Bill Harris, two heroic innovators. Massive versus morsellized grafts?