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EDITORIAL

In Memoriam: The Matrix Coil

W.J. van Rooij, M. Sluzewski, and J. Peluso

In this issue, the results of the Matrix and Platinum Science (MAPS) trial provide level 1 evidence that there is no beneficial effect of the polymer-modified Matrix detachable coil (Stryker, Kalamazoo, Michigan) over standard platinum coils in the recurrence rate of coiled intracranial aneurysms.[1] Although several previous studies indicated similar results,[2-4] this MAPS trial is the death blow for the "bioactive" coil. This is good news for patients and hospitals because the spilling of money by the excessive costs of these coils can now be avoided without compromising patient care.

It took the neurointerventional community more than 10 years (and many millions of dollars) to prove that a marketing concept launched by Boston Scientific (now Stryker) does not hold true in clinical practice. The history of the Matrix coil started in the beginning of this millennium. When the initial monopoly of Boston Scientific with the Guglielmi detachable coil ended with the introduction of similar coils by other manufacturers, Boston Scientific developed the concept of "bioactive" coils to regain market share. The Matrix coil was introduced, and this coil was coated with a bioabsorbable polyglycolic/polylactic acid (PGLA) polymer that was intended to accelerate neointimal healing at the neck of the aneurysm and thus was believed to provide a more stable occlusion at follow-up. The choice of this PGLA coating was primarily to get the device past regulatory hurdles and onto the market. Proof of efficacy of biologic activity was not a priority. PGLA is widely used in sutures as Vicryl (Ethicon, Cincinnati, Ohio) and has an excellent safety profile in humans. With this in mind, Boston Scientific managed to pass the regulatory process of the US Food and Drug Administration by claiming that Matrix was "substantially equivalent" to platinum coils. Although this obtained FDA approval was based on equivalency, marketing that followed was not. On the contrary, Matrix was marketed as a revolutionary new device.

After testing the coil in a few swine,[5] Matrix was launched as a new concept: Instead of aneurysm thrombosis following mechanical disruption of the intra-aneurysmal blood flow, Matrix would provide a durable biologic healing by improved neointimal proliferation and fibrosis. The marketing machine went off on full throttle, heavily supported by several of our peers. The concept of accelerated healing of aneurysms with significantly lower recurrence rates was very appealing, and many physicians started to treat their patients with the new Matrix coil, despite it being almost double the cost of standard coils.

In the meantime, a registry of 100 aneurysms was launched by Boston Scientific to provide extra arguments on sales (Acceleration of Connective Tissue Formation in Endovascular Aneurysm Repair [ACTIVE]). However, the results of this registry were not better than could have been expected from standard coils. On the contrary, many aneurysms were not immediately completely occluded, resulting in an alarmingly high early rebleeding rate of 7% (3 of 41 ruptured aneurysms). In sales meetings with potential Matrix users, the results of this registry were deliberately misinterpreted.[6] Even after published criticism on these misleading interpretations,[7] Moret and Viñuela persisted in peculiar explanations of the results in favor of the Matrix coil.[8] The disappointing findings of the ACTIVE registry have never been published. The marketing machine soon got overheated. At meetings and in scientific reports, the "proof of concept" was repeatedly illustrated: Many physicians reported a white band between the coil mesh and the parent artery called the "white collar sign," interpreted as a thick connective tissue barrier that prevented further aneurysmal filling.[9] Anyone with knowledge of imaging physics readily recognized that this band was caused by the Mach effect, a well-known optical illusion that occurs both with Matrix and platinum coils.[10,11] In a heterogeneous human autopsy study and in several experimental studies in swine and rabbits, the phenomenon of fibrous neck healing by the bioactive Matrix coils was enthusiastically claimed and communicated by Szikora et al[12] and Murayama and Viñuela,[13,14] though scientific evidence was lacking.

To overcome the initial criticism on the Matrix coil[15] and to reduce the reported high friction of the coated coils inside the microcatheter, Boston Scientific applied some minor modifications to the coil and the second-generation Matrix was introduced as Matrix2. After evaluation of this Matrix2 coil in a heterogeneous study including cases from the ACTIVE study, Murayama and Viňuela claimed without statistical evidence that use of Matrix2 coils resulted in improved mechanical performance and anatomic outcome compared with Matrix1 coils.[16] The marketing machine of Boston Scientific thus continued, and Matrix effectively survived the initial period, despite the publication of more clinical studies that failed to show a beneficial effect of the bioactive Matrix coils.[17] Even despite imposed scientific bias in a French registry design toward favorable results for Matrix, a beneficial effect of Matrix could not be shown.[18,19] Finally, the MAPS trial was announced in 2008; and now, 6 years later, the definitive results clearly indicate that Matrix coils are not better than standard platinum coils.

What can we learn from this Matrix saga, with Boston Scientific/Stryker supported by some of our overenthusiastic peers? How can we avoid large sums of public money being spilled on unproven devices to enhance the profits of device companies? We, as doctors, have to get back into the driver's seat, and we should take the lead from the industry in developing devices. Instead of selling our soul to the devil by using unproven devices at high costs from manufacturers with clever and possibly misleading marketing strategies, we should tell the industry what devices to make after adequate scientific hypotheses and clinical tests that convince regulatory bodies like the FDA. In addition, we should be more critical of our overenthusiastic peers involved in cutting-edge technology with a critical eye to the interpretation of their

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first clinical results with new devices. In addition, device manufacturers should assume their public responsibility instead of mainly striving for financial profit and high stock prices.

Only then can scientific and financial blunders like the Matrix coil be averted. For now, finally, we hang out the flag for the burial of the Matrix coil.

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EDITORIAL

Counterpoint—Response to "In Memoriam: The Matrix Coil"

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In this issue of the *American Journal of Neuroradiology* (*AJNR*), the Matrix and Platinum Science (MAPS) trial results are published.[1] The trial concluded that there was no superiority of the Matrix coil (Stryker, Kalamazoo, Michigan) over bare platinum coils. The MAPS investigators and sponsor should be congratulated on their willingness to test the efficacy of Matrix. The MAPS trial in no way negates the premise that the modification of coil surfaces or composition could potentially enhance coil performance and/or the long-term durability of coil embolization. To broadly extrapolate the MAPS results to all surface modified coils makes little sense.

While the approach taken by industry to promote the Matrix coil during the product launch certainly had serious flaws, this controversy should not cloud, or in any way diminish, the important clinical data provided by the MAPS study. With the benefit of hindsight, it appears that the coil vendor, as well as physician users, share responsibility for not demanding more robust data of improved efficacy over bare platinum coils before the routine use of Matrix in patients. Fortunately, our field continues to mature, and we have evolved past this to a large extent, as evidenced by the myriad industry-sponsored comparative coil trials that have been completed (Cerecyte trial, HydroCoil Endovascular Aneurysm Occlusion and Packing study) and those that are currently underway (Patients Prone to Recurrence After Endovascular Treatment, Hydrogel Endovascular Aneurysm Treatment trial, Framing Eighteen Coils in Cerebral Aneurysms trial).[1,2] These trials, like MAPS, represent real progress within our field and reflect recognition by physicians, as well as industry, that treatment decisions must be guided by reliable clinical trial data rather than marketing concepts that are based largely on preclinical studies.

Extensive preclinical studies were performed to better understand the results of coating bare platinum coils with a bioresorbable polymer. In retrospect, many of these studies were suboptimal in that they used an experimental aneurysm model that is now known to have low hemodynamic stresses and a high incidence of spontaneous thrombosis.[3]

The canine bifurcation model represents a better one for determining aneurysm coil performance, both angiographically and histologically.[4-9] In this model, the original version of Matrix was shown to undergo greater coil compaction and aneurysm neck recurrence compared with the conventional bare platinum Guglielmi detachable coil (GDC; Boston Scientific, Natick, Massachusetts), indicating that either the coil or the coating resulted in

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