# Braided Metal Cerclage Cables:
# Anatomy of "The Perfect Metal Debris Factory"

Metal cerclage cables have been implicated as a significant source of metallic debris that, along with other sources such as modular junctions and metal-on-metal (MoM) articulations, contributes to the joint replacement patient's total systemic metal debris load.[1] Analysis of the construction of a braided metal cable reveals a very large number of potential wear sites formed where adjacent wire filaments composing the braided cable contact one another along the length of the cable. It is expected that these numerous contact sites result in "fretting wear" as the patient ambulates and loads the cable.

**Fretting** is defined as "*A special wear process that occurs at the contact area between two materials under load and subject to minute relative motion by vibration or some other force.*"[2]

In addition to fretting wear as a source of metal debris, dissolution of metal ions due to galvanic corrosion should also be considered. It has been shown that fretting can greatly enhance galvanic corrosion rates of implant materials due to fretting wear's removal of the passive oxide layer that confers electrochemical stability as well as "biocompatibility" to the cable material.[3] Metal cerclage cable materials are often "dissimilar" to one or more of the large masses of metal joint prostheses implanted nearby, creating an environment for galvanic corrosion.

"**Galvanic Corrosion** occurs when a metal or alloy is electrically coupled to another metal or conducting nonmetal in the same electrolyte. The three essential components are: materials possessing different surface potential, a common electrolyte and a common electrical path."[4]

Cross-sectional images of two common metal cerclage cables reveal a surprisingly large number of potential sites for fretting wear. The 7 x 7 wire bundle format (Fig. 1) tends to be used in older cable designs while the 19 x 7 (Fig. 2) format is utilized in some newer designs. The 7 x 7 wire bundle cable yields a total of 96 sites where individual wires filaments interact and "articulate" with adjacent filaments when the cable is loaded as the patient ambulates. The 19 x 7 bundle contains 263 of these wire filament wear sites.

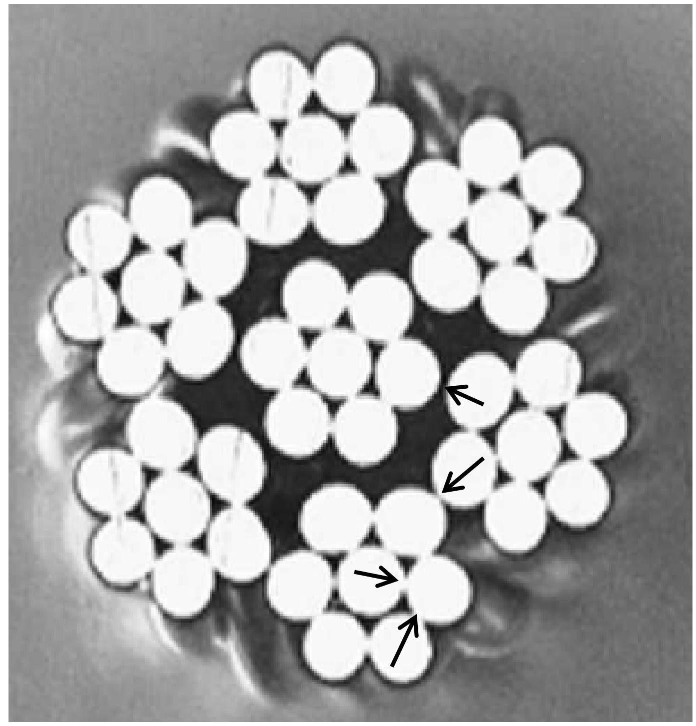

**Fig. 1.** Cross-section of a "7 x 7 wire cable bundle".[5] Arrows show where adjacent wire filaments interact with their neighbors under load. A total of 96 paired wire filament wear couples are present.

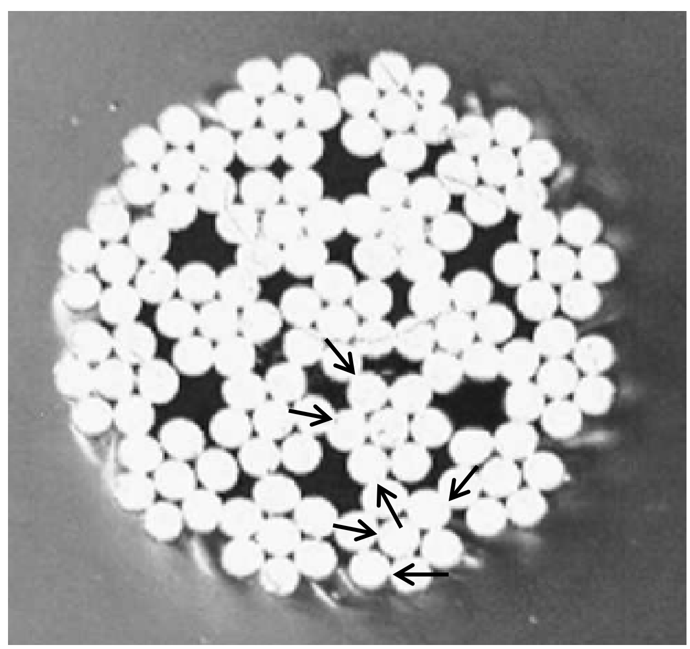

**Fig. 2.** Cross-section of a "19 x 7 wire cable bundle".[5] Arrows show where adjacent wire filaments interact with their neighbors under load. A total of 263 paired wire filament wear couples are present.

These wear sites are actually lines of contact that run the length of each pair of wire filaments making up the wear couple (Fig. 3). Taking a typical 11 cm circumferential length of cable as used in the femur, and multiplying this length by the total number of these wear couples, a 10.56 meter “total articular length” for the 7 x 7 bundle and a 28.93 meter “total articular length” for the 19 x 7 bundle is derived**.** Since the wires are wound in a helical shape these lengths are actually greater. Of course in many orthopedic constructs more than one cable is used, resulting in a multiple of these total articular lengths.

Was the unintended consequence of attempting to design a metal cerclage cable that offered improved strength, flexibility and handling characteristics, as compared to older wire cerclage, the creation of “the perfect metal debris factory”?

An understanding of the extent of these MoM articulations present in braided metal cables, along with the recognition that these wire filaments were not engineered to be optimized MoM articulations, raises serious concerns about braided metal cerclage cable’s contribution to systemic metal wear debris loads in joint replacement patients. Wear debris from metal implants are known to cause osteolysis that contributes to early implant failure. Metal wear debris from implants also yields metal oxides, hydroxides and phosphates which become systemic throughout the body and have poorly understood potential toxic effects.[6]

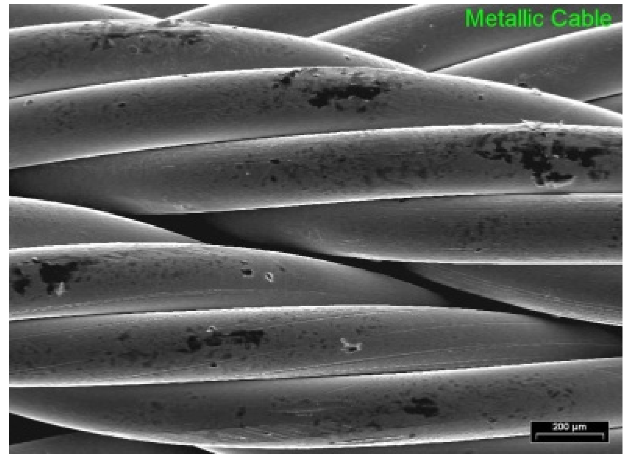


**Fig. 3.** SEM photo of a metal cerclage cable. Strands of braided metal cable exhibit substantial metal-on-metal interface area.


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4. ASM Handbook, Volume 13A Corrosion: Fundamentals, Testing, and Protection. ASM International p 210.
5. Barrack et al (2005). Current Status of Trochanteric Reattachment in Complex Total Hip Arthroplasty. Clin Orthop 441:237.
6. Keegan et al (2007). Orthopaedic Metals and Their Potential Toxicity in the Arthroplasty Patient. J Bone Joint Surg 89-B:567.