
Recent advances in foreign body extractors

Remoção de corpos estranhos oculares - atualização

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SUMMARY

The latest technological advances are reviewed and a new instrument dedicated to ferrous foreign body removal, “the Rare-Earth IOM”, is described. The Rare-Earth intraocular magnet is a simple but powerful instrument that replaces the older and bulkier electromagnets commonly used for the removal of intraocular ferrous foreign bodies. This instrument does not work at large distances from the eye and therefore cannot be used externally.

Palavras-chave: corpo estranho intra-ocular, imã, ferro e vitrectomia.

INTRODUCTION

It has been reported that over 80% of the trauma cases involving penetrating injuries are caused by magnetic foreign bodies⁽¹⁾, but the surgical removal of intraocularly located foreign bodies has been mostly performed with specialized forceps rather than electromagnets. Before presenting a new modality, we will analyse the recent advances made with the others.

FORCEPS

Many variations of the foreign body forceps instruments have been fashioned. With the acceptance of the pars plana approach to vitreous surgery, the size of the foreign body forceps was reduced to 20 gauge and various jaw designs were introduced. In order to remove smooth glass-like foreign bodies, Hutton added a silicone rubber coating to Neubauer's invention. This softer surface would more easily take the shape of the foreign body and improved the gripping action⁽²⁾.

Wilson further reduced the overall size of the forceps and introduced a fully retractable, three hooked-shaped jaws designed for better gripping of irregularly shaped foreign bodies⁽³⁾. Fine diamond crystals were later impregnated into the jaws of the foreign body forceps⁽⁴⁾. The pyramidal shape and ability to penetrate all other materials provided the best gripping action for foreign body forceps. To ease the surgeon's manipulative, three dimensional motions during foreign body extraction, Hickingbotham⁽⁴⁾ also introduced the spring loaded self-closing mechanism concept to maintain a constant, uniform gripping force on foreign bodies, regardless of their composition.

ELECTROMAGNETS

The use of the electromagnetic principle for the removal of ferrous foreign bodies was introduced in 1879⁽⁵⁾. Larger electromagnets were later produced to increase the magnetic pull-force, improving the

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foreign body extraction success ratio. These devices were ceiling suspended, mounted on tracks, and needed powerful electrical motors for adequate positioning. Others were operated by gimballed cranes which were mounted on rails and were usually manually positioned over the patient's head. These large devices were commonly known as "Giant Magnets". During extraction, continuous electrical power was applied to these electromagnets by a foot-switch operated by the surgeon.

The limitation of these electromagnets were many, and besides their bulk, they tended to heat rapidly thereby losing their magnetic efficiency. The surgeon then had to wait for the electromagnet metallic body to cool before re-energizing it. In some instances, this process had to be repeated many times prior to successful removal of the foreign body⁽⁶⁾.

Modern technology allowed for a rapidly pulsed direct current wave to be incorporated into the electromagnet power console. This advance permitted the generation of higher instantaneous magnetic forces and allowed a reduction in heat dissipation. The pulsatile electromagnet body was thusly reduced in size and hand-held probes were made. These devices weighed over 2 kilograms and had a magnetic efficiency comparable to that of the older one ton Giant-Magnets⁽⁷⁾.

In surgery, the pulsatile electromagnets are positioned externally at a very close distance to the eye. In most instances, the magnetic axis is oriented along the direction of the track made by the penetrating intraocular foreign body. Upon energizing, the foreign body is pulled backward and follows its entrance path. For those foreign bodies located at the posterior segment of the eye, in some instances the external wound is closed and a pars plana sclerotomy is performed. In either case, the externally located magnetic

pole-piece is directed towards the new opening made in the eye. The pulsatile electromagnetic devices were more successful at removing foreign bodies than were the Giant-Magnets. For the most part, this is due to the ease with which the hand-held devices could be oriented. Until the advent of pars plana vitreous surgery, the hand-held pulsatile electromagnet was the instrument of choice for the removal of all ferrous intraocular foreign bodies. With either of the above electromagnetic instruments, the magnetic pole is external to the eye. Once the foreign body is dislodged, it will travel with increasing speed toward the magnetic pole. Thus, a secondary incarceration will occur if the magnetic axis is not exactly aligned with the eye wound (Figure 1). Secondary incarcerations are sometimes difficult to manage, especially if the ciliary body is involved.

In an effort to ease the capture of

ferrous intraocular foreign bodies and to prevent secondary incarceration, we modified the hand-held Bronson electromagnet. A 32 mm long cylindrically shaped needle made of magnetic steel was machined and press-fitted into a hole made in the center of the existing pole piece. The blunt needle had a tip diameter of 1.65 mm (16 gauge). A maximum pull-force of 35 grams was measured with the tip in contact with a steel ball. A secondary incarceration of a foreign body was still possible with this modified instrument if the electrical power is applied to the magnet before physical contact with the foreign body and if the magnetic axis is slightly misaligned, the foreign body will travel directly toward the externally located magnetic pole (Figure 2).

Although modern foreign body forceps are light-weight and inexpensive compared to hand-held electromagnets, they still have a

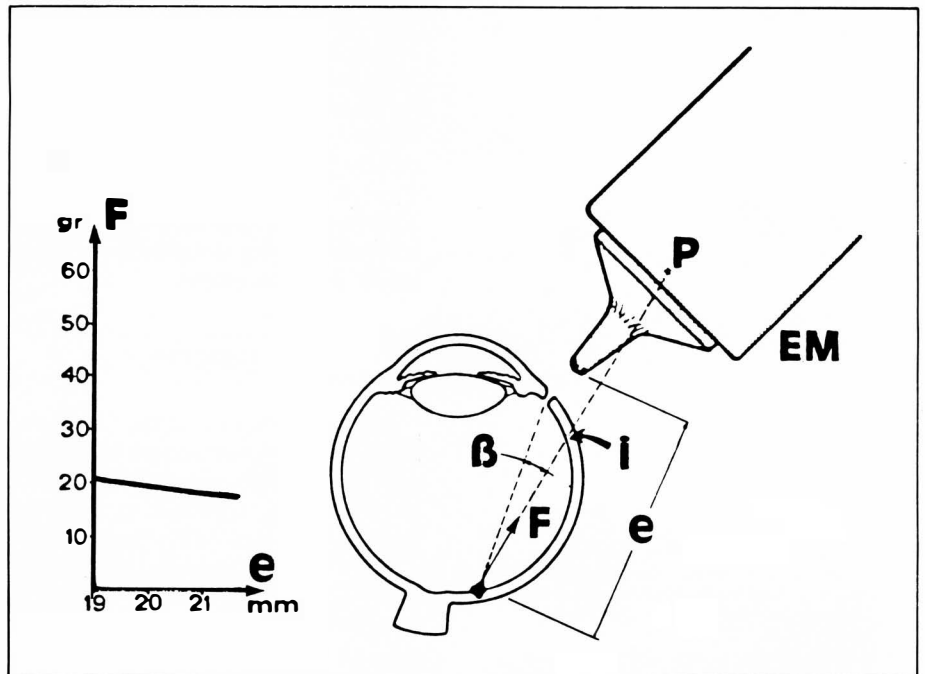


Figure 1: Diagrammatic Representation of forces involved using the Standard Electromagnet. When the magnetic pole (P) and the foreign body are not aligned with the wound, the line of force is angled (B) and a secondary incarceration of the foreign body is possible (i). The force field graph $F = f(e)$ demonstrates the near constancy of the pull-power of the electromagnet (EM) equipped with a short extraocular tip. The flatness of the slope mathematically explains the "jumping" effect observed with all electromagnets.

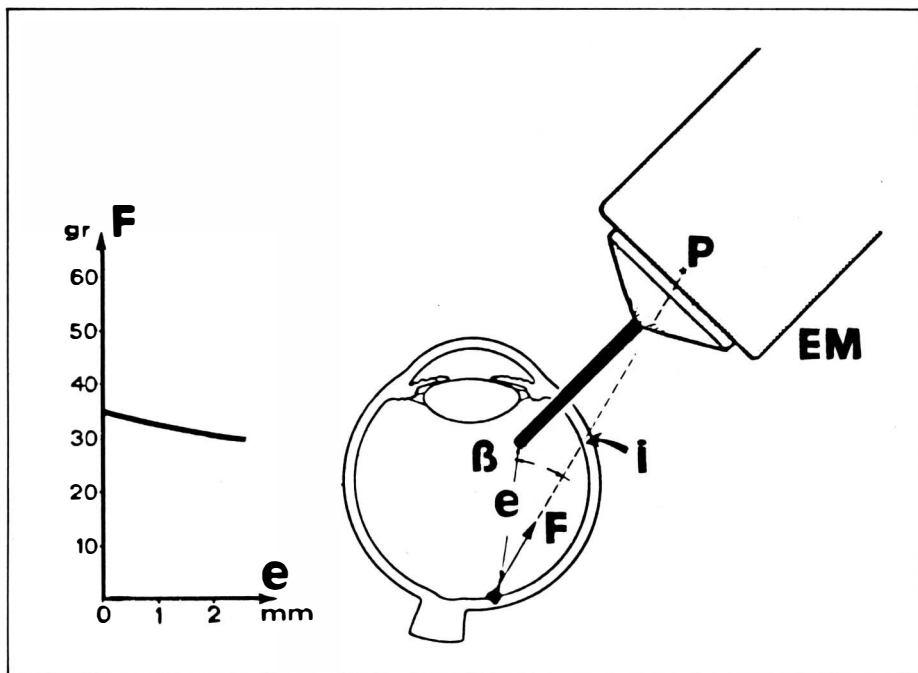


Figure 2: Diagrammatic Representation of Forces Involved With the Modified Electromagnet. The addition of a thin extension to the pole piece does not prevent a secondary incarceration at (i). Power is applied to the electromagnet (EM) before contact is made with the foreign body. Note the slight increase in the slope and intensity of force-field obtained with the new intraocular tip. The added extension does not eliminate the "jumping" effect.

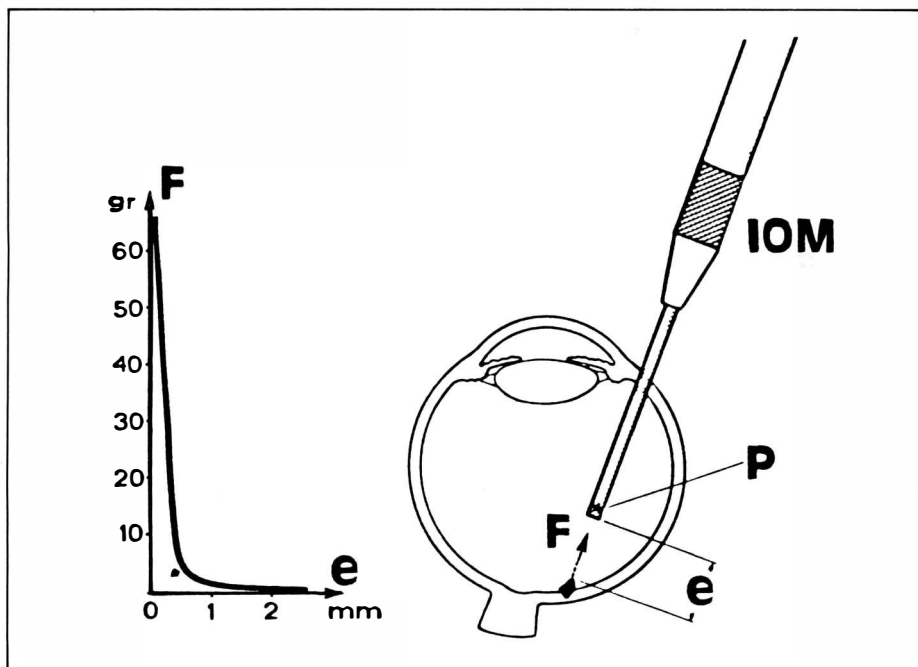


Figure 3: Diagrammatic Representation of Forces Involved With the Rare-Earth IOM. The magnetic pole (P) of the rare-earth IOM is located at the tip of the instrument and is always closest to the foreign body. Secondary incarceration is thusly impossible. The force-field diagram is strongly sloped. Very large pull-forces exist only at close proximity to the foreign body, making the IOM free of the "jumping" effect characterizing electromagnets.

disadvantage their moving jaws are not well suited for the removal of foreign bodies laying on or incarcerated in the retina. In some instances, the moving jaws will catch and pull delicate tissue and cause iatrogenic tears and holes in the retina.

LODESTONES

In ancient times, lodestones were used for the removal of iron foreign bodies. It has been reported that over two thousand years ago, these natural permanent magnets were used to remove foreign bodies by Indian surgeons⁽⁶⁾.

THE RARE-EARTH IOM

The magnetic field generated by permanent magnets are inferior to those obtained with modern electromagnets. Electromagnetic instruments may cause foreign body secondary incarceration and as demonstrated in Figures 1 and 2, it is due the misalignment of the magnetic pole, the wound and the foreign body. The major complication associated is actually a by-product of the electromagnet's power: the higher the electromagnetic force field, the higher the acceleration force, thus the greater the damage made by the impacting foreign body.

A highly polished, cobalt alloyed magnetic bar 75 mm in length and 1.60 mm in diameter was encased in an anodized aluminum handle. The mounted magnetic bar was then subjected to an intensely polarized 1 Mega Gauss magnetic field for 10 seconds, permanently magnetizing this new surgical instrument. The intraocular Magnet (IOM) weighs only 10 grams and is small when compared to the hand-held electromagnet.

The Rare-Earth IOM pull-force is 90 grams and the permanent magnetic energy imparted to the rare-earth IOM is long lasting. We

have found experimentally that the instrument loses about 15% of its energy per year but can easily be recharged by specialty laboratories. The Rare-Earth IOM is sterilizable by flash autoclaving and by ETO gas. The use of high temperature heat sterilization is not advised. Rare-earth materials should never be subject to flames.

It is sometimes convenient for the surgeon to release a foreign body caught by the Rare-Earth IOM tip. Such situations arise most frequently when elongated foreign bodies present themselves sideways to an insufficiently enlarged sclerotomy site. As the X-rays and ultrasound tests detect this type of foreign body prior to surgery, this situation can be avoided. Using a disposable, thin-walled catheter of appropriate size, the surgeon can fashion a simple coaxial cannula fitting the IOM tip. This cannula permits easy and safe unimanual intraocular manipulation of the foreign body. If the smallest dimension of the foreign body is such that it fits into the cannula, it can then be trapped by merely sliding the cannula over the IOM tip, then extracted thru a thigh wound.

When electromagnets placed in front of the wound are energized, it is sometime possible observe the foreign body "jumping" towards the magnet tip. With the Rare-Earth

IOM, no foreign body "jumping" effect is observed as the instrument is introduced into the vitreous cavity. As the graph of Figure 3 demonstrates, the pull-force becomes significant only at a distance of 1 mm or less. The greatest pull-force is obtained only when a direct contact with the foreign body is achieved⁽⁹⁾.

To accommodate surgeons using the 3-port vitrectomy technique, a 19 gauge model was made. The pull-force of this model is 15 grams. As the average foreign body dimension is larger than 1 millimeter, the sclerotomy site often has to be enlarged prior to extraction. This 19 gauge device was also found useful for the removal of foreign bodies present in the anterior segment of the eye. When using the Rare-Earth IOM, as with forceps or electromagnets, the foreign body should always be free of encapsulating tissues. This is perhaps most important with intraretinal foreign bodies. To prevent intraoperative intraocular bleeding, we further suggest the prior cauterization of surrounding tissues before the extraction of encapsulated foreign bodies.

RESUMO

São descritos os avanços tecnológicos na remoção de corpos estranhos imantáveis e um novo ímã intra-ocular ("Rare-Earth IOM"). Trata-se de um instrumento simples, porém potente que substitui os eletroímãs. Não funciona a grandes distâncias e, portanto, não pode ser usado externamente.

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CGC 48.939.250/0001-18