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·技术与方法·

适用于磁压榨吻合的平移钳的设计*

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摘要 目的：提出了磁压榨吻合操作中可用于磁体夹持固定的平移钳的结构设计方案。**方法：**分析本团队多种原创性磁压榨吻合技术操作中存在的缺陷和不足，认为目前磁压榨吻合操作中依靠术者徒手控制或利用现有血管钳对磁体进行夹持和固定，是造成操作中诸多不便的主要原因。从力学角度分析了常规血管钳夹持磁体易导致磁体滑脱的原因，指出设计加工磁吻合专用钳是解决目前磁吻合操作不便的有效措施。在此基础上提出了利用平移钳来固定磁体的结构设计方案，并从力学角度进行了受力分析，设计出了用于磁压榨吻合操作中磁体夹持固定的平移钳。**结果：**平移钳的结构设计能够稳定夹持磁体，避免磁体滑脱；同时，借助齿轮传动结构控制钳头的平行移动能够更好地控制磁体的精准对吸和分离，可进一步简化操作，避免副损伤，节省手术操作时间。**结论：**平移钳能满足多种形状及大小的磁体的夹持和固定，可有效控制磁体的吸合与分离，极大地方便操作。该平移钳加工简单，使用方便，有助于推动磁压榨吻合技术在临床广泛开展。

关键词：磁压榨技术；磁吻合；平移钳

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The Design of Parallel Moving Clamp for Magnetic Compression Anastomosis*

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ABSTRACT Objective: The structural design scheme of the parallel moving clamp which can be used for the clamping and fixing of the magnet in the magnetic pressing anastomosis operation is proposed. **Methods:** The shortcomings and deficiencies of the original magnetic compression anastomosis technology of our team were analyzed, the magnets that magnetic compression anastomosis operation need by hand alone or by using the existing vascular forceps clamping and fixing, and it is the main reason of inconvenience in operation. From the mechanics point of view, analyzed the reason of the conventional vascular forceps hold the magnet can lead to the slippage of the magnet. And pointed out that the design and processing of magnetic anastomosis dedicated forceps is an effective measure to solve the problem of the inconvenience during magnetic anastomosis. On this basis, the structural design scheme of using the parallel moving clamp to fix the magnet is proposed. The mechanics analysis of the magnet is made. The parallel moving clamp with the magnets for clamping and fixing in the magnetic compression anastomosis are designed. **Results:** The structural design of the parallel moving clamp can stably clamp the magnet and prevent the magnet from slipping off. Meanwhile, the parallel movement of the clamp head can be controlled by the gear transmission structure to better control the precise attract and separation of the magnet, thereby further simplifying the operation, avoiding the unnecessary damage and saving operation time. **Conclusions:** The parallel moving clamp can be a variety of shapes and sizes to meet the magnet clamping and fixing, it can effectively control the magnet pull and separation, facilitate the operation.

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The parallel moving clamp processing simple, easy to use, and will promote magnetic compression anastomosis technology widely carried out in the clinic.

Key words: Magnetic compression technique; Magnamosis; Parallel moving clamp

Chinese Library Classification(CLC): TH77; Q64; R197.39 Document code: A

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前言

磁压榨技术(Magnetic compression technique,MCT)借助磁性材料间的“非接触性”磁场力,可用于空腔脏器吻合重建[1]。目前 MCT 在血管吻合[2-8]、胃肠道吻合[9-11]、胆肠吻合[12-15]、食管闭锁 / 狭窄[16,17]等方面显示出良好的效果,该技术甚至可用于直肠阴道瘘的闭合修补[18,19]。在磁压榨吻合中所使用的磁体一般为高磁学性能的磁体,目前最常用的是烧结钕铁硼,这种磁性材料具有较高磁能积,在满足吻合所需的磁力时,与四氧化三铁磁性材料及钐钴磁性材料相比,能够将大大减小磁体体积。

在磁吻合中,吻合磁体大多为圆柱状或条状,且磁体体积一般较小,磁体无附属结构装置,使用磁体进行吻合时常依靠术者徒手捏拿或使用血管钳夹持。受手术视野的限制,徒手捏拿磁体往往缺乏足够的操作空间。通用的血管钳钳夹常出现夹持不牢固致磁体转动和滑脱,而对于针孔结构的血管吻合磁环则较难一次性实现精准对合,影响吻合操作。

1 材料与方法

1.1 设计思路

通过力学分析可发现血管钳钳夹磁体时,由于钳口角度的问题,磁体受到向钳口方向的合力作用(如图 1A-B 所示),加之磁体为坚硬的无形变物体,所以常常出现磁体从钳口滑脱的问题。基于此,我们提出了平移钳的设计方案,平移钳口夹持磁体时,两边钳口对磁体施加方向相反大小相等的作用力,增加夹持钳对磁体的稳定性(如图 1C 所示)。另外,当吻合时磁体在逐渐靠近的过程中,受磁体磁力的影响,磁体的稳定性和可控性较差, 利用专门的磁体夹持钳可提高吻合过程中磁体对合的可控性,非常有利于手术操作。而钳口的平行张合运动,则可以利用手柄前端的弧形齿轮结构和钳头的直线齿轮结构来实现。

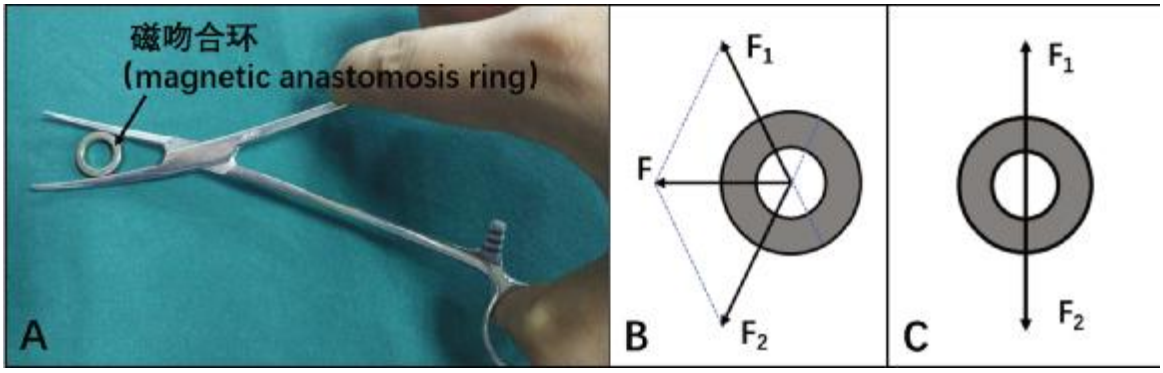

图 1 血管钳和平移钳夹持磁吻合环的受力示意图

Fig.1 A diagram of stress when the Vascular clamp and parallel moving clamp holding the magnetic anastomosis ring

1.2 结构设计

平移钳的结构如图 2 所示:第一钳口 1 和第二钳口 2 为平行关系,第二钳口 2 上有直线齿口 3,第一手柄 5 头端为弧形齿口 4,在第一手柄 5 的中后段内侧面有第一锁扣 6,在第二手柄中后段内侧面有第二锁扣 7,第一手柄 5 和第二手柄 8 依靠铆钉 9 实现铆连接。为避免磁体与平移钳之间产生相互吸引力而影响操作,平移钳的加工材料应选用非顺磁性材料,如钛合金、铜、高纯度不锈钢、高强度高分子材料等。多功能可更换钳头如图 3 所示,可满足各种形状的磁体的夹持与固定。

2 结果

使用实例: 当向第一手柄 5 和第二手柄 8 施加向内的力时,第一手柄 5 和第二手柄 8 围绕铆钉 9 转动,第一手柄 5 前端的弧形齿口 4 可带动平行齿口 3 移动,同时带动第二钳口 2 平行移动。在夹持用力过程中第一锁扣 6 和第二锁扣 7 可互锁,这样大大增加平移钳对磁体的控制。平移钳的钳头为可更换设计,多种设计的钳头可满足不同形状的磁体的夹持、固定和吻合操作。

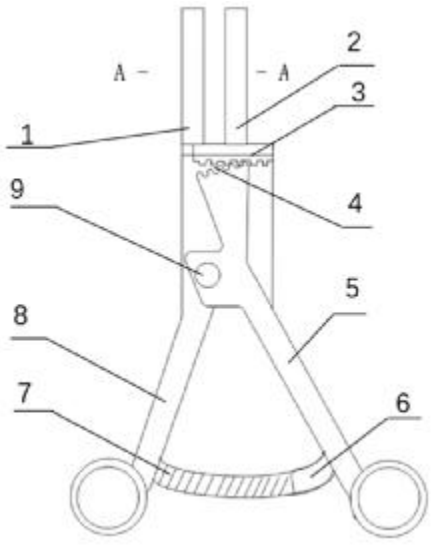

图 2 平移钳结构示意图

Fig.2 A diagram of the parallel moving clamp

例如我们既往设计的磁压榨直肠阴道瘘闭合修补术中用于吻合的磁体为弧形，在术中实际操作时磁体依靠徒手放置，放置过程中对磁体的掌控程度较差(如图 3A 所示[20])。借助平移钳的设计方案可可在磁体径线方向开通方孔，平移钳钳头可设计成与磁体的方孔间隙相配，这样可方便掌控两个磁体的放置和吸合(如图 3B 所示)。

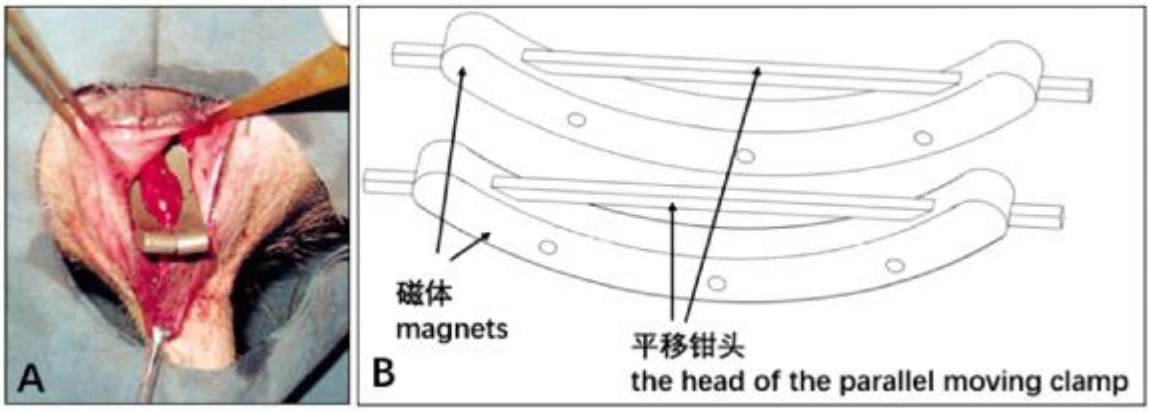

图 3 适用于直肠阴道瘘闭合修补磁体的平移钳钳头设计

Fig.3 The pliers head design of the parallel moving clamp for repair the rectovaginal fistula

在利用针孔结构的磁吻合环实施血管端端吻合时，一方面要保证针孔结构的磁吻合环被夹持固定牢固(如图 4A-C[21])，以利于血管外翻；另一方面血管两端磁环在对合过程中要保持磁环的稳定，以利于磁环针孔相对。当借助平移钳辅助吻合时，可同时满足上述两方面要求，大大方便吻合操作(如图 4D)。

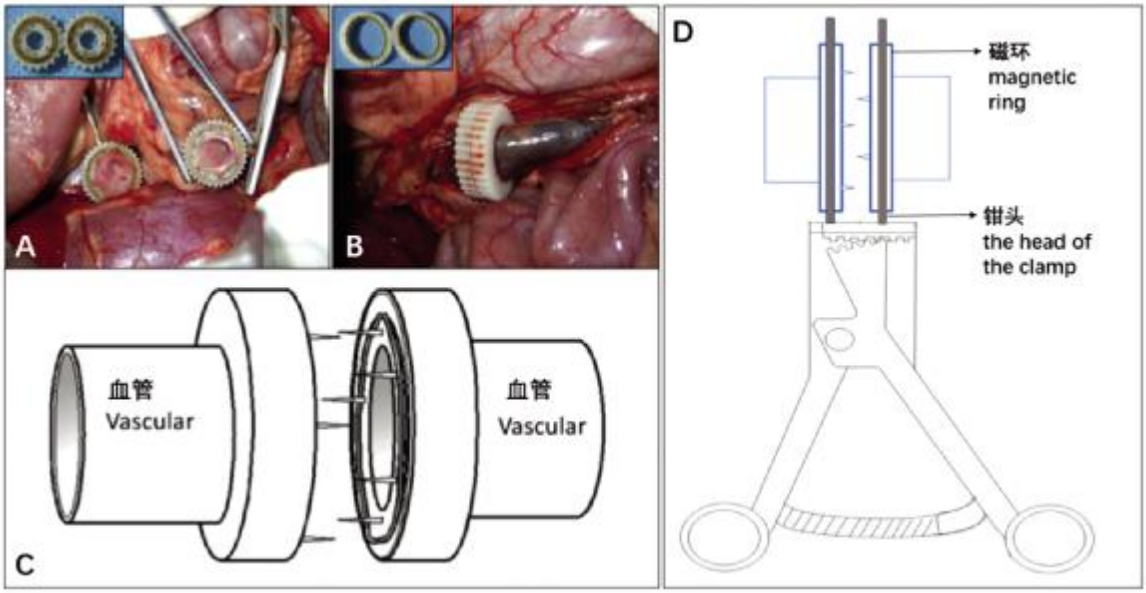

图 4 平移钳辅助实施血管端端磁吻合

Fig.4 Parallel moving clamp assisted in the implementation of vascular end-to-end magnetic anastomosis

3 讨论

磁压榨是近年来迅速发展起来的一种外科技术，磁压榨技术可用于空腔脏器吻合重建、食管下段增强括约肌功能抗返流[22-27]、狭窄或闭锁胆道 / 食管的再通、瘘口修补等诸多方面。磁压榨技术(magnetic compression technique，MCT)、磁锚定技术(magnetic anchor technology，MAT)、磁导航技术(magnetic navigation technology，MNT)、磁悬浮技术(magnetic levitation technology，MLT)构成了磁外科(magnetic surgery，MS)体系的核心技术。目前临床上应用最广、技术最成熟的是磁压榨技术。磁锚定技术及磁导航在临床上也有应用的相关报道[28-31]。

磁压榨作为一种器官吻合重建技术具有操作简单、吻合时间快、吻合效果可靠、术后吻合口漏及吻合口狭窄发生率低等优点。西安交通大学第一附属医院肝胆外科在磁压榨吻合技术上有诸多创新研究。目前已在临床上开展磁压榨胆肠吻合、磁压榨胰肠吻合、磁压榨直肠阴道瘘修补、磁压榨血管快速吻合转流、磁压榨狭窄胆管疏通、磁压榨胰腺假性囊肿胃吻合等多种国内外创新手术，取得了良好的临床效果。但是我们在前期临床使用过程中发现，目前尚无用于磁压榨吻合的专用手术器械，在实际使用时磁体通常依靠徒手捏拿放置，在狭小空间操作时常常会受限，不利于操作。同时，当两个磁体相互靠近相吸压榨组织时，磁体间相互吸引力会瞬时增加，磁体会出现移位、

误压榨非吻合组织等可能,常给术者操作造成不便。

目前临床上使用的手术器械大多为不锈钢材质,与磁体会相吸干扰吻合过程。另外,血管钳在钳夹组织时钳头成一定锐角,夹持磁体时磁体受到向外的合力作用,磁体会出现滑脱。在考虑到以上两方面因素后,我们设计了磁压榨专用吻合钳,在材质方面采用铜、铝、硬质高分子塑料等非顺磁性材料。在钳口设计方面,考虑到要确保磁体夹持和磁体相吸时位置的稳定性,钳口需要保持平行移动,为此采用了手柄弧形齿与钳头直线齿相互啮合的传动结构来实现钳口的平移功能。

平移钳设计方案在磁压榨吻合手术中的应用具有以下优点:①多功能可更换钳头设计可满足对不同形状的磁体的夹持及固定需求;②磁压榨吻合时,对吸过程中磁体随间距变小可导致磁体间吸力突然增强从而带来瞬间对吸,在这过程中可能会出现磁体位置偏移,或磁体对位不齐(尤其见于针孔结构的磁性血管吻合环),平移钳可完美解决上述问题;③非顺磁性材料可避免在操作中磁体与平移钳之间相互吸引,影响磁体吸合;④使用简单方便;⑤设计独特,结构巧妙,加工简单。

前期相关研究已显示出了磁压榨吻合技术的优越性,平移钳的设计可进一步简化吻合操作、提高效率、减小副损伤,将对磁压榨吻合技术的临床推进具有积极推动作用。

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