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低强度脉冲超声波对肌腱愈合的促进作用*

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摘要 目的:分析低强度脉冲超声波(low intensity pulsed ultrasound,LIPU)对Ⅱ区屈指肌腱愈合的促进作用,并探讨其减少肌腱粘连的临床效果。**方法:**选取2010年8月至2013年4月在我院接受Ⅱ区屈指肌腱损伤修复术治疗的患者80例并随机分为两组。LIPU组(33例,共39指),该组患者均接受系统的低强度脉冲超声波进行治疗;对照组(34例,共41指),所有患者在治疗时放置超声探头,但不接通电源。在术后12周,采用视觉模拟评分法(visual analogue scale, VAS)评估患手疼痛程度;采用肌腱总主动活动度(total active motion, TAM)评定标准评价肌腱的功能状况;采用Lovett分级法评价患指屈指肌力。**结果:**两组术后无肌腱再断裂病例出现。术后12周时,LIPU组与对照组的VAS疼痛评分分别为 (1.9 ± 1.8) 和 (2.3 ± 1.9) ($t=0.996$, $P=0.337$)。根据TAM系统评定标准,LIPU组与对照组的优良率分别为94.9%和70.7%,组间差异有统计学意义($X^2=12.798$, $P=0.000$),LIPU组显著高于对照组,两组患指屈指肌力恢复正常的发生率分别为100%和95.1%,组间差异无统计学意义($X^2=1.951$, $P=0.162$)。**结论:**LIPU具有促进Ⅱ区屈指肌腱愈合,改善患指主动活动功能的效果,且不增加肌腱断裂的风险,但其促进肌腱愈合的机制尚需进一步实验研究证实。

关键词:低强度脉冲超声波;屈指肌腱;愈合;术后粘连

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Effects of Low Intensity Pulsed Ultrasound on the Improvement of Flexor Tendon Healing*

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ABSTRACT Objective: To analyze the effects of the low intensity pulsed ultrasound (LIPU) on the healing of Zone-II flexor tendon and to explore the reduction of the adhesion formation by LIPU. **Methods:** 67 patients (80 digits) with zone-II flexor tendon repairs in our hospital from August 2010 to April 2013 were assigned and randomly divided into the control group and LIPU group. Patients in the LIPU group (33 cases, 39 fingers) were treated by LIPU, while the patients in the control group (34 cases, 41 fingers) were treated by the conventional method without the ultrasound therapy. All the patients were evaluated at 12 weeks after surgery by blinded observers. The function of the tendon was evaluated by the Strickland formula (total active motion) system, the pain scores of patients were evaluated by the visual analogue scale (VAS) and flexor strength was assessed. **Results:** The tendon re-rupture was not found after the surgery for all patients. At 12 weeks after surgery, VAS pain scores for LIPU group and the control group were (1.9 ± 1.8) and (2.3 ± 1.9) , respectively ($t = 0.996$, $P = 0.337$). According to TAM system, the excellent rates of LIPU group was 94.9% which was higher than that of the control group 70.7% ($X^2=1.951$, $P=0.162$). The rate of the flexor strength to restore normal level in the LIPU group was 100% which was higher than that of the control group 95.1% ($X^2=1.951$, $P=0.162$). **Conclusions:** LIPU therapy provides greater active finger motion than control group after zone-II flexor tendon repair without increasing the risk of tendon rupture. Further experiments are needed to reveal the mechanism of LIPU on tendon healing.

Key words: Low intensity pulsed ultrasound; Flexor tendon; Healing; Postoperative adhesions

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前言

随着工业化的进程和城市建设的发展,手部外伤成为创伤

急诊中十分常见的损伤,而超过50%的手外科急诊涉及肌腱损伤。肌腱修复对于患者手功能恢复至关重要。临床上修复断裂缺损肌腱的方法有直接缝合、自体肌腱移植、同种异体肌腱移

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植、异种肌腱移植、人工肌腱移植等,术后常规制动4周(肌腱移植者甚至制动更长时间)。然而肌腱修复术后的长期制动,使肌腱产生粘连,导致手功能恢复效果不理想。尤其是屈指肌腱Ⅱ区的损伤,相当大比率的患者在肌腱修复手术之后的3个月到半年之后不得不接受二期松解手术,费用高,痛苦大。

近年来,低强度脉冲式超声波(low intensity pulsed ultrasound, LIPU)的生物学效应引起了国内外分子生物学者以及创伤专家的关注。以往研究证实,LIPU可被用来有效促进骨折愈合及其它组织修复^[1-6]。但对于肌腱愈合的相关研究却很少,本研究通过观察LIPU对人体肌腱愈合的影响,试图寻找一种安全、可靠、简便、有效的治疗手段,以期促进肌腱组织的愈合。

1 资料与方法

1.1 研究对象

本研究获我院机构处和伦理委员会批准。2010年8月至2013年4月间因屈指肌腱损伤而就诊手术治疗的成年患者入选研究。受试前,患者均被口头告知并签署实验知情同意书。填写调查问卷,包括年龄、性别、职业、致伤原因、致伤机制、致伤前全身健康状况、致伤前手功能状况。

纳入标准:单纯屈指肌腱损伤患者(Ⅱ区切割伤);年龄18-60岁。

排除标准:小于18岁或大于60岁;6个月之内使用皮质醇(全身或损伤局部)治疗者;糖尿病患者;断指或合并骨折患者;精神障碍者;不能配合治疗者;

最终共有67例患者(80指)进入研究,患者的年龄为19-58岁,平均为38.5岁。通过随机数字表,采取前瞻、随机、双盲法将患者分成两组,其中一组为LIPU组,接受系统的LIPU治疗,该组纳入患者33例,共39指,患者的平均年龄为 36.9 ± 15.8 岁,其中男20例,女13例;另一组为假LIPU组,治疗中放置超声探头,但不接通电源,该组纳入患者34例,共41指,患者的平均年龄为 39.1 ± 17.2 岁。两组在年龄及性别构成比方面,差异无统计学意义($P > 0.05$)。

1.2 治疗方法

1.2.1 手术方法 肌腱吻合手术均由同一组临床医师完成,患者在臂丛麻醉下行清创、肌腱修复术,改良Kessler法,4/0尼龙线缝合肌腱,术后制动于腕关节轻度屈曲(20°),掌指

(metacarpophalangeal, MP)关节屈曲,近侧指间(proximal interphalangeal, PIP)关节及远侧指间(distal interphalangeal, DIP)关节伸直位,常规抗炎补液治疗,并观察伤口愈合情况及患指血运。

1.2.2 术后处理 术后2周拆线,在石膏保护下开始LIPU/假LIPU治疗,治疗连续14天,术后4周,去除外固定,开始手功能锻炼,直至术后12周。

1.2.3 LIUP 治疗方法 LIPU治疗设备为深圳市圣祥高科技有限公司生产的超声波治疗仪,型号:838C-T-L-I(深圳市圣祥高科技有限公司,中国,广东,深圳,518048)治疗。超声波参数:频率:1.5 MHz;波形:正弦波;信号类型:脉冲;信号时长:200s;间歇周期:800s;重复速率:1 kHz;强度30 mW/cm²。将探头涂抹耦合剂后,垂直放置于肌腱损伤处,(假超声波治疗组同样放置探头,但不接通电源)治疗每次20分钟,每日于相同时段治疗一次。治疗周期为2周。

1.3 评估方法

术后2周评估伤口的愈合情况。在术后12周,采用视觉模拟评分法(visual analogue scale, VAS)^[7]评估患手疼痛程度;根据美国手外科协会制定的肌腱总主动活动度(total active motion, TAM)^[8]评定标准评价肌腱的功能状况,TAM=患指总屈曲度[MP屈曲度数+PIP屈曲度数+DIP屈曲度数]-总伸直受限度[MP伸直受限度数+PIP伸直受限度数+DIP伸直受限度数],TAM与正常指相等为优,TAM>正常指的75%为良,TAM>正常指的50%为中,TAM<正常指的50%为差;采用Lovett分级法^[9]评价患指屈指肌力。

1.4 统计学方法

采用SPSS13.0软件进行数据的统计学处理。计量数据以均数 $\pm$ 标准差表示,计数资料以率表示。采用Student t检验或 χ^2 检验进行数据的组间比较;检验水准均取双侧 $\alpha=0.05$ 。

2 结果

2.1 临床资料及术后2周伤口愈合情况

LIPU组和假LIPU组在性别、年龄、体质量比和总指数方面均无统计学差异($P > 0.05$)(表1)。将上述两组均行肌腱吻合手术,术后2周所有病例伤口均甲级愈合,无感染等不良反应的发生,无肌腱再断裂病例的出现。

表1 两组的临床资料比较

Table 1 Comparison of clinical data of patients between two groups

	LIPU group(n=33)	Control group(n=34)	P Value
Gender n(%)			0.826
Male	20(60.6%)	18(53.0%)	
Female	13(39.4%)	16(47.0%)	
Age(y)	36.9 ± 15.8	39.1 ± 17.2	0.467
BMI	20.6 ± 3.4	21.0 ± 2.9	0.810
Digits	39	41	0.774

2.2 患手疼痛程度的分析

所有病例均获得随访,在术后12周时,LIPU组与假LIPU

组的VAS疼痛评分分别为 1.9 ± 1.8 和 2.3 ± 1.9 ,组间差异无统计学意义($t=0.996$, $P=0.337$)(图1)。

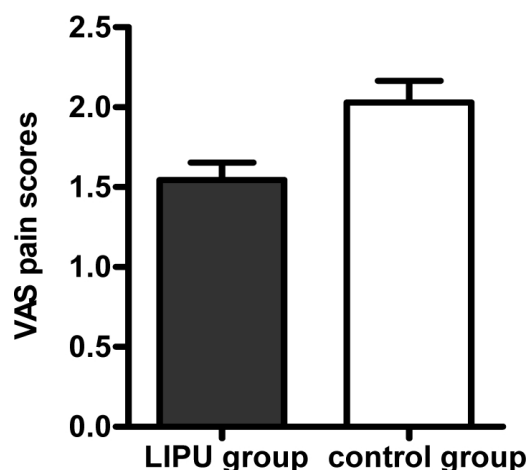


图1 两组的疼痛评分比较

Fig.1 Comparison of Pain score between two groups

2.3 肌腱功能状态和患指屈指肌力的评估

根据 TAM 系统评定标准,LIPU 组中优 2 指,良 35 指,中 2 指,差 0 指;假 LIPU 组中优 0 指,良 29 指,中 10,差 2 指;两组的优良率分别为 94.9%和 70.7, 组间差异有统计学意义($X^2=12.798$, $P=0.000$),LIPU 组显著高于假 LIPU 组(表 2)。经 Lovett 分级法评价,LIPU 组中 39 指的患指屈指肌力均为 V 级,假 LIPU 组中 V 级 39 指,IV 级 2 指,两组患指屈指肌力恢复正常的发生率分别为 100%和 95.1%, 组间差异无统计学意义($X^2=1.951$, $P=0.162$)(表 2)。

3 讨论

目前,临床上修复断裂缺损肌腱的方法有直接缝合、自体肌腱移植、同种异体肌腱移植、异种肌腱移植、人工肌腱移植等^[10-12],术后需常规制动 4 周(肌腱移植者甚至制动更长时间)。

表 2 两组的临床效果数据对比

Table 2 Comparison of clinical results between two groups

Grouping	TAM excellent rates	Rate of the flexor strength to restore normal level
LIPU group(n=33)	94.9%	100%
Control group(n=34)	70.7	95.1%
t/X ² Value	12.798	1.951
P Value	0.000	0.162

然而肌腱修复术后的长期制动,使肌腱往往产生粘连,导致手功能恢复效果不理想^[13]。尤其是屈指肌腱 II 区的损伤,相当大比率的患者在肌腱修复手术之后的 3 个月到半年之后不得不接受二期松解手术。因此,如何促进肌腱修复术后的愈合,进而减少肌腱粘连的发生率仍是目前广大手外科医师密切关注的问题之一。

十几年来,医生和科学家们通过改良肌腱缝合方法,研究生物材料(如透明质酸钠、己丁聚糖等)^[14-15]、生长因子(如类胰岛素样生长因子 1、转化生长因子等)^[16]、干细胞^[17]对肌腱愈合的促进作用,但疗效都不能肯定。近年来,LIPU 的生物学效应引起了国内外分子生物学者以及创伤专家的关注。尽管这种超声波的使用频率仍为 1-3MHz,但强度却大大降低,可低至 30mW/cm²,且为脉冲式,传递给组织的机械能量一般小于 3mg/cm²。其优点在于,首先它克服了组织致热不良作用,其次,该超声波具有刺激细胞增殖及细胞外基质合成的效应。

多项基础研究证实,LIPU 可被用来有效促进骨折愈合及其它组织修复^[1-2]。超声探头所发出的声波在组织内传导,作用于细胞膜上的压力感受器,引起膜电位的变化而产生生物学反应。低强度超声波穿过人体时引起的组织温度变化在 1℃ 以内,这一温度变化尽管很低,但是仍然可以引起细胞内酶反映的改变,通过第二信使系统发挥作用^[18]。但临床研究也证实 LIPU 可促进肌腱愈合的临床研究却鲜有报道^[19]。

在本研究中,我们通过前瞻性随机对照临床试验对 LIPU 治疗肌腱损伤的效果进行了评估,重点考察其促进肌腱愈合与减少肌腱粘连的作用。研究结果显示,两组均无肌腱再断裂病例出现。经术后 12 周评估,LIPU 组与假 LIPU 组的 VAS 疼痛评分差异无统计学意义($t=0.996$, $P=0.337$),在患指屈指肌力恢

复率方面,组间差异也无统计学意义($X^2=1.951$, $P=0.162$),但根据 TAM 系统评定标准,两组功能恢复的优良率差异有统计学意义($X^2=12.798$, $P=0.000$),LIPU 组显著优于假 LIPU 组。本研究结果表明,LIPU 具有促进屈指肌腱损伤愈合的效果,可有效降低屈指肌腱吻合术后的粘连发生率,且不增加肌腱断裂的风险。

LIPU 具有促进屈指肌腱愈合的生物学机制目前尚不明确。本研究设立的超声波参数较为单一,治疗时间均为每次 20 分钟,LIPU 组中未根据超声波不同应用时间与治疗强度设立亚组,因此 LIPU 促进肌腱愈合的最佳时间与治疗强度尚需相关研究证实。另外,本研究的术后观察时间相对较短,在术后长时间随访中,相比未采用 LIPU 治疗的患者,LIPU 治疗者功能效果是否更佳,也有待进一步研究。

总之,LIPU 具有促进 II 区屈指肌腱愈合,改善患指主动活动功能的效果,且不增加肌腱断裂的风险,但其促进肌腱愈合的机制尚需进一步实验研究证实。

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