물리의학

발표일시 및 장소 : 10 월 18 일(금) 14:55-15:05 Room A(5F)

OP1-2-5

Comparison of regeneration of direct and alternating microcurrent on rabbit atrophied calf muscle

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Purpose

High intensity direct current has been reported to be effective in preventing and regenerating muscle atrophy in several previous studies. A previous study demonstrated that alternating microcurrent therapy (MT) might prevent progression of gastrocnemius (GCM) muscle atrophy and facilitate the regeneration of muscle cell. Moreover, low intensity currents were more effective than high intensity currents. To the best of our knowledge, no study has been conducted to compare the effect of microcurrent therapy according to the type of electric current. In this study, we aimed to compare the regenerative effect of direct and alternating microcurrent therapy on atrophied calf muscle in cast-immobilized rabbit

Method

Twelve-week-old 18 male New Zealand white rabbits were randomly allocated into 3 groups of 6 rabbits. Right gastrocnemius muscle was used for immobilization by cast (IC) for 2 weeks. MT (direct current or alternating current) and sham MT was applied daily for 1 hour in each session. IC for 2 weeks and sham MT for 2 weeks after cast removal (CR) (group 1), IC for 2 weeks and alternating current (AC) MT for 2 weeks after CR (group 2), and IC for 2 weeks and direct current (DC) MT for 2 weeks after CR (group 3). In DC group, stimulating current was set at 200 μA, constant current (12-14V). Probe (cathode) was placed on the posterior aspect of calf muscle and reference electrode (anode) was placed on the back of rabbit. In AC group, alternating (200 μA, 30 Hz, rectangular pulse) MT were applied onto the skin over the GCM muscle medially as well as laterally. Clinical parameters including both circumference of calf muscles, compound muscle action potential (CMAP) of tibial nerve, and thickness of GCM muscles were measured by ultrasound before euthanasia (Figure 1). Atrophic change of Rt. calf circumference, CMAP of Rt. tibial nerve, thickness of Rt. GCM was calculated by [Lt. side– Rt. side / Lt. side X 100]. Muscle sections were immunohistochemically stained for type 2 fibers using monoclonal anti-myosin antibody. Cross sectional area (CSA) of 150 muscle fibers in type 1 and type 2 was measured at GCM muscles (Figure 2).

Result

Mean atrophic changes of Rt. calf circumference, amplitude of CMAP on Rt. tibial nerve, and Rt. medial and lateral GCM muscle thickness in group 2 and 3 were significantly lesser than those in group 1, respectively ($p < .05$) (Table 1). Histological findings showed that mean CSA of medial and lateral GCM muscle fibers in group 2 and group 3 were significantly greater than those in group 1 respectively ($p < .05$) (Table 1). However, there was no significant difference in clinical parameters and histologic findings between the group 2 and 3.

Conclusion

This study showed that both direct and alternating microcurrent therapy may be effective in promoting the regeneration of GCM muscle atrophy as demonstrated by improvement in clinical parameter and histology.

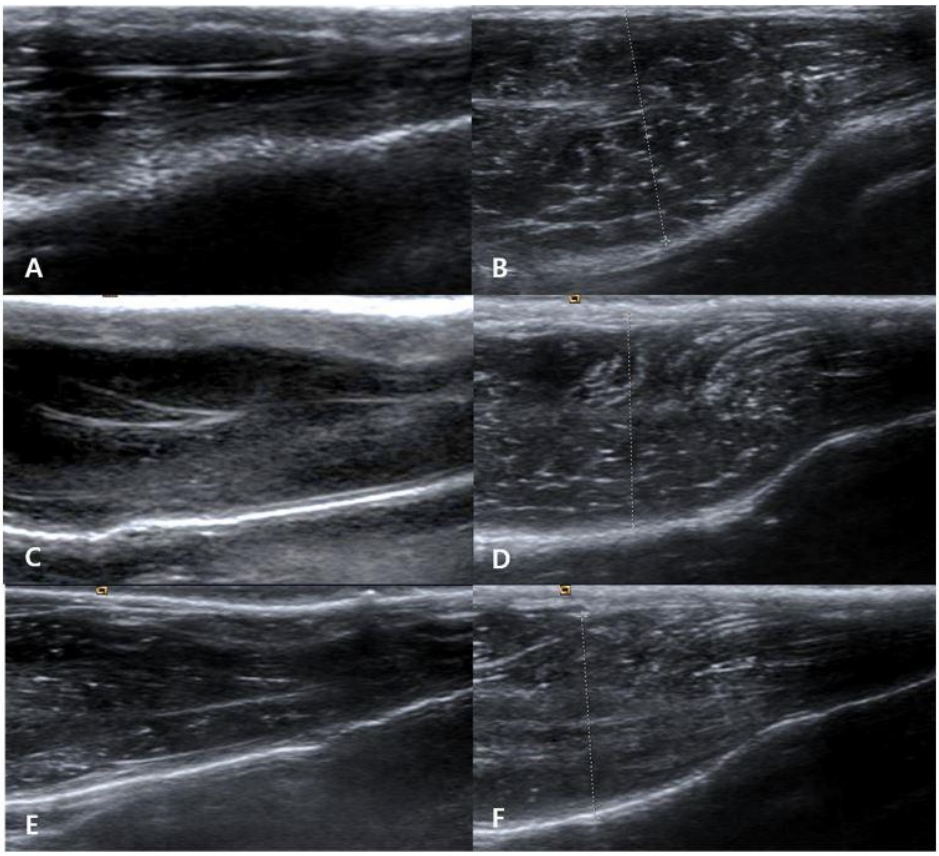

Figure 1. Ultrasound images of right gastrocnemius (A, C, E) and left gastrocnemius (B, D, F). In group 1, severe atrophy was seen in right gastrconemius muscle (A) compared with left gastrocnemius without cast (B). Regenerated right gastrocnemius muscle was seen (C) in group 2 (C) and group 3 (E) compared with left gastrocnemius muscle without cast in each rabbit (D, F).

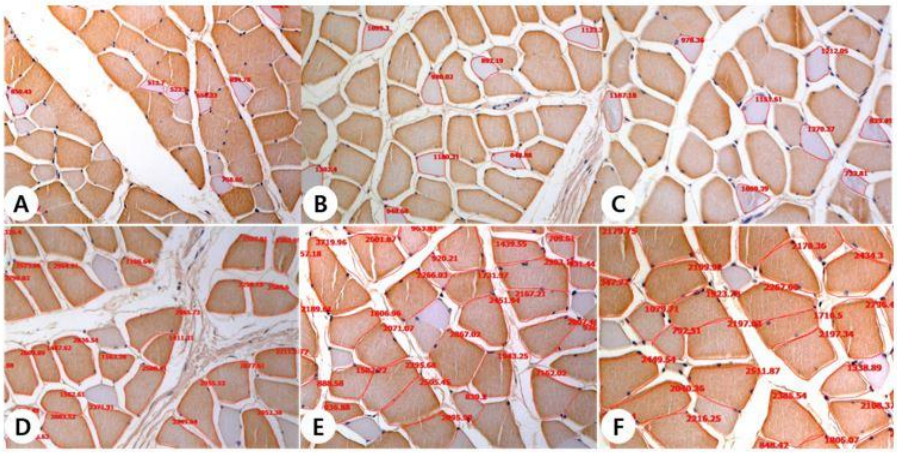

Figure 2. Muscle sections were immunohistochemically stained for muscle fiber. The cross sectional area (red circle) of gastrocnemius type 1 (A-C) and type 2 (D-F) muscle fiber was measured using image morphometry program. Atrophied muscle fibers were seen in group 1 (A, D). Cross sectional areas of muscle fibers were increased in group 2 (B, E) and group 3 (C, F) as compared to group 1.

Group 1: IC for 2 weeks and sham MT for 2 weeks after CR ; Group 2: IC for 2 weeks and AC MT for 2 weeks after CR ; Group 3: IC for 2 weeks and DC MT for 2 weeks after CR;

IC, immobilization by cast; MT, microcurrent therapy; CR, cast removal; AC, alternating current; DC, direct current

Table 1. Comparison of Regenerative Effect of Clinical Parameters and Cross Sectional Area among Four Groups

	Atrophic change (%)				CSA (μm^{2})	
	Circumference of Rt. calf	CMAP on Rt. tibial nerve	Rt. GCM muscle thicnkness		Rt. GCM total fiber	
			medial	lateral	medial	lateral
Group 1 (n=6)	25.7 ± 0.9 %	22.6 ± 1.0 %	23.3 ± 1.2 %	23.8 ± 1.4 %	1586.5 ± 17.7	1598.0 ± 17.9
Group 2 (n=6)	12.7 ± 1.5 %*	11.1 ± 1.3 %*	13.2 ± 1.4 %*	14.8 ± 1.3 %*	1678.8 ± 47.2*	1797.1 ± 34.4*
Group 3 (n=6)	10.4 ± 1.6 %†	9.4 ± 1.9 %†	12.8 ± 1.6 %†	13.2 ± 1.4 %†	1731.3 ± 33.8†	1817.4 ± 31.0†

Values are presented as mean ± standard deviation

Group 1, IC for 2weeks and sham MT for 2 weeks after CR; Group 2, IC for 2weeks and AC MT for 2 weeks after CR; Group 3, IC for 2weeks and DC MT for 2 weeks after CR

GCM, gastrocnemius muscle; CMAP, compound motor action potential; CSA, cross sectional area; IC, immobilized by cast; CR, cast removal; MT, microcurrent therapy; AC, alternating current; DC, direct current.

*) $p < .05$ one-way ANOVA, Tukey's post hoc test among group 1 and 2

†) $p < .05$ one-way ANOVA, Tukey's post hoc test among group 1 and 3