ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2024, 32(4), 35–41

Effect of stabilizer pressure biofeedback on post-thyroidectomy neck pain in postmenopausal women: a randomized controlled trial

DOI: https://doi.org/10.5114/pq/172746

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Abstract

Introduction. To investigate the effect of stabilizer pressure biofeedback on post-thyroidectomy neck pain, disability, endurance capacity of deep cervical flexors (DCFs), and cervical range of motion (ROM) in women after menopause.

Methods. Thirty-six women aged 50–65 years with post-thyroidectomy neck pain were incorporated in this study. Participants were assigned randomly into two groups. Each group was comprised of 18 women. Group A underwent active stretching exercises of the neck muscles. Group B underwent cranio-cervical flexion training using stabilizer pressure biofeedback in addition to active stretching exercises. Q1: The treatment interventions were administered 3 times per week for six weeks. A stabilizer pressure biofeedback device was utilized to evaluate the endurance capacity of the DCFs. A digital goniometer was used to measure the cervical spine ROM. The Neck Pain and Disability Scale (NPDS) was utilized to assess neck pain and disability levels prior to and following six weeks of treatment.

Results. Group A had no significant improvement over group B in the endurance capacity of the DCFs. Both groups (A and B) showed significant increases in cervical ROM and decreases in NPDS. However, comparing the two groups post-treatment, group B showed a statistically significant improvement in all outcome measurements.

Conclusions. Stabilizer pressure biofeedback is efficacious in enhancing the endurance of DCFs and ROM, in addition to reducing neck pain and disability in postmenopausal women who experience neck pain after thyroidectomy.

Key words: mastectomy, breast neoplasms, scar tissue, myofascial treatment, range of motion, muscle elasticity

Introduction

The prevalence of thyroid disorders in females is 5–20 times higher than in males. Furthermore, thyroid problems become more common with age. As a result, postmenopausal and older women are more likely to develop thyroid gland autoimmunity, nodular goiters, hypothyroidism, and malignancies [1]. Thyroid nodules and carcinomas are common in women > 50 years of age. A thyroid disorder that remains unnoticed increases the risk of depression, cardiovascular disease, cognitive impairment, bone fractures, and mortality [2]. After thyroidectomy, > 80% of patients experience neck pain, significantly reduced neck ROM, and the number of trigger points increases. They also experienced higher levels of discomfort and impairment [3].

During hemi- or total thyroidectomy, the strap muscles are enclosed in an investment layer of the deep fascia of the neck, continuously entangling the sternocleidomastoid muscles laterally on each side. The integrating layer of the deep fascia of the neck must be dissected vertically at the middle without cutting any muscle over the full length of exposure. Sometimes, if strap muscles adhere to the thyroid mass, they can be partially excised to ensure a secure margin [4].

A relationship exists between the degree of neck discomfort and the function of deep cervical flexor (DCF) muscles in females who have ongoing neck pain. Advanced degrees of pain are correlated with longer delays [5]. Long-term neck pain can be caused by muscle strain, ischemia, and damage to the anterior longitudinal ligament. Patients exhibit restricted cervical mobility and ambulation in a manner suggestive of a robotic gait during the early postoperative period to support and protect their incisions [6].

Robotic walking after thyroidectomy has an adverse impact on the patient's quality of life. This is because a considerable number of patients experience discomfort in the cervical spine, headaches, stiffness of the shoulder, and limited mobility in the neck and/or shoulders [3]. DCF muscles are crucial for maintaining postural control and neck stability [7]. However, neck pain can lead to a decrease in the strength as well as the endurance of those muscles. DCF training has already been identified as a successful solution for reducing neck pain and promoting proper neck and shoulder postures [7].

Pressure biofeedback unit (PBU)-assisted cranio-cervical flexion training has been found to be more helpful in enhancing the endurance of the DCFs in individuals with mechanical neck pain [8]. Incorporating visual feedback for patients during task performance has been shown to enhance the discharge rate of active motor neurons and increase the recruitment of motor units [9]. The augmentation of muscle strength through the feedback mechanism is attributed to physiological factors such as a heightened mean activation rate, recruitment of motor units, as well as improved synchronization among working motor units [10]. The use of PBU training and stretching exercises has been shown to be efficacious in im-

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Received: 13.05.2023
Accepted: 21.09.2023

Citation: Hassan ES, Botla AM, Abdou MY, Attalla AHA, Ali KM, Aboelmaged SR. Effect of stabilizer pressure biofeedback on post-thyroidectomy neck pain in postmenopausal women: a randomized controlled trial. Physiother Quart. 2024;32(4):35–41; doi: https://doi.org/10.5114/pq/172746.

proving the flexibility of shortened muscles and strengthening weakened muscles, which are crucial for enhancing muscular performance [11].

Subjects and methods

This was a single-blinded (only assessor), randomized, controlled parallel-group study. Participants were recruited from Cairo University Hospital. The study was performed between October 2022 and April 2023.

Participants

Thirty-six postmenopausal women diagnosed with neck pain for two weeks after thyroidectomy were selected from the Department of Surgery at El Kasr Al Ainy Hospital, Cairo University. Female participants in the study ranged in age from 50 to 65 years and had a body mass index (BMI) of less than 35 kg/m^2. Postmenopausal women were excluded from the study if they had neck pain from other conditions such as a spinal fracture, osteoporosis, spinal cord compression, congenital postural deformity, inflammatory disorders of the spine, spinal infections, and significant neurological disorders.

Sample size calculation

The necessary sample size was determined by sample size calculations for both study groups using G*POWER software (version 3.1). Using data on hold time from Ashfaq and Riaz [8], a two-sided *t*-test with an α error probability of 5%, a power of 80%, and an effect size of 0.97 was then carried out, resulting in a sample size of 18 subjects per group. The concealed allocation method was implemented using sealed, sequentially numbered opaque envelopes. The randomization process started with the primary author, who did not take part in the data-gathering process. After the envelope was unsealed, the second author administered the treatment in accordance with the predetermined group allocation. The third author, who was not aware of the group assignment, gathered data at both the starting point and following the intervention periods.

Interventions

Group A involved 18 postmenopausal women with post-thyroidectomy neck pain. They performed active neck stretching exercises 3 times a week for 6 weeks. Group B involved 18 postmenopausal women with post-thyroidectomy neck pain who received cranio-cervical flexion training utilizing stabilizer pressure biofeedback alongside active neck stretching exercises 3 times a week for 6 weeks.

Active neck stretching exercises

All women in groups A and B were given active neck stretching exercises (longus coli, trapezius, scalene, and semispinalis cervicis) 2 weeks after surgery to be conducted 3 times a week for 6 weeks.

Postmenopausal women were instructed to execute three sets of every stretching movement, maintaining a 15-second holding at the peak range before returning to the normal position (morning, afternoon, and late afternoon) [12]. In the initial session, which was under observation, participants were given feedback on their performance in stretching exercises [13].

Participants were instructed to execute the following actions in a specific sequence:

1. It was ensured that the shoulders and neck were relaxed properly.
2. Rotate the face towards the right and then towards the left.
3. Tilt the head toward the right and then the left.
4. Shoulders were rotated in a circular manner.
5. The prescribed action involved gradually elevating both hands to their maximum extent [13].

Stabilizer pressure biofeedback

Each woman in group B got instructions on cranio-cervical flexion training. The stabilizer pressure biofeedback device utilized in this study was manufactured by the Chattanooga Stabilizer Group, Inc. (Hixson, TN 37343, USA) and was used to monitor the constant contractile force of the deep neck muscles for approximately 20 min 3 times a week for six weeks.

Position: It was ensured that the crook's neck and head were held in a straight line. The PBU airbag was folded and positioned below the occiput. The therapist initiated the use of the device by inflating the PBU to an initial pressure of 20 mm Hg to solely occupy the gap between the posterior aspect of the neck and the underlying supportive material while avoiding any undue extension of the cervical spine [10].

Target movement: Patients were instructed to gently nod their heads in the direction of "yes" until the pressure sensor read 2 mm Hg over baseline, and then to nod their heads in the direction of 4, 6, 8, and 10 mm Hg without pausing in between (it was recommended that the pressure sensor record a measurement of 30 mm Hg upon completion of the movement sequence). Five increments were held for 10 s, each for 2 s. Patients should repeat the highest technique level 10 times with 10-second holds [10].

Outcome measures

Neck pain and disability level

The NPDS was used to assess pain levels and disability at the neck in post-thyroidectomy women in every group at the starting point as well as after the treatment program. The NPDS contained 20 elements. Each item was given a VAS score of 100 mms, with number markers at 0, 1, 2, 3, 4, and 5. The 20-item scale assessed neck movement issues, the extent of pain, and its influence on occupational, interpersonal activities, recreational, and functional areas of life. The NPDS total score was computed to detect the extent of pain at the neck, with higher scores indicating more pronounced effects [14]. The NPDS was also found to be reliable and valid for assessing discomfort as well as impairment in subjects suffering from neck disorders. The NPDS proved to have the highest degree of constructive validity across the other questionnaires unique to neck pain [15].

Neck muscular endurance measurement

This study evaluated the endurance of the DCF muscles in women from two groups (A and B) using stabilizer pressure biofeedback before and following the treatment program. The maximum pressure increase was attained and maintained for 10 s above the baseline mm Hg. Endurance was defined as the maximum number of times an individual could sustain the highest pressure for 10 s. The patients avoided tricks with superficial neck flexors. The therapist palpated these contractions to keep track of them [13].

Cervical range of movement (ROM)

Before and after the treatment program, the ROM of the cervical spine for each female participant in groups A and B were assessed using a digital goniometer.

Each participant was instructed to assume an upright sitting position. Cervical ROMs were examined in forward flexion, backward extension, lateral flexion on both sides, and right-left rotational movements [16, 17].

Statistical analysis

The scores were statistically analyzed utilizing SPSS for Windows, version 22 (SPSS Inc., Chicago, IL, USA). The test of Shapiro–Wilk was employed to measure the distribution's normality and revealed that the data were distributed normally ($p > 0.05$). Therefore, the paired *t*-test was utilized for intragroup data and the unpaired *t*-test was used for intergroup data. The mean values and standard deviations were determined.

Results

Figure 1 depicts a flow diagram of the patients throughout the study. There were no reported adverse effects or complaints during or after the treatment.

Table 1 represents the comparison of subject characteristics between both groups, and it shown no significant difference between both groups.

As shown in Table 2, the following results were obtained.

1. The endurance capacity of the DCFs showed no statistically significant increase in the control group ($p = 0.14$) but a substantial increase in the study group ($p = 0.003$). There was no substantial variance ($p = 0.51$) among the pre-treatment groups, while there was a statistically substantial variance ($p = 0.01$) among the mean values of both groups post-treatment in favor of group B.

2. Cervical flexion ROM significantly increased in groups A and B ($p = 0.001$). There was no substantial difference ($p = 0.67$) among the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.01$) among the mean values of both groups post-treatment in favor of group B.

3. Cervical extension ROM significantly increased in groups A ($p = 0.01$) and B ($p = 0.001$). There was no substantial difference ($p = 0.62$) among the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.02$) between the mean values of the two groups post-intervention in favor of group B.

4. Cervical LT lateral flexion ROM significantly increased in groups A ($p = 0.02$) and B ($p = 0.001$). There was no substantial difference ($p = 0.2$) among the pre-treatment groups, but there was a statistically significant difference ($p = 0.01$) among the mean values of both groups post-treatment in favor of group B.

5. Cervical RT lateral flexion ROM significantly increased in groups A ($p = 0.02$) and B ($p = 0.001$). There was no substantial difference ($p = 0.25$) among the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.002$) among the mean values of both groups post-treatment in favor of group B.

6. The cervical LT rotation ROM was significantly increased in group A ($p = 0.001$) and B ($p = 0.001$). There was no significant difference ($p = 0.19$) between the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.02$) between the mean values of both groups post-treatment in favor of group B.

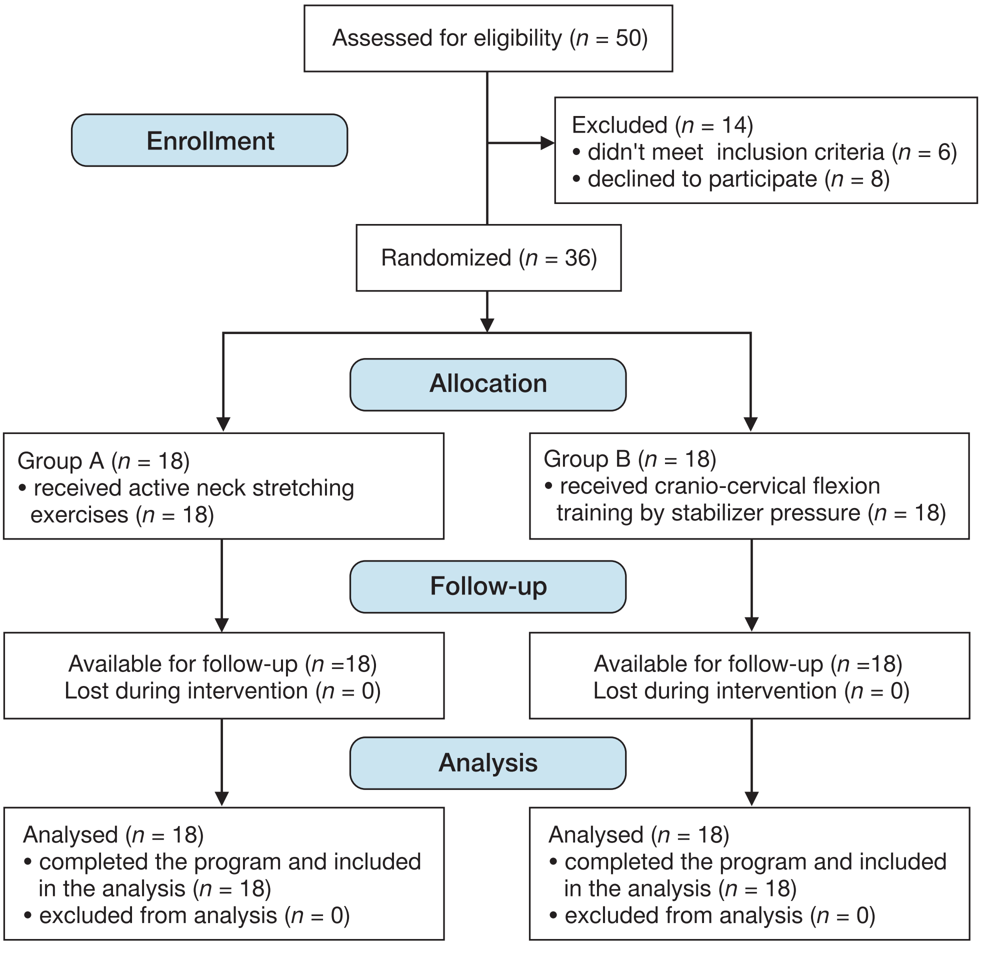

Figure 1. Flowchart of participant recruitment and allocation

Table 1. Comparison of subject characteristics between groups A and B

Items	Group A (mean ± *SD*)	Group B (mean ± *SD*)	*t*-value	*p*-value
Age (years)	56.55 ± 4.1	58.11 ± 4.3	–0.42	0.81
BMI (kg/m^2)	30.33 ± 2.9	29.95 ± 2.7	0.07	0.29
Endurance capacity (%)	64.44 ± 7.1	66.88 ± 8.7	–0.9	0.51

BMI – body mass index

Table 2. Neck endurance capacity, cervical ROM, and cervical NPDS mean scores between and within groups

Variables		Pre-test (mean ± *SD*)	Post-test (mean ± *SD*)	% of change	*p*-value
Endurance capacity (%)	group A	64.44 ± 7.1	66.05 ± 7.4	2.4	0.14
	group B	66.88 ± 8.7	75.38 ± 12.2	11.2	0.003*
	p-value	0.51	0.03*		
Cervical flexion (°)	group A	44.51 ± 4.7	56.44 ± 8.2	21.1	0.001*
	group B	42.11 ± 5.2	63.55 ± 11.8	33.7	0.001*
	MD	–2.4	7.11		
	p-value	0.67	0.01*		
Cervical extension (°)	group A	52.88 ± 10.2	57.50 ± 9.1	8	0.02*
	group B	53.27 ± 10.4	64.11 ± 6.1	16.9	0.001*
	MD	0.39	6.61		
	p-value	0.67	0.01*		
Cervical LT lateral flexion (°)	group A	33.94 ± 4.6	37.27 ± 5.1	8.9	0.02*
	group B	32.11 ± 5.5	42.05 ± 2.4	23.6	0.001*
	MD	1.83	6.61		
	p-value	0.2	0.01*		
Cervical RT lateral flexion (°)	group A	33.33 ± 3.8	37.55 ± 4.9	11.2	0.02*
	group B	31.77 ± 5.3	42.5 ± 2.4	25.2	0.001*
	MD	–1.56	4.95		
	p-value	0.25	0.002*		
Cervical LT rotation (°)	group A	51.38 ± 5.8	58.55 ± 6.4	12.2	0.001*
	group B	52.5 ± 8.4	65.22 ± 9.7	19.5	0.001*
	MD	1.12	6.67		
	p-value	0.19	0.02*		
Cervical RT rotation (°)	group A	51.33 ± 6.8	59.83 ± 5.8	14.2	0.001*
	group B	52.72 ± 8.5	64.72 ± 9	18.5	0.001*
	MD	1.39	4.89		
	p-value	0.32	0.04*		
NPDS	group A	42.5 ± 6.2	32 ± 11.1	24.7	0.001*
	group B	39.66 ± 5.9	26.61 ± 8.2	32.9	0.001*
	MD	–2.84	–5.39		
	p-value	0.32	0.04*		

LT – left, RT – right
* significant values

7. Cervical RT rotation ROM significantly increased in groups A ($p = 0.001$) and B ($p = 0.001$). There was no substantial difference ($p = 0.32$) among the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.004$) between the mean values of the groups post-intervention in favor of group B.

8. The NPDS measurements substantially decreased in groups A and B ($p = 0.001$). There was no substantial difference ($p = 0.32$) among the pre-treatment groups, whereas there was a statistically significant difference ($p = 0.04$) between the mean values of the groups post-intervention in favor of group B.

Discussion

This study evaluated how neck pain, disability, DCF endurance, and cervical ROM in postmenopausal women were affected by DCF muscle training utilizing stabilizer pressure biofeedback.

The current study's results indicated that group A experienced a non-significant increase in DCF endurance, whereas group B experienced a significant improvement. There was a significant improvement in all neck ROM (forward flexion, backward extension, lateral bending, and rotation), pain, and disability levels in favor of group B. The study group might have shown superior results to the control group because performing exercises with continuous feedback input motivates patients to practice them properly and increases their involvement in treatment. Extrinsic feedback is categorized into 2 types: knowledge of the results (KR) and knowledge of the performance (KP). Pressure biofeedback is a category of KP that is delivered throughout and following one's accomplishment of a task and is typically connected to how the task is accomplished. The caregiver provides the patient with knowledge about the performance of the deep neck flexors (DNFs) via the device, and through paying attention to the information, a "closed loop" is formed by the patient. Feedback assists in neuromuscular learning and is a collection of mechanisms linked with practice and/or experience that led to long-term improvement in the ability to respond. As a result, the patients gain more motivation. Biofeedback approaches are utilized to augment a patient's sensory feedback processes with accurate knowledge about bodily functions that might otherwise be unavailable. So, rewarding oneself is a type of operational learning [18]. The study's results agree with those of Nezamuddin et al. [10], who found that DCF training utilizing pressure biofeedback was so efficient than conventional intervention for the performance of muscles and neck pain.

The current study's findings agree with those of Kang [19], who carried out a randomized controlled trial to investigate how DNF exercises using a PBU affected cervical flexibility, the endurance of muscles, and maintenance of forward head posture. A PBU was used to measure muscle endurance and a cervical ROM tool was used to test neck mobility. The findings of this study showed that the training of DCFs utilizing a PBU for six weeks enhanced cervical flexibility and DNF muscular endurance.

Our findings are congruent with those of earlier research conducted by Gong et al. [16]. They showed that DNFs trained with a PBU for six weeks affected neck flexibility and muscle endurance in 20 undergraduates with a forward head position. Cervical (ROM) equipment was used to examine neck mobility and a PBU was used to assess muscle endurance. After six weeks, the experimental group had more cervical ROM and muscle endurance than the control group.

Karthi et al. [20] examined the influence of endurance exercises for DCF muscles utilizing pressure biofeedback for neck pain caused by mechanical forces, and they came to the conclusion that DCF muscle training with visible pressure biofeedback was more helpful in increasing pain relief, cervical ROM, and endurance of DCF, as well as decreasing the NDIS.

Iqbal et al. [21] also reported that the inclusion of pressure biofeedback on DNF training reduced neck discomfort and disability more effectively than conventional stretching exercises alone. Moreover, they explained their results as feedback helping neuromuscular learning, which is a collection of mechanisms linked to practice [21]. Pain reduction following conventional and pressure biofeedback training might be attributed to a variety of factors, including a surge in endorphins, stimulation of ergo receptors, and improved motor function following exercise [10].

Regarding the influence of flexibility exercises on neck discomfort and disability, the findings of the current study agree with those carried out by Abd-El Mohsen and Ahmed [22], who stated that educating patients about stretching neck musculature after thyroidectomy considerably reduced neck pain and impairment ratings. In addition, Nagib et al. [12] reported that active neck stretching exercises for one month after surgery had a substantial effect on neck pain and ROM in postmenopausal women after total thyroidectomy.

Jang et al. [23] examined the efficiency and safety of earlier cervical stretching exercises to minimize post-thyroidectomy complaints and symptoms in thyroid surgery patients. They concluded that performing neck stretching immediately is safe and beneficial for minimizing neck discomfort, wound adhesion, and scar hypertrophy while improving ROM in patients undergoing thyroid surgery. When muscle fibers are reflexively inhibited via autogenic or reciprocal inhibition, the contractile parts of the muscles are less resistant to elongation. Inhibition techniques, however, are solely intended to relax muscle contractile components, not the connective tissue in and around the contracted muscles [24].

The DCF muscles maintain the head in a good postural position on the neck. The equilibrium between the anterior and posterior neck stabilizers is disrupted by impaired DCF function, resulting in poor posture, which contributes to cervical disability. As a result, using stabilizer pressure biofeedback to train DNFs improves the balance between postural muscles [25].

It has been proposed that when muscular performance is reduced, normal alignment and posture are lost, contributing to cervical impairment. The equilibrium among the stabilizers in the back portion of the neck and DCFs was assumed to be disturbed. Therefore, DCF training is recommended to increase postural muscle endurance and decrease in neck pain [26].

The cranio- cervical flexion test seems to be an excellent method for precisely engaging DCFs while limiting sternocleidomastoid muscle augmentation. Restoration of DCF's supportive capacity has been linked to reduced cervicogenic headaches and neck discomfort. Therefore, DCF muscle training is advised for neck discomfort [27].

Conclusions

Six weeks of DCF training utilizing stabilizer pressure biofeedback alongside stretching exercises of the cervical muscles improved neck pain, ROM, endurance, and disability scores better than stretching exercises alone in postmenopausal women after thyroidectomy.

Clinical message

According to this study, stabilizer pressure biofeedback added to a stretching exercise program showed notable efficacy in improving neck pain, muscle endurance, and active ROM of the neck in postmenopausal women with post-thyroidectomy neck pain.

Limitations

It is recommended that future studies have a larger sample size, ideally with at least 18 participants in each group, to ensure greater generalizability. The study should be conducted on postmenopausal women of different age groups and both sexes.

Acknowledgements

The authors express their gratitude to all the participants who participated in this study for their valuable cooperation.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the institutional review board of the Faculty of Physical Therapy, Cairo University approved the study (approval No.: P.T. REC/012/003185). It was registered at Pan African ClinicalTrials.gov (No. PACTR202209867747025).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

Funding

This research received no external funding.

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