ORIGINAL ARTICLE

Effects of cervical traction with and without EMG biofeedback in patients with cervical radiculopathy- A randomised controlled trial

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Abstract

Objective: To find out the effects of cervical traction with and without electromyography biofeedback on range of motion, pain, level of disability and muscle tension.

Method: The randomised controlled trial was conducted at the Fauji Foundation Hospital, Rawalpindi, Pakistan, from July 2021 to July 2022, and comprised patients aged 30-50 years having radicular symptoms persistent for 1-6 months, and underwent cervical traction. The subjects were randomly allocated to Group A with electromyography biofeedback, and Group B without electromyography biofeedback. Both the groups received conventional therapy including hot pack, transcutaneous electrical nerve stimulation, cervical mobilisation and isometrics. The frequency of the treatment was 2 sessions per week over 6 weeks. Data was collected at baseline, after 2, 4 and 6 weeks. Data collection tools included visual analogue scale, neck disability index, inclinometer and electromyography biofeedback. Data was analysed using SPSS 21.

Results: Of the 44 patients, 22(50%) were each of the two groups. In Group A, there were 16(72.7 %) females and 6(27.3 %) males with mean age 43.72+6.71 years. Group B had a similar gender distribution while the mean age was 43.95+5.58 years. In both the groups, neck pain and cervical range of motion improved significantly post-intervention ($p<0.05$), but Group A values were significantly better than Group B ($p<0.05$). Cervical disability and muscular tension were not significantly different in both intragroup and intergroup comparisons ($p>0.05$).

Conclusion: Cervical traction with added electromyography biofeedback effectively lowered cervical pain intensity and improved cervical range compared to cervical traction alone. Electromyography biofeedback showed no additional benefits in managing disability and muscular tension.

RCT registration Number: Clinical Trials. govt with ID: NCT05352464.

Key Words: Radiculopathy, Cervical, Electromyography feedback, Cervical pain, Tractions, Visual analogue scale.

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Introduction

As a result of underlying musculoskeletal disorders, such as degenerative changes in the cervical spine and herniated discs, cervical radiculopathy, colloquially referred to as "Pinched Nerve", manifests as a neurological condition characterised by a constricted or stenosed intervertebral foramen. The nerve root is compressed at the corresponding foramen due to this constriction.[1] In the neck and upper extremities, a compressed nerve root may induce numbness, tingling, pain and motor dysfunction. Typically, cervical radiculopathy causes a decline in the contractility of the upper arm muscles' reflexes. The distribution of these signs and symptoms can be observed in the myotome and dermatome of the affected nerve root.[2] Severe cervical radiculopathy may manifest bilaterally, characterised by nerve root compression and varying degrees of bony spur presence on both sides. A person can develop weakness, and perceive numbness and pain that radiates to the affected part.[3]

Although the numerous pathological mechanisms that cause cervical radiculopathy can affect individuals of any age, they are most prevalent between the ages of 40 and 50. Annual incidence rates for cervical radiculopathy are stated to be 63.5 per 100,000 females and 107.3 per 100,000 males.[4] For a proper diagnosis, patient history and clinical examination are indispensable. Electrophysiological testing, computed tomography (CT), and magnetic resonance imaging (MRI) are essential supplementary imaging modalities. Cervical radiculopathy can be treated surgically, but there is evidence suggesting conservative management to be more effective than surgical treatment, suggesting multimodal treatment strategies that include cervical traction, manual therapy techniques, and strengthening exercises.[5,1]

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Neck stiffness that may cause reduction in cervical ranges and secondary shortening of the involved muscles, such as trapezius, scalene and sternocleidomastoid, may occur as well.

Physiotherapy techniques that are commonly used for cervical radiculopathy may include hot packs, diathermy, sonotherapy, transcutaneous electrical nerve stimulation (TENS), isometric strength training, and cervical traction to reduce pain and improve functionality at the cervical spine.[6,7] Manual therapy techniques that include muscle energy techniques, mobilisation of the spine, natural apophyseal glides, sustained natural apophyseal glides and proprioceptive neuromuscular facilitation techniques are also proven to show results for the cervical radiculopathy condition.

Positive results are evident from electromyography (EMG) biofeedback and cervical traction that numerous physiotherapists have implemented. Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance.[8] Two types of biofeedback are available that have the ability of improving muscle activation patterns in people with neck pain: EMG biofeedback, and pressure biofeedback. EMG biofeedback is a type of neuromuscular biofeedback in which electrodes are directly applied on the skin over the targeted muscles. The biofeedback device examines the EMG activity of the muscles, and provides the user with auditory, visual or sensory feedback to increase or decrease the activity of certain muscles.[8,9] A study compared EMG biofeedback, active exercise, passive treatment and no treatment controls in the treatment of work-related neck and shoulder pain. The results suggested that EMG biofeedback produced a generalised relaxation effect in the neck and shoulder muscles, which was not found in the other intervention groups.[10] Traction provides immediate relief from nerve root compression, and aids in the management of acute pain,[11,12] while EMG biofeedback facilitates patients in learning how to utilise their feeble muscles more efficiently by generating an electrical feedback signal in response to muscle activation.[13] A study compared ambulant EMG biofeedback and ergonomic counselling to ergonomic counselling alone on work-related neck and shoulder pain and disability, and found that both groups showed significant reduction in self-reported pain intensity and disability, suggesting that the use of EMG biofeedback can cause reduction in muscular tension and, therefore, decrease pain.[14]

The current study was planned to determine the effects of cervical traction with and without EMG biofeedback on pain, range of motion (ROM), level of disability and muscle tension in patients with cervical radiculopathy.

Patients and Methods

The randomised controlled trial (RCT) was conducted at the Fauji Foundation Hospital, Rawalpindi, Pakistan, from July 2021 to July 2022.The conduct and reporting of the trial followed the CONSORT 2010 guidelines to ensure methodological transparency and reproducibility. The completed CONSORT checklist is included as supplementary material.[15] After approval from the institutional ethics review committee, the study was registered with Clinical Trials.govt with ID: NCT05352464. The sample size was calculated using G*Power version 3.1.9.712 with a difference between two independent means (two groups), power 0.80 (1-β), margin of Type I error alpha (α) 0.05 and a medium effect size having Cohen's f value 0.87.[16] Non-probability convenience sampling technique was used.

After screening, patients were included if they were aged 30-50 years and had radiculopathy brought on by muscle spasm or posterolateral disc herniation, and had symptoms lasting for the preceding 1-6 months, including pain that radiated accompanied by tingling and weakness in the hands, forearms and arms. Those excluded were individuals with thoracic outlet syndrome, diabetes mellitus, carpal tunnel syndrome, severe sensory and/or motor manifestations, herniation of the central cervical disc, congenital disorders affecting the cervical spine, dizziness caused by vertebrobasilar insufficiency or vestibular dysfunctions, or contraindications to mobilisation techniques.

After taking written informed consent, the participants were randomly allocated to Group A with EMG biofeedback, and Group B without EMG biofeedback. The randomisation was done using the sealed envelope method. Both the groups received continuous traction for 15 minutes in sitting position with the neck in a neutral position with a tension of 7kg force. For EMG biofeedback, Group A participants were asked to position themselves in a seated position on a chair while EMG electrodes were positioned at the C5-C6 paraspinal muscles to detect muscle activity and convert it into visual and auditory stimuli generated by the apparatus (Figure). The patients were asked to try to relax the tension of the neck muscles as much as they could by lowering the visual and auditory impulses from the device. Whereas Group B participants muscle activity was recorded was recorded and analysed with the EMG signal offline without generating the visual and auditory signals.

Both the groups also received conventional therapy,

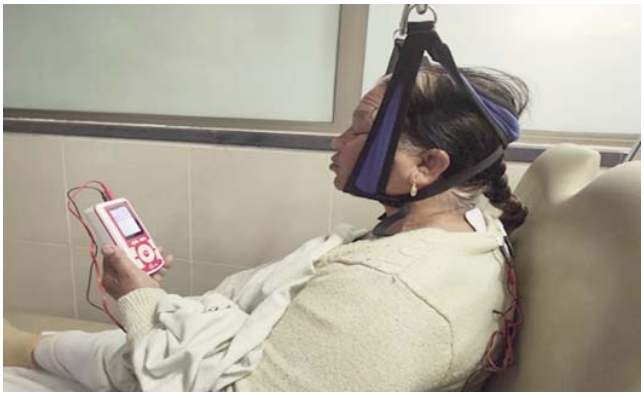

Figure: Cervical traction with electromyography (EMG) biofeedback.

including hot pack for 30 minutes, TENS with pulse width of 50-200us and high frequency of 50-100Hz for 30 minutes, Maitland grade 3-4 cervical mobilisation for 30 seconds, and cervical muscles isometrics in the sitting position. The frequency of the treatment was 2 sessions per week for 6 weeks. Data was collected at baseline, and after 2, 4 and 6 weeks. The tools used were the visual analogue scale (VAS) for measuring neck pain, the Neck Disability Index (NDI) for measuring the level of disability[17], an inclinometer for measuring cervical ROM, and EMG biofeedback for measuring muscle tension.[18]

Data was analysed using SPSS 21. Data was expressed as frequencies and percentages, or means + standard deviation, as appropriate. After Shapiro-Wilk test confirmed data normality, repeated measure analysis of variance (ANOVA) was employed for intragroup analysis, while independent t-test was used for intergroup analysis. P<0.05 was considered statistically significant.

Results

Of the 44 patients, 22(50%) were each of the two groups. In Group A, there were 16(72.7 %) females and 6(27.3 %) males with mean age 43.72+6.71 years. Group B had a similar gender distribution while the mean age was 43.95+5.58 years.

Table-1: Intragroup comparisons.

Variable		Group A		Group B	
		Mean ± SD	P-value	Mean ± SD	P-value
VAS	Baseline	5.54 ± 0.85	0.000	5.31 ± 0.47	0.000
	2nd Week	3.86 ± 0.94		5.13 ± 0.90	
	4th Week	2.72 ± 1.03		3.61 ± 0.72	
	6th Week	1.06 ± 1.69		1.23 ± 9.2	
Cervical Flexion	Baseline	58.27 ± 11.39	0.007	56.81 ± 12.3	0.000
	2nd Week	67.04 ± 8.68		64.77 ± 9.31	
	4th Week	76.59 + 7.92		72.50 ± 9.35	
	6th Week	79.54 ± 7.85		73.86 ± 20.64	
Cervical Extension	Baseline	44.54 ± 9.74	0.000	45.90 ± 10.76	0.000
	2nd Week	52.50 ± 10.55		54.77 ± 11.90	
	4th Week	61.04 ± 9.54		60.22 ± 11.07	
	6th Week	64.31 ± 8.63		61.36 ± 12.92	
Right Side Flexion	Baseline	32.95 ± 5.26	0.000	31.36 ± 6.01	0.000
	2nd Week	38.63 ± 4.13		36.59 ± 3.58	
	4th Week	42.27 ± 2.97		40.90 ± 3.33	
	6th Week	44.61 ± 7.96		41.04 ± 2.83	
Left Side Flexion	Baseline	33.40 ± 4.97	0.000	34.54 ± 8.85	0.000
	2nd Week	37.86 ± 4.24		38.86 ± 8.00	
	4th Week	41.59 ± 3.58		42.40 ± 8.78	
	6th Week	43.63 ± 3.83		46.13 ± 10.11	
Right Rotation	Baseline	55.00 ± 12.9	0.000	57.31 ± 10.0	0.000
	2nd Week	62.72 ± 13.70		65.45 ± 9.37	
	4th Week	69.31 ± 13.65		70.68 ± 10.26	
	6th Week	74.31 ± 14.25		71.68 ± 19.32	
Left Rotation	Baseline	63.63 ± 12.26	0.000	63.18 ± 11.29	0.000
	2nd Week	69.36 ± 12.73		70.22 ± 9.81	
	4th Week	70.68 ± 11.88		71.04 ± 9.34	
	6th Week	82.04 ± 11.71		74.92 ± 8.39	

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NDI	Baseline	27.22 ± 7.44	0.000	27.77 ± 6.20	0.000
	2nd Week	23.18 ± 6.89		24.81 ± 6.33	
	4th Week	20.90 ± 7.33		21.68 ± 6.86	
	6th Week	13.81 ± 9.16		16.45 ± 9.53	
EMG Pre Pull	Baseline	25.59 ± 9.9	0.001	31.07 ± 7.78	0.003
	2nd Week	25.68 ± 9.36		28.13 ± 8.63	
	4th Week	24.86 ± 8.77		27.77 ± 9.50	
	6th Week	22.95 ± 10.12		25.68 ± 9.29	
EMG During pull	Baseline	25.95 ± 9.88	0.004	28.50 ± 7.93	0.007
	2nd Week	23.77 ± 9.26		26.22 ± 7.87	
	4th Week	22.90 ± 9.08		25.59 ± 9.29	
	6th Week	21.95 ± 9.45		24.09 ± 9.86	
EMG End of pull	Baseline	25.00 ± 9.79	0.009	27.54 ± 7.70	0.022
	2nd Week	22.86 ± 9.41		24.87 ± 8.33	
	4th Week	22.22 ± 8.98		24.81 ± 10.36	
	6th Week	21.09 ± 9.01		23.18 ± 9.14	
EMG Post Pull	Baseline	27.13 ± 11.10	0.000	28.66 ± 7.59	0.003
	2nd Week	24.00 ± 9.72		25.22 ± 9.48	
	4th Week	21.95 ± 8.65		25.00 ± 11.17	
	6th Week	22.27 ± 9.31		22.45 ± 9.17	

VAS: Visual analogue index, NDI: Neck disability index, EMG: Electromyography, SD: Standard deviation.

Table-2: Intergroup comparisons.

Variables		Group A Mean ± SD	Group B Mean ± SD	P-value
VAS	Baseline	5.54 ± 0.85	5.31 ± 0.47	0.081
	2nd week	3.86 ± 0.94	5.13 ± 0.90	0.000
	4th week	2.72 ± 1.03	3.61 ± 0.72	0.002
	6th week	1.06 ± 1.69	1.23 ± 9.2	0.001
Cervical Flexion	Baseline	58.27 ± 11.39	56.81 ± 12.3	0.686
	2nd week	67.04 ± 8.68	64.77 ± 9.31	0.407
	4th week	76.59 + 7.92	72.50 ± 9.35	0.125
	6th week	79.54 ± 7.85	73.86 ± 20.64	0.04
Cervical Extension	Baseline	44.54 ± 9.74	45.90 ± 10.76	0.662
	2nd week	52.50 ± 10.55	54.77 ± 11.90	0.506
	4th week	61.04 ± 9.54	60.22 ± 11.07	0.794
	6th week	64.31 ± 8.63	61.36 ± 12.92	0.378
Cervical right side flexion	Baseline	32.95 ± 5.26	31.36 ± 6.01	0.356
	2nd week	38.63 ± 4.13	36.59 ± 3.58	0.087
	4th week	42.27 ± 2.97	40.90 ± 3.33	0.159
	6th week	44.61 ± 7.96	41.04 ± 2.83	0.048
Cervical left side flexion	Baseline	33.40 ± 4.97	34.54 ± 8.85	0.602
	2nd week	37.86 ± 4.24	38.86 ± 8.00	0.608
	4th week	41.59 ± 3.58	42.40 ± 8.78	0.374
	6th week	43.63 ± 3.83	46.13 ± 10.11	0.288
Cervical right side rotation	Baseline	55.00 ± 12.9	57.31 ± 10.0	0.222
	2nd week	62.72 ± 13.70	65.45 ± 9.37	0.453

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	4th week	69.31 ± 13.65	70.68 ± 10.26	0.710
	6th week	74.31 ± 14.25	71.68 ± 19.32	0.02
Cervical left side rotation	Baseline	63.63 ± 12.26	63.18 ± 11.29	0.899
	2nd week	69.36 ± 12.73	70.22 ± 9.81	0.802
	4th week	70.68 ± 11.88	71.04 ± 9.34	0.674
	6th week	82.04 ± 11.71	74.92 ± 8.39	0.014
NDI	Baseline	27.22 ± 7.44	27.77 ± 6.20	0.793
	2nd week	23.18 ± 6.89	24.81 ± 6.33	0.417
	4th week	20.90 ± 7.33	21.68 ± 6.86	0.720
	6th week	13.81 ± 9.16	16.45 ± 9.53	0.355
EMG biofeedback pre-pull	Baseline	25.59 ± 9.9	31.07 ± 7.78	0.361
	2nd week	25.68 ± 9.36	28.13 ± 8.63	0.371
	4th week	24.86 ± 8.77	27.77 ± 9.50	0.297
	6th week	22.95 ± 10.12	25.68 ± 9.29	0.357
EMG biofeedback during pull	Baseline	25.95 ± 9.88	28.50 ± 7.93	0.351
	2nd week	23.77 ± 9.26	26.22 ± 7.87	0.349
	4th week	22.90 ± 9.08	25.59 ± 9.29	0.339
	6th week	21.95 ± 9.45	24.09 ± 9.86	0.467
EMG biofeedback end of pull	Baseline	25.00 ± 9.79	27.54 ± 7.70	0.345
	2nd week	22.86 ± 9.41	24.87 ± 8.33	0.602
	4th week	22.22 ± 8.98	24.81 ± 10.36	0.381
	6th week	21.09 ± 9.01	23.18 ± 9.14	0.449
EMG biofeedback post-pull	Baseline	27.13 ± 11.10	28.66 ± 7.59	0.597
	2nd week	24.00 ± 9.72	25.22 ± 9.48	0.678
	4th week	21.95 ± 8.65	25.00 ± 11.17	0.318
	6th week	22.27 ± 9.31	22.45 ± 9.17	0.438

VAS: Visual analogue index, NDI: Neck disability index, EMG: Electromyography, SD: Standard deviation.

In both the groups, neck pain and cervical ROM (flexion, right-side flexion, left-side rotation and right-side rotation) improved significantly post-intervention ($p<0.05$) (Table 1), but Group A values were significantly better than Group B ($p<0.05$)

(Table 2). Cervical disability and muscular tension were not significantly different in both intragroup and intergroup comparisons ($p>0.05$).

Discussion

In the current study, VAS scores indicated that pain levels in both the groups decreased significantly ($p=0.001$). A significant difference, however, was observed between the groups, with the treatment incorporating EMG biofeedback demonstrating a more substantial enhancement compared to the treatment lacking EMG biofeedback. Previous studies have also demonstrated that the implementation of a wireless EMG sensor during cervical traction treatment resulted in a substantial reduction in neck distress (-<0.05).[19,20] The findings are consistent with studies demonstrating the efficacy of EMG biofeedback cervical traction on patients with unilateral cervical radiculopathy, including reduced muscle tension, increased pain inhibition and more range of cervical movements compared to cervical traction alone.[21,22]

The current results showed that both the treatment groups attained a significant improvement in ROM, encompassing cervical flexion, cervical extension, cervical rotation to the right and left, and cervical flexion to the right and left sides ($p<0.01$). Nevertheless, intergroup comparison showed significant difference in left-side rotation ($p=0.014$), cervical flexion ($p=0.04$), and right-side rotation ($p=0.048$) in Group A. This discrepancy could potentially be accredited to sample inconsistency concerning the initiation of pain and preceding physical therapy interventions that were being applied at the onset. One 2020 study reported comparable results concerning the statistical improvement of neck ROM following cervical traction with EMG biofeedback[21] Furthermore, the effectiveness of cervical traction and conservative physical therapy in restoring ROM is

validated by prior research.[23,24]

Disability of the cervical spine was also an element of focus in the current study. There was no significant difference detected between the groups at the end of therapy and over time (p>0.05), signifying that both treatments had an identical effect on decreasing cervical impairment. Additionally, the results from the intragroup analysis showed that both the groups attained a drop in disability ratings (p=0.001). The result was consistent with the findings reporting that the application of wireless EMG biofeedback significantly reduced neck impairment (p=0.05).[19] A 2019 study to determine whether EMG biofeedback could efficiently increase the activation ratio of the upper trapezius to serratus anterior muscles during shoulder rehabilitation showed that EMG biofeedback was effective for stimulating these muscles. In addition, experiential studies have shown that cervical isometrics, electrotherapy and cervical traction were all efficacious in reducing neck disability.[25] Similar results were obtained in another study which reported that the combination of electrotherapy and cervical traction was a highly effective treatment for neck impairment (p<0.05).[26] Nevertheless, the current results failed to indicate any significant variations in the variable of neck disability.

An earlier research discovered that myoelectric activity decreased substantially (p<0.05) during cervical traction pulls in patients with unilateral cervical radiculopathy.[21] A 2004 study observed a substantial reduction in the myoelectric activity of the cervical muscles when used in conjunction with cervical traction, EMG biofeedback significantly reduced nerve root compression and prevented muscular spasms.[11]

The potential additional benefits of incorporating EMG biofeedback into a routine physical therapy regimen regarding disability and muscular tension showed no significant results. Further research can be done on functional mobility of the upper extremity and quality of life as supplementary outcomes.

Conclusion

When incorporated into a conventional physical therapy regimen, EMG biofeedback with traction decreased pain intensity and modulated the ROM.

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Conflict of Interest: None.

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Consolidated Standards of Reporting Trials (CONSORT) 2010 checklist.*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	4
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	4
Participants	4a	Eligibility criteria for participants	4
	4b	Settings and locations where the data were collected	4
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	5
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	5
	6b	Any changes to trial outcomes after the trial commenced, with reasons	4
Sample size	7a	How sample size was determined	4
	7b	When applicable, explanation of any interim analyses and stopping guidelines	4
Randomisation:			4
Sequence generation	8a	Method used to generate the random allocation sequence	4
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	4
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4

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Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	5
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	5
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	6
	13b	For each group, losses and exclusions after randomisation, together with reasons	6
Recruitment	14a	Dates defining the periods of recruitment and follow-up	6
	14b	Why the trial ended or was stopped	6
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	6
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	6
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	6
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	6
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	6
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	8
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	8
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	8
Other information			
Registration	23	Registration number and name of trial registry	9
Protocol	24	Where the full trial protocol can be accessed, if available	9
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	9

Citation: Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMC Medicine. 2010;8:18. © 2010 Schulz et al.

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up-to-date references relevant to this checklist, see www.consort-statement.org.

AUTHOR'S CONTRIBUTION:
SS: Daya collection, assembling, analysis and interpretation.
MK: Concept and design.
KAK: Drafting.
ZNQ: Data analysis and interpretation.
SO: Critical revision.
SK: Statistical expertise.