International
Journal of Medical and Exercise Science
(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

EFFECTS OF KINESIO TAPING IN SHOULDER SUBLUXATION FOR REDUCING PAIN AND JOINT SPACE IN STROKE PATIENT-A CASE STUDY

Search engine:
www.ijmaes.org

Thanzeena.S.S[1], Renjith.T.R[2], Sanju Vijayan[3], Jabir S[4], Andrews J Milton[5]

Corresponding Author:
[1]BPT Graduate, Department of Physiotherapy, Bethany Navajeevan College of Physiotherapy, Thiruvananthapuram, Kerala, Mail id: thanzeena22@gmail.com
Co-Authors:
[2]Assistant Professor, Bethany Navajeevan College of Physiotherapy, Thiruvananthapuram, Kerala
[3]BPT Graduate, Department of Physiotherapy, Bethany Navajeevan College of Physiotherapy, Thiruvananthapuram, Kerala
[4]Assistant Professor, Al Azhar College of Allied Health Science, Thodupuzha, Kerala
[5]Principal, Bethany Navajeevan College of Physiotherapy, Thiruvananthapuram, Kerala

ABSTRACT

Background of the Study: A male patient aged 66 year old male, came to Royal SUT Hospital with chief complaints of having severe pain and difficulty in shoulder movements in his left upper extremity for about two weeks. By checking his case sheet it was found that he had a history of stroke before one month. **Method:** MRI showed that it was the right MCA infarction. While he was admitted to ICU during the stroke his GCS score was E2V2M3. He was then intubated and started anticoagulation therapy. The physiotherapy interventions for the first 2 weeks include positioning, passive movements, DVT prevention, and airway clearance techniques from the third week, along with these interventions strengthening, balance and mobility training were also given. He had severe shoulder pain after one week and difficulty in shoulder movements. In the left UE, there was shoulder drooping and winging of the scapula, ROM was also decreased. Pain was assessed using VAS. For measuring shoulder subluxation, finger palpation method was used to evaluate sulcus sign. For reducing the pain and joint space related to subluxation therapeutic muscular technique of kinesio taping was applied for 4 weeks (10-12 hours per day) along with the routine conventional treatment. **Result:** The VAS score and sulcus sign indicates that after applying kinesio taping technique, there is marked reduction in pain and joint space in inferior shoulder subluxation. **Conclusion:** Based on the result of the present study it has been concluded that the kinesio taping is an effective intervention in reducing pain and joint space due to shoulder subluxation in stroke patient.

Keywords: MCA infarction, Kinesio taping, Sulcus sign, Shoulder Subluxation, VAS

Received on 24th October 2025; Revised on 18th November 2025; Accepted on 28th November 2025
DOI:10.36678/IJMAES.2025.V11I04.001

INTRODUCTION

Stroke (cerebrovascular accident [CVA]) is the sudden loss of neurological function caused by an interruption of the blood flow to the brain. Ischemic stroke is the most common type, affecting about 80% of individuals with stroke, and results when a clot blocks or impairs blood flow, impairs blood flow, depriving the brain of essential oxygen and nutrients. Hemorrhagic stroke occurs when blood vessels rupture, causing leakage of blood in or around the brain.

Strokes are classified by etiological categories (thrombosis, embolus, or haemorrhage), specific vascular territory (anterior cerebral artery syndrome, middle cerebral artery syndrome, and so forth), and management categories (transient ischemic attack, minor stroke, major stroke, deteriorating stroke, young stroke).The middle cerebral artery (MCA) is the most common artery involved in acute stroke. It branches directly from the internal carotid artery and consists of four main branches, M1, M2, M3, and M4. These vessels provide blood supply to parts of the frontal, temporal, and parietal lobes of the brain, as well as deeper structures, including the caudate, internal capsule, and thalamus.

Stroke is the fifth leading cause of death in the United States and the second leading cause of death worldwide. The overall prevalence of stroke in the U.S. is 2.6% in adults over 20 years old. Approximately 85% of these are ischemic strokes, and over half of all ischemic strokes occur in MCA territory. The risk increases as you get older; the risk is higher in men at a younger age, but the risk of death is higher overall in women. Modifiable risk factors include hypertension, smoking, obesity, alcohol consumption, hyper-lipidaemia, physical inactivity, diabetes, and cardiac causes such as cardiomyopathy, heart failure, atrial fibrillation etc.

Clinically, a variety of focal deficits are possible, including changes in the level of consciousness and impairments of sensory, motor, cognitive, perceptual, and language functions. The most common characteristics of MCA syndrome are contralateral spastic hemiparesis and sensory loss of the face, UE, and LE, with the face and UE more involved than the LE, Aphasia, unilateral neglect, anosognosia, apraxia, spatial disorganization, homonymous hemianopia etc. Medical management includes thrombolytic, Anticoagulants, Anti platelet therapy, Antihypertensive agents, Anti cholesterol agents, Antispasmodic agents, Anticonvulsants, Antidepressants etc. Carotid endarterectomy is a surgical procedure used to remove fatty deposits from the carotid artery.

Hemiplegic shoulder pain (HSP) and subluxation are common complications after stroke. The incidence of shoulder subluxation has been reported from 17-81% depending on the duration of the stroke and the diagnostic measurement and is probably the most cited problem causing shoulder complication after a stroke. The consequences that might follow would be shoulder pain, limitation of movement, injury to the neurovascular tissues around the shoulder joints and delayed neurological recovery after a stroke.

The kinesiology taping (also known as ‘elastic taping ‘) is a method invented by Dr. Kase in Japan in the 1970s. This method is different from strapping or rigid taping technique. The elastic tape is a hypoallergenic skin tape with elastic components. This kind of elastictape is designed to allow for a longitudinal stretch of 55-60% of its original extent. By using the kinesiology tape, different stretches and directions can yield different effects for

reducing pain, correcting alignment, facilitating neuromuscular activity, and alleviating inflammation and edema. So that it can be used for patients with shoulder subluxation to reduce the pain, and correct the subluxation.

Biomechanics

Sterno Clavicular Kinematics: The three rotational degrees of freedom at the sterno-clavicular joint are most commonly described as protraction/retraction, elevation/depression and anterior/ posterior rotation of the clavicle.

Elevation and Depression: The clavicular motions of elevation and depression occur around a approximately anteroposterior (A-P) axis between the convex clavicular surface and the concave surface formed by the sternum and first costal cartilage. The sterno clavicular joint axis is described as lying lateral to the joint at the costo-clavicular ligament. With clavicle elevation, the lateral end of the clavicle moves upward as the medial clavicle articular surface tolls superiorly and slides inferiorly on the sternum and first rib. During depression, the lateral clavicle moves downward as the medial clavicle articular surface rolls inferiorly and slides superiorly. The range of clavicular elevation has been reported up to 48°, whereas passive depression from neutral is limited to less than 159°. The full available range of clavicle elevation generally not used during functional arm elevation.

Protraction and Retraction: Clavicle protraction and retraction occur at the sterno clavicular joint around an approximately vertical axis that also appears to be located at the costoclavicular ligament with protraction, the lateral clavicle moves anteriorly in the transverse plane, while with retraction of the lateral clavicle moves posteriorly. During protraction, the medial clavicleis expected to roll and glide anteriorly on the sternum and first costal cartilage with the opposite joint kinematics occurring during retraction. Approximately 15° to 20°of protraction and 30° of retraction are available.

Anterior and posterior rotation: Anterior/ posterior rotation occurs as a spin between the saddle-shaped surfaces and inferior conus of the medial clavicle and manubrium costal facet and disc. The clavicle rotates primarily posteriorly from neutral, bringing the inferior surface of the clavicle to face anteriorly. This has also been referred to as backward or upward rotation rather than posterior rotation. From this posteriorly rotated position, the clavicle can then rotate anteriorly to return to neutral. Available anterior rotation past neutral is limited to less than 10°.The range of available clavicular posterior rotation may be as much as 50°.

Acromio clavicular kinematics: The primary rotations at the acromio clavicular joint are internal/external rotation, anterior/posterior tilting, and upward/ downward rotation.

Internal and external rotation: Internal/ external rotation of the scapula relative to the clavicle occurs around an approximately vertical axis through the acromio clavicular joint. Internal and external rotation at the acromio clavicular joint can be visualised best as orienting the glenoid fossa of the scapula anteromedially and postero laterally respectively. These motions occur in part to maintain contact of the scapula with the horizontal curvature of the thorax as the clavicle protracts and retracts, sliding the scapula around the thorax in scapular internal and external rotation. These motions also "aim" the glenoid fossa toward the plane of

humeral elevation, which is an important function for maintaining congruency and stability between the humeral head and scapula, and for maximizing the function of glenohumeral muscles, capsule, and ligaments. The available ROM at the acromio clavicular joint is difficult to measure.

Anterior and posterior tilting: Anterior/ posterior tilting of the scapula relative to the clavicle occurs around an oblique coronal axis through the joint. Anterior tilting has result in the acromion moving forward and the inferior angle of the scapula moving backward. During posterior tilting the acromion are moves backward and the inferior angle moves forward. Scapular tilting, like scapula internal/external rotation, occurs to maintain the contact of the scapula with the contour of the thorax and to orient the glenoid fossa relative to the humeral head. Available passive motion anterior/ posterior tilting at the acromio clavicular joint is 60° in cadaveric acromio clavicular joint specimens separated from the thorax. The magnitude of anterior/posterior tilting during in vivo arm elevation is approximately 20° although up to 40°or more may be possible in the full range from maximum flexion to extension.

Upward and downward rotation: Upward/ downward rotation of the scapula relative to the clavicle occurs about an oblique "A-P" axis that is roughly perpendicular to the plane of the scapula, passing midway between the joint surfaces. Upward rotation tilts the glenoid upward and moves the inferior angle laterally, while downward rotation does the opposite. The amount of available passive motion upward/downward rotation occurring directly at the acromio clavicular joint is limited by the coracoclavicular ligament. Conway describes 30°of upward rotation and 17° of downward rotation actively at the acromio clavicular joint in vivo. Others have described 15°- 16° of upward rotation occurring during active humeral abduction.

Glenohumeral Kinematics: The glenohumeral joint is usually described as having three rotational degrees of freedom: flexion/extension, abduction/ adduction, and medial/lateral rotation.

Flexion and extension: Flexion and extension occur about a coronal axis passing through the centre of the humeral head. The glenohumeral joint is often considered to have 120 of flexion and about 50 of extension.

Medial/Lateral rotation: Medial and lateral rotation occur about a long axis parallel to the shaft of the humerus and pasting though the outer of the humeral head. The range of medial/lateral rotation of the humerus varies with position. With the arm at the side, medial and lateral rotation may be limited. Abducting the humerus to 90° frees the arc of rotation, with glenohumeral values of 130°or greater.

Abduction and Adduction: Abduction/ adduction of the glenohumeral joint around an A-P axis passing through the humeral head centre. The range of abduction of the humerus in the frontal plane (whether the abduction is active or passive) will be diminished if the humerus is maintained in neutral or medial rotation. When the humerus is elevated in the plane of the scapula there is less restriction to motion because the capsule is less twisted than when the humerus is brought farther back into the frontal plane. The ROMs for abduction of the glenohumeral joint (If impact of the greater tubercle is avoided) are reported to be anywhere from 90°to 120°.

Static Stabilization of the Glenohumeral joint: The incongruence of the glenohumeral

articular surfaces, bony geometry alone cannot maintain joint stability with the arm relaxed at the side, requiring the contribution of other mechanisms. With the humeral head resting on the fossa, gravity imparts a caudally directed translator force on the humerus. To maintain equilibrium, acranially directed force is needed and could be supplied by active contraction or passive tension of muscles, such as the deltoid, supraspinatus or the longheads of the biceps brachii and triceps brachii. The structures of the rotator internal (superior capsule, superior glenohumeral ligament and coracohumeral ligament) that are taut when the arm is at the side possess both the magnitude and orientation for this stabilisation function.

The resultant vector formed from the gravity and rotator internal capsule vectors creates a force that compresses the humeral head into lower portions of the glenoid fossa and prevents inferior humeral head translation. In addition to passive tension from the rotator internal capsule, two other mechanisms help provide static stability in the glenohumeral joint with the arm at the side. In a healthy joint, the capsule is airtight and there is negative intra-articular pressure. This negative pressure creates a relatively inferior humeral translation caused by the force of gravity. Loss of intra-articular pressure produced by venting the capsule or tears in the glenoid labrum, results in large increase in inferior humeral translations. The degree of glenoid inclination also influences glenohumeral joint stability with the arm in the dependent position.

Paralysis or dysfunction in the supraspinatus may lead to gradual inferior subluxation of the glenohumeral joint. Without the reinforcing passive tension of the intact supraspinatus muscle, the sustained load on the connective tissue structures of the rotator internal capsule apparentlycan causes these structuresto gradually stretch (become plastic), which results in a loss of joint stability. Inferior glenohumeral subluxation is commonly encountered in patients with diminished rotator cuff function caused by stroke or other brain injuries.

Dynamic stabilization of shoulder joint

The Deltoid and Glenohumeral Muscle Stability: It is widely recognized that the deltoid muscle plays a key role (in conjunction with thenatus) in the movement of the gleno humeral joint during abduction. Additionally, the anterior deltoid is identified as the primary muscle involved in the movement of the glenohumeral joint during flexion. Both abduction and flexion are actions that involve elevation and share numerous biomechanical characteristics. The majority of the force of contraction of the deltoid from this initial position causes the humerus and humeral head to translate superiorly, because of the line of action of the deltoid with the arm at the side, only a small moment arm in this position directly contributes to rotation (abduction) of the humerus.

The Rotator Cuff and Glenohumeral Stabilization: The supraspinatus, infraspinatus, teres minor, and sub- scapularis muscles and tendons compose the rotator cuff. These muscles are considered to be part of a "cuff" because the inserting tendons of each muscle of the cuff blend with and reinforce the glenohumeral capsule both anteriorly (subscapularis) and posterior (supraspinatus, infraspinatus, and teres minor). Each of the rotator cuff muscles has lines of action that significantly contribute to the dynamic stabilisation.

The Supraspinatus and Glenohumeral Stabilization : The supraspinatus is still an effective stabilizer of the glenohumeral joint, however, because of its contribution to compression Because the more superior location of the supraspinatus results in a line of action that lies farther from the glenohumeral joint a ns than the action lines of the other rotator cuff muscles, the larger supraspinatus moment arm is capable of independently producing a full or nearly full range of glenohumeral joint abduction while simultaneously stabilising the joint. Gravity acts as a stabilising synergist to the supraspinatus by offsetting the small upward translatory pull of themuscle. The superior capsule and its connections to structures of the rotator interval capsule, sometimes considered part of the reinforcing cuff of the glenohumeral joint. The biceps muscle is capable of contributing to the force of flexion and can, if the humerus is laterally rotated, contribute to the force of abduction.

Scapulo humeral rhythm: Scapulohumeral rhythm (also referred to as glenohumeral rhythm) is the kinematic interaction between the scapula and the humerus, first published by Codman in the 1930s.The scapula and humerus move in 1:2 ratios. When the arm is abducted 180 degrees, 60 degrees occurs by rotation of the scapula, and 120 degrees by rotation of the humerus at the shoulder joint[13].

Intervention:

The Kinesio taping technique was applied in order to reduce pain and joint space related to shoulder subluxation. It aimed to activate the neuromuscular function and produce mechanical support to the shoulder. Tapes of 5 cm width were used for patients. The facilitation technique was used for the deltoid, supraspinatus, and teres minor.

First, the supraspinatus was taped. The shoulder was positioned in an abduction position at about 30 degrees with a slight flexion and internal rotation, and the humeral head was repositioned to the normal place. The first 4 cm of the tape was applied to the original site of supra spinatus (superior medial border of the scapula) with no tension and the remaining strip was applied over the muscle to the insertion site (greater tubercle of humerus) with about 25–50% of the full available tension. After this, the patient's shoulder was placed in abduction at 30 degrees. Taping of the middle part of deltoid muscle begun by attaching the first is by 4cm of the strip over the acromion process with no stretch. Then, the rest of the strip was stretched downward to the deltoid tuberosity with 20–30% of tension. For taping the teres minor, the shoulder was flexed with a little internal flexion. The base of the tape was placed on the inferior angle of scapula. The rest of the strip was stretched with 15–25% of tension and placed along the axillary border of the scapula to the greater tuberosity of the humerus.

The last one strip of tape was used to reduce the subluxation of the shoulder and was cut into Y shape before taping. After reposition of the shoulder, the tape was anchored at the midpoint of upper arm and then, the two strips were stretched with a tension of 50–70% and placed along the anterior and posterior borders of deltoid separately to above the acromio clavicular joint. Once the tape is applied next three day continues used the same tape. After removing the tape, the skin was cleaned with warm water to keep it healthy. After the third day we reapplication tape will be there. It continues 8 weeks[14] .

Purpose of the study: The purpose of the present study is to determine the effects of kinesio taping in shoulder subluxation for reducing pain and joint space in stroke patient.

Case Description:

Mr Salim, a 66 year old male, came to Royal SUT Hospital with chief complaints of having severe pain and difficulty in shoulder movements in his left upper extremity for about two weeks. By checking his case sheet it was found that he had a history of stroke before one month. MRI showed that it was the right MCA infarction. He also has a history of diabetes mellitus and systemic hypertension. While he was admitted to ICU during the stroke his GCS score was E2V2M3. He was then intubated and started anticoagulation therapy.

After 4 days he was shifted to the room and physiotherapy treatment had started from the fifth day itself. The physiotherapy interventions for the first 2 weeks include positioning, passive movements, DVT prevention, and Airway clearance techniques from the third week, along with these interventions strengthening, balance and mobility training were also given. Then he was discharged from the hospital and continued physiotherapy at home. For about past one week, he had severe shoulder pain and difficulty in shoulder movements. So he consulted a Neurologist, Radiograph of the shoulder in the AP view had been taken and it shows left inferior shoulder subluxation. Then the doctor referred him to the physiotherapy department.

On evaluation he was conscious and there is weakness on left arm and left leg. In the left UE, there was shoulder drooping and winging of the scapula. ROM were also decreased. Pain was assessed using VAS. For measuring shoulder subluxation, finger palpation method was used to evaluate sulcus sign. For reducing the pain and joint space related to subluxation therapeutic muscular technique of kinesio taping was applied for 4 weeks (10-12 hours per day) along with the routine conventional treatment.

Finger Breadth Grading Scale	
0	No Subluxation
1	½ finger breadth gap
2	1 finger breadth gap
3	11/2 finger breadth gap
4	2 finger breadth gap
5	21/2 finger breadth gap

Table 1. Finger breadth grading scale

Assessment chart		
Outcome Measures	**Test Result**	
	Pre-Test	**Post-Test**
Visual Analogue Scale	5/10	2/10
Finger Breadth (sulcus sign)	Two finger gap	Less than one finger gap

Table 2. Pre and post treatment assessment

RESULT OF STUDY

The vas score and sulcus sign indicates that after applying kinesio taping technique, there is marked reduction in pain and joint space in inferior shoulder subluxation.

DISCUSSION

Stroke is a serious medical condition that occurs when blood flow to the brain is disrupted either due to ischemia or haemorrhage. This will results in sudden loss of neurological function .Hemiplegia is the total or partial paralysis of one side of the body. MCA stroke is the common type. It usually causes contralateral spastic paresis and sensory loss of face [1]5.

Shoulder subluxation is a common complication that can occur after a stroke. About 81% of individuals will have & post-stroke shoulder subluxation. Muscle weakness is the primary reason. Kinesio taping can be applied to the shoulder muscles to treat shoulder subluxation. This case report is an example of the effects of kinesio taping in shoulder subluxation for reducing pain and joint space in stroke patient. Patients participated in a 4 week session along with routine conservative treatment interventions.

It is reasonable that the reduced shoulder subluxation can decrease the stimulation of nociceptors, resulting in pain modulation also. The alignment correction and intramuscular effect of taping has been widely examined and accepted. Reduction in subluxation can provide an opportunity to the injured tissue to heal[16].

Kinesio Taping can provide immediate benefits in proprioception and pain relief, making it useful for acute situations. It also allows for movement and may enhance functional performance better than rigid bracing, which limits motion. Kinesio Taping can be an effective tool for improving instability, particularly when used alongside other techniques. Its ability to enhance proprioception while allowing movement makes it a valuable addition to rehabilitation and performance strategies[17,18].

This study result also shows that kinesiology taping is effective in reducing pain and joint

space associated with shoulder subluxation in hemiplegic conditions[19].

CONCLUSION

Based on the result of the present study it has been concluded that the kinesio taping is an effectiveinterventioninreducingpainandjoints paceduetoshouldersubluxationinstroke patient.

REFERENCE

1. Susan B. O'Sullivan ,Thomas J. Schmitz, George D. Fulk, Physical Rehabilitation, Sixth edition
2. Lin Yang et al, "The Effect of Kinesiology Taping on the Hemiplegic Shoulder Pain: A Randomized Controlled Trial", Hindawi Journal of Healthcare Engineering, 2018.
3. N. Sayiner Caglar et al ,"Pain syndromes in hemiplegic patients and their effects on rehabilitation results", Journal of PhysicaltherapyScience,vol.28,no. 3,pp.731–737, 2016.
4. S. Suethanapornkul et al, "Post stroke shoulder subluxation and shoulder pain: a cohortmulti centre study, Journal of the Medical Association of Thailand, vol. 91, no. 12, pp. 1885–1892, 2008.
5. M. Paci et al Shoulder subluxation after stroke: relationships with pain and motor recovery, Physiotherapy Research International, vol. 12, no. 2, pp. 95–104, 2007.
6. Arya K.N et al, Rehabilitation methods for reducing shoulder subluxation in post-stroke hemiparesis: a systematic review. Topics in stroke rehabilitation. 2018 Jan 2; 25(1):68-81.
7. Anwer S et al, Incidence, prevalence, and risk factors of hemiplegic shoulder pain: a systematic review. International journal of environmental research and public health. 2020 Jul; 17(14):4962.
8. Stolzenberg D et al, Current and future interventions for glenohumeral subluxation in hemiplegia secondary to stroke. Top Stroke Rehabilitation 2012; 19:444-456.
9. Kumar P et al, Risk and associated factors for hemiplegic shoulder pain in peoplewith stroke: a systematic literature review. Physical Therapy Reviews. 2022; 27(3):191–204.
10. Pamela k Levangie, Cynthia. C. Norkin, Joint Structure and Function, a Comprehensive analysis, sixth edition. DavidJ. Magee, Orthopaedic Physical Assessment, Sixthedition
11. Huang SW, Liu SY, Yang CP. Relationship between severity of shoulder subluxation and soft tissue injury in hemiplegic stroke patients. Journal of Rehabilitation Medicine. 2012 Sep; 44(9):733-9.
12. Hartwig M,Gelbrich G, Griewing B. Functional orthosisin shoulder joint subluxation after ischaemic brain stroke to avoid post-hemiplegic shoulder-hand syndrome: a randomized clinical trial. Clinical Rehabilitation. 2012 Sep; 26(9):807-16.
13. Eljabu W, Klinger HM, von Knoch M. The natural course of shoulder instability and treatment trends: a systematic review. J Orthop Traumatol. 2017 Mar; 18(1):1-8.
14. Najenson T, Yacubovich E, Pikielni SS. Rotator cuff injury in shoulder joints of hemiplegic patients. Scand J Rehabil Med. 1971; 3(3):131-7.
15. Murie-Fernández M, CarmonaIragui M, GnanakumarV, MeyerM, FoleyN,Teasell R. Painful hemiplegic shoulder in stroke patients: causes and management. Neurologic. 2012 May; 27(4):234-44.
16. Wei Gong et al, Effect of kinesio taping on

shoulder pain after stroke, Journal of Hainan Medical University 2018; 24(20): 77-80.

17. Bimo Sutomo et al, Effects of Elastic Taping Application Added on Conventional Rehabilitation Therapy to Improve Shoulder Pain and Upper Extremity Motor Function on Subacute Phase Stroke Patients with Shoulder Subluxation, Indonesian Journal of Physical Medicine and Rehabilitation 2020;9(02), 95 - 112.
18. Yim J, Kim B. Effectiveness of Shoulder Taping in Treating Hemiplegic Shoulder Subluxation: A Randomized Controlled Study of 35 Patients. Medical Science Monitor, 2024 May 31.
19. Mariela Filipova et al, The application of kinesio tape in thrombolysed patients with ischemic stroke, Journal of IMAB-Annual Proceeding Scientific Papers 29 (2), 4935-4938, 2023.

Thanzeena. S.S, Renjith. T.R, Sanju Vijayan, Jabir S, Andrews J Milton (2025). Effects Of Kinesio Taping In Shoulder Subluxation For Reducing Pain And Joint Space In Stroke Patient-A Case Study , ijmaes; 11(4); 2546-2555.