Abstract

The plantar reflex (PR) is a polysynaptic superficial reflex. It is a sensitive and reliable method for evaluating the integrity of the motor pathways to the lower limb, but can be misinterpreted if not properly elicited. This article focuses on the anatomical considerations, elicitation, and interpretation of the plantar reflex. The physiological basis of Babinski’s sign, i.e., an abnormal extensor Plantar response, its causes and fallacies in the interpretation of the response are discussed while also highlighting the alternate methods of eliciting the extensor plantar response.

Keywords: Plantar reflex (PR), Babinski’s sign

Introduction

The plantar reflex (PR) is one of the most important and well studied reflex in the body; and yet its elicitation and interpretation remains an art. It is basically a polysynaptic superficial reflex, designed to withdraw the stimulated part, i.e., the foot from a potentially dangerous stimulus.

Anatomical considerations

The reflex arc for the PR comprises of the afferent and efferent fibres in the tibial nerve and the L4-5 to S1-2 cord segments. The reflexogenic area is the first sacral dermatome, with the receptor nerve endings being located in the skin on the sole of the foot. The afferent fibres travel in the tibial nerve which is a branch of the sciatic nerve, to relay in the L4-5 to S1-2 cord segments. The efferent fibres from the spinal cord travel back in the sciatic nerve which divides into two large branches just proximal to the knee. Fibres supplying the toe flexors travel in the tibial nerve while those supplying the toe extensors travel in the peroneal nerve to reach the foot. Injury or transection of the tibial nerve therefore, would interrupt the afferent and efferent arcs of the normal plantar response, leaving the toe extensor muscles innervated. Interruption of the reflex arc can cause a diminution or absence of the reflex.

Supraspinal influences from the cortex also influence and modify the spinal reflex or response. Impulse from the lumbosacral cord segments ascend up through the spinal cord and the brainstem to the parietal areas of the brain, which in turn has connections with the motor centres of the cortex. Efferent impulses from motor and premotor areas then descend down, either in the corticospinal pathways or in intimate association with them, to terminate in relation to the anterior horn cells in the lumbosacral cord segments subserving the plantar reflex. As a consequence, a lesion anywhere along the corticospinal pathway can modify the response on the contralateral side of the body if the lesion is above the pyramidal decussation, and on the same or homolateral side of the body if the lesion is below the medullary decussation in the cord itself. The PR being a polysynaptic reflex, the interneurons in the reflex arc connect with motor neurons at several segmental levels, leading to a co-ordinated motor response or movement of the foot and lower limb following cutaneous stimulation of the sole of the foot. (N. B.: Interneurons are groups of neurons between sensory and motor neurons that govern co-ordinated activity).

Elicitation of the plantar reflex (PR)

The PR is elicited by stroking the lateral or outer border of the sole of the foot with the thumb nail or a blunt point like the end of the handle of the reflex hammer or the tip of a key. The stimulus is directed from the heel forwards towards the little toe, and on reaching the foot pad, directed transversely across the metatarsal pad from the little to the base of the great toe. The stimulus should stop short of the base of the toes because extending the stroke to the base of the toes produces unpredictable movements.

Before eliciting the reflex, the patient should be instructed to relax and let his limb remain as floppy as possible. The
leg should be positioned in such a way that the knee is straight or slightly flexed and the thigh externally rotated. It is important to distract the patient with conversation after warning him that the sole of the foot will be scratched. It is advisable to hold the patient's ankle with one hand, to keep the foot in place and control the pressure of the plantar stroke. The stimulus should be firm, gentle and should cause neither pain nor tickle. A sharp stimulus is applied only if the initial stimulus fails to elicit a response. The response can be reinforced by rotation of the patient's head to the opposite side. Following the stimulus, it is important to watch the big toe at the metatarsophalangeal joint and the remainder of the foot. The response usually occurs after the plantar stroke has moved a few centimeters along the sole to produce a spatial and temporal summation of the applied stimulus.

Interpretation of the response
The plantar response may be:
1. Normal flexor plantar response
2. Pathologic or abnormal extensor plantar response (Babinski's sign)

Normal flexor plantar response
In normal people after infancy, there is a plantar flexion of the foot and toes along with adduction of the toes. The primary movement is a plantar flexion of the great toe at the metatarsophalangeal joint, even if the terminal joint appears to extend. The response is a fairly rapid one and may be accompanied at times by an associated flexion of the hip and knee on the stimulated side.

Abnormal extensor plantar response (Babinski's sign)
Joseph Babinski, a French neurologist, first differentiated between a normal and a pathologic plantar response and described the Babinski sign in 1896. The Babinski's sign is encountered in patients with pyramidal tract dysfunction and is characterised by a dorsiflexion or extension of the great toe with or without fanning or abduction of the other toes. The fully developed response is also accompanied by dorsiflexion of the ankle and flexion of the hip and knee joint and slight abduction of the thigh, leading to a withdrawal of the leg on plantar stimulation. The Babinski sign is always pathological. There is no such thing as a negative Babinski sign.

The muscles taking part in a fully developed response include the extensor hallucis longus, tibialis anterior, extensor digitorum longus, hamstring group of muscles, and the tensor fasciae latae. The dorsiflexion of the toes may be the only visible effect, but the contraction of the thigh and leg muscles is always present and can be detected by palpation. Contraction of the tensor fasciae latae has been referred to as Brissaud's reflex.

The fully developed extensor plantar response forms part of the primitive 'flexion reflex synergy' of the lower limbs designed to withdraw the limb from a painful stimulus. This spinal defence reflex mechanism described by Sherrington, activates all the muscles involved in shortening the stimulated limb. It involves flexion of the hip and knee, dorsiflexion of the ankle and extension of the great toe. The 'toe and foot extensors' although named extensors by anatomists, are in fact flexor in a physiological sense, because their action is to shorten the limb and contract reflexly along with other flexor muscles. The physiologist looks on the Babinski sign as simply a part of the 'primitive flexion reflex'.

The Babinski sign may be a normal occurrence in the first year of life. In the infant, before myelination of the nervous system is complete and an upright stance has been achieved, the normal plantar response is extensor, due to a brisker 'flexion synergy' as part of the withdrawal response to pain. As the nervous system matures and the pyramidal tracts gain more control over spinal motor neurons, the 'flexion synergy' becomes less brisk and the toe 'extensors' are no longer a part of it. When the child assumes an upright posture, the plantar response becomes part of the postural reflex maintaining the tones of the foot and leg. At this time, the normal response to stimulation becomes a flexor movement of the toes and the 'withdrawal extensor' movement is suppressed by the influence of the pyramidal tract over the spinal reflex arc. The toe then goes down instead of up, as a result of a segmental reflex involving small foot muscles and the overlying skin.

The pyramidal tract thus maintains a suppressor action on the 'flexion reflex' synergy. Pyramidal tract dysfunction however, allows the response to revert to the primitive
withdrawal movement by releasing or facilitating the ‘flexion reflex synergy’ of which contraction of the extensor hallucis longus muscle forms an integral part. A Babinski sign can appear only if the intraspinal pathways of the ‘flexion reflex synergy’ are operative, however severe the motor deficit in the foot. The motor neurons of the leg muscles are laminated into separate columns within the anterior horns of the cord, each of which supply proximal or distal flexor or extensor muscles. Both structural as well as functional lesions of the pyramidal tract fibres projecting onto the lumbosacral anterior horn cells and interneurons supplying the leg muscles subserving the ‘flexion reflex synergy’ can release the Babinski sign. Reversible pathophysiologic conditions result in, or produce, a transient extensor plantar response. Structural lesions produce more lasting effects.

Causes of an extensor plantar response

- Pyramidal tract lesions
- Normal children upto one year of age
- Deep sleep
- Coma
- General Anaesthesia
- Post-ictal stage of epilepsy
- Electroconvulsive therapy (ECT)
- Hypoglycaemia
- Alcohol intoxication
- Narcosis
- Hypnosis
- Following severe physical exhaustion
- Head trauma with concussion.

Types of Babinski sign

- True Babinski sign – includes all the components of the fully developed extensor plantar response.
- Minimal Babinski sign – is characterised by contraction of the hamstring muscles and the tensor fasciae latae which can be detected by palpation of the thigh.
- Spontaneous Babinski sign – is encountered in patients with extensive pyramidal tract lesions. Passive flexion of the hip and knee or passive extension of the knee may produce a positive Babinski sign in adults, as may foot manipulation in infants and children.
- Crossed extensor response/bilateral Babinski sign – may be encountered in cases with bilateral cerebral or spinal cord disease. Unilateral foot stimulation elicits a bilateral response in such cases.
- Tonic Babinski reflex – is characterised by a slow prolonged contraction of the toe extensors. It is encountered in patients with combined frontal lobe lesions and extrapyramidal involvement.
- Exaggerated Babinski sign – may take the form of a flexor or extensor spasm. Flexor spasms can occur in patients with bilateral UMN lesion at the supraspinal or spinal cord level. Extensor spasms can occur in patients with bilateral corticospinal tract lesion but preserved posterior column function.

Babinski mimickers

- Pseudo Babinski sign
- Inversion of plantar reflex
- Withdrawal response

Pseudo Babinski sign

This sign may be encountered in patients with choreoathetosis where the upgoing toe is a manifestation of hyperkinesia.

Inversion of the plantar reflex

If the short flexors of the toe are paralysed, or the flexor tendons have been severed, an extensor plantar response may be obtained even in the absence of UMN lesions and is termed inversion of the plantar reflex of peripheral origin.

Withdrawal response

Most people tend to withdraw their feet from a plantar stimulus as they are unable to tolerate the sensation. This reflex withdrawal interferes with the normal response. It is basically a voluntary movement or withdrawal due to a ticklish or unpleasant sensation. It is encountered in sensitive individuals or patients with plantar hyperaesthesia due to peripheral neuritis, and can be
confused with a positive Babinski’s sign. It is characterised by a dorsiflexion of the ankle along with hip and knee flexion. In such a situation, it is important to repeat the stimulus more gently and hold the foot at the ankle, or try alternative stimuli. A true Babinski sign can be clinically distinguished from the false Babinski by a failure to inhibit the extensor response by pressure over the base of the great toe. Moreover, unlike the voluntary withdrawal of the toes, the true Babinski sign is reproducible.

Fallacies in the interpretation of the plantar response

- No response to the plantar stimulus may be observed in certain situations. Patients with callosities of the feet may be unable to feel the plantar sensation. Sensory loss in the S1 dermatome may be encountered in patients with peripheral neuropathy or tibial nerve injury and it interferes with the afferent limb of the reflex arc leading to an absence of the reflex.

- Cases with proven damage to the pyramidal system may have a normal plantar response. The possible explanation for this is that corticospinal fibres not only originate in different parts of the cortex, but also have different terminations. Babinski sign can be expected only when the leg fibres of the pyramidal tract are involved.

- An extensor plantar response may be obtained in the absence of damage to the pyramidal tract due to possible dissociation of the nerve fibres in the spinal reflex arc, with excitation of the distal motor neurons and inhibition of the impulses via flexor reflex afferent nerve fibres, since they are mediated by different neurons.

- Babinski response may not be observed in UMN lesions with complete paralysis of the extensors of the toes. The toes are unable to extend due to a total paralysis of the muscles. In such cases, contraction of the tensor fasciae latae may be taken as a positive sign.

- Bony deformities like ‘hallux valgus’ may prevent any movement of the big toe. In such a situation it is important to observe the movement of the other toes.

- In patients with ‘pes cavus’ it is difficult to assess the movement of the big toe. The toe could be so retracted as to appear to be in the extensor position to start with. In such a situation, it is important to observe the movement at the metatarsophalangeal joint because if the terminal joint alone is observed, a further extension of the same may be quite misleading.

- An equivocal response is sometimes observed and is difficult to interpret.

Role of videotape and EMG in the interpretation of the Plantar Response

A positive Babinski sign is confirmed if:

- The upward movement of the great toe is caused by contraction of the extensor hallucis longus muscle (EHL).

- Contraction of the EHL occurs synchronously or concurrently with reflex activity in other flexor muscles that may or may not be brisk enough to be appreciated visually.

Videotaping and EMG can thus aid the clinical interpretation in patients with unexpected finding or an equivocal response.

Alternate methods to elicit the extensor plantar response

The method of Babinski is probably the most sensitive and reliable method for elicitation of the plantar reflex, but may at times fail to do so or produce an equivocal response. Other methods can then be used to elicit the response and include some of following techniques:

- Chaddock’s sign: The stimulus is applied along the lateral aspect of the foot, below the external malleolus.

- Oppenheim’s reflex: Firm pressure is applied along the shin of the tibia from below the knee up to the ankle with the knuckles of the examiner’s index and middle finger.

- Gordan’s sign: The calf muscle is squeezed.

- Schaefer’s sign: Squeezing the Achilles tendon.

- Gonda’s sign: The fourth toe is pressed downwards
and then released with a snap.

- **Stransky sign**: The fourth toe is abducted maximally and then released suddenly.
- **Bing’s sign**: Multiple pinpricks are given on the dorsolateral surface of the foot.
- **Moniz sign**: The ankle is forcefully plantar flexed and then released.
- **Thockmorton sign**: The dorsal aspect of the metatarsophalangeal joint of the great toe is percussed.
- **Strumpell sign**: Forceful pressure is applied over the anterolateral region.
- **Cornell sign**: The dorsum of the foot is scratched along the inner side of the extensor tendon of the great toe.

Most of these signs imply an increase in the reflexogenous zone and denote responses from different parts of the receptive field. When sufficiently facilitated, the reflex may be elicited by other stimuli as well. Indeed, in extreme cases of UMN deficit, the complete ‘flexion reflex’ may be exhibited spontaneously and continuously; the patient lies in bed, the hip and knee flexed, and the ankle and great toe dorsiflexed. In other cases of severe UMN deficit, almost any unpleasant stimulus, such as scratching, pinching, or pricking, will evoke the ‘flexion reflex’, even when applied as high as the thigh, far from the usual reflexogenous zone.

In conclusion, the plantar reflex (and the Babinski sign) is a sensitive and reliable method for evaluating the integrity of the nervous system and motor pathways to the lower limbs. Historically, unknown to Babinski, several painters like Botticelli, Raphael, and Leonardo da Vinci had already demonstrated this phenomenon in their paintings, thereby blending art with science. Even though its elicitation is an art and observer bias may occur with regards to its interpretation, its clinical utility remains unchallenged.

**References**


**ANNOUNCEMENT**

A new service has been launched that has been specifically designed to provide medical researchers/scientists facility to self-archive their articles/publications. This service, OpenMED@NIC, an open Access Archive for MEDical and Allied Sciences is available from [http://openmed.nic.in](http://openmed.nic.in). This is a discipline based/International Archive that accepts both published and unpublished documents having relevance to research in Medical and Allied Sciences including Bio-Medical, Medical Informatics, Dental, Nursing, and Pharmaceutical Sciences. These could be preprints (pre-refereed journal paper), postprints (refereed journal paper), conference papers, conference posters, presentations, technical reports/departmental working papers and theses. In case of non-English documents, descriptive data (Author, Title, Source, etc.), abstract, and keywords must be in English. Submitted documents will be placed into the submission buffer and would become part of OpenMED archive on their acceptance.

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