

Tonic Reflexes of the Foot

THEIR ORTHOPAEDIC SIGNIFICANCE IN NORMAL CHILDREN AND IN
CHILDREN WITH CEREBRAL PALSY*†

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Certain tonic reflex movements of the foot are worthy of orthopaedic interest, for they are a potential cause of deformity. These reflexes are easily elicited at birth and normally disappear in an orderly sequence during the first years of life. If one or more reflexes fail to disappear, a reflexly induced deformity may occur. The concept of reflexly induced deformity is that if a reflex movement repeatedly occurs, the involved structures will eventually assume the distorted attitude produced by the reflex movement, and a contracture develops. Such deformities are more common in patients with cerebral palsy in whom disappearance of these reflexes is frequently delayed, but they are also observed in essentially normal infants during the first year of life. Recognition and management of these deformities require understanding of the reflexes, including the areas of elicitation, adequate stimulus, and the pathway of the reflex arc.

Reflex movements of the foot in response to cutaneous stimulation have been observed in the human fetus at the eleventh week of menstrual age¹¹. By the fourteenth week, the majority of reflexes encountered in the neonate are readily obtainable. In the first hours and days after birth there is a rapid diminution of reflex activity⁵ that continues at a lesser rate until, by the end of the first year, superficial reflex activity cannot be elicited by ordinary means of stimulation. The disappearance of superficial reflex activity of the foot is presumed to be due to a suppression accomplished by the maturing cerebral cortex³ because removal of certain areas of the cerebral cortex causes the return of previously suppressed reflexes. In children with brain damage the suppressive ability of the cortex is evidently impaired, since superficial reflex activity of the foot may persist throughout childhood.

The term tonic is employed because these reflex movements occur slowly, as though tonus or tension was accumulating, in contrast to the abrupt phasic response of a tendon jerk. These reflex movements are patterned responses requiring coordinated participation of several muscles. There is a compulsive quality of the movement that prevails despite the patient's obvious efforts to resist. Tonic reflexes are characterized by a substantial latent period (one to three seconds) between the initial stimulus and the responsive movement. They are superficial reflexes in that they are elicited by stimulation of the skin alone. Four tonic reflexes of the foot are recognized:

1. The toe-grasping reflex (Fig. 1-A) is a flexion and adduction of the toes in response to stimulation of the ball of the foot, near the base of the second and third toes. Since Barraquer's original description in 1921, the many interesting features of the toe-grasping reflex—its presence in normal infants⁴, persistence in children having mongolism⁴, reappearance in monkeys after premotor lesions¹², similarity to the grasping reflex of the hand¹⁴, and its function as part of the righting reflex mechanisms¹²—have been the subject of considerable investigation and of excellent reviews^{3,9,14}.

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2. The inversion reflex * (Fig. 1-B) is a tonic inversion of the foot in response to stimulation of the medial border of the foot near the head of the first metatarsal. The prime movers appear to be the anterior and posterior tibial muscles. Flexion or extension of the toes is variable. The toes usually deviate toward the medial border of the foot.

3. The eversion reflex * (Fig. 1-C) is an eversion of the foot in response to stimulation of the lateral border of the foot over the head of the fifth metatarsal and the base of the little toe. Primary muscle activity is observed in the peroneals, principally the peroneus brevis. The toes often deviate toward the lateral border of the foot with a fanning effect. Flexion or extension of the toes is variable.

4. The dorsiflexion reflex * (Fig. 1-D) is a dorsiflexion of the foot in response to stimulation of the central portion of the plantar surface of the heel. The prime mover is the tibialis anterior. The extensors of the toes frequently participate. The similarity of this reflex to the dorsiflexion movement that occurs in the triple-flexion response is evident; however, the frequently observed associated extension of the hip and knee is in distinct contrast to the flexion of the hip and knee that occurs in the triple-flexion response.

METHOD

The children included in this study came from the Children's Orthopedic Hospital, the Boyer Avenue Spastic Preschool and Clinic, and the Warren Avenue Spastic School, where I have had the opportunity to supervise orthopaedic care. One hundred and fifty children, of all ages, with cerebral palsy were available for periodic study. Fifty normal subjects and eight patients with spinal paraplegia (three children, five adults) were also observed in the hospital wards and in private practice.

The ultimate adequate stimulus for these reflexes is not understood. In the newborn, the lightest touch on the ball of the foot is sufficient to produce the toe-grasping reflex ^{4,13}. This form of stimulation, although equally adequate in the neonate for the other three tonic reflexes of the foot, rapidly loses its effectiveness during the first months of an infant's life. It is then that the value of a summated stimulus becomes evident. Digital stroking and brushing, although useful, do not afford a continuous uniform stimulus on which to base day-to-day observations. A small electrical massage vibrator † fitted with a soft sponge-rubber applicator was finally selected for these studies. During operation, the applicator moves a few millimeters across (or with) the skin sixty times per second. The impact of the stroke is comfortably low. The effect of this vibratory stimulator is not confined to the skin alone, but is transmitted for some distance through the underlying tissues. If applied directly over the belly of a spastic muscle, the stimulator may induce a contraction of the muscle; this possibility does not impair its usefulness as a surface stimulator but does demand critical interpretation of any movements induced.

During the testing, each patient was recumbent, with the feet extended over the edge of the examining table. Visual stimulation ⁶ was allowed, in as much as no blindfold or shield was used. The sponge applicator of the vibrator was held gently against the reflexogenous area and moved with the foot as the reflex movement occurred. Stimulation was continued until the reflex ceased and the foot moved away from the stimulator. The duration (in seconds) of the reflex was recorded. No attempt was made to record movement that persisted longer than thirty seconds.

* The descriptive terms, inversion, eversion, and dorsiflexion, were selected by me in 1955, in the absence of prior reference. The selection was made in keeping with the suggestion of Wartenburg that reflexes should be named on the basis of the reflex movement evoked rather than on the point of stimulation. The recent publication of Fradis and Botez employs the terms "medial groping" and "lateral groping" to describe, perhaps more aptly, movements similar, if not identical, to what I call the inversion and the eversion reflexes. However, the functional significance of these motions may be other than that of groping.

† Andis Vibrator, Type A.V., 110 volts, 60 cycles, 15 watts.



FIG. 1-A

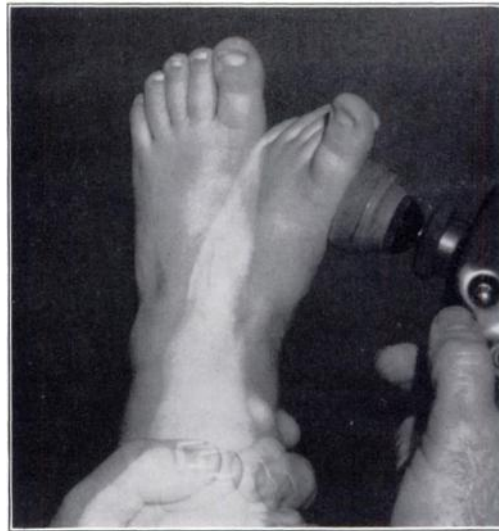


FIG. 1-B



FIG. 1-C

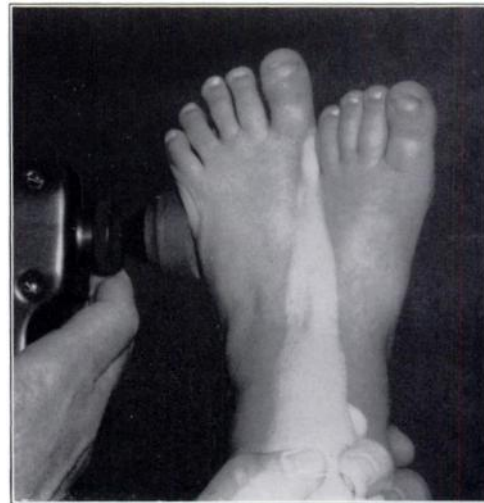


FIG. 1-D

Figs. 1-A through 1-D: Four tonic reflexes of the foot. Shadow views made with exposure before and during application of the vibratory stimulator.

Fig. 1-A: Toe grasping.

Fig. 1-B: Inversion.

Fig. 1-C: Eversion.

Fig. 1-D: Dorsiflexion.

It is also possible, although less comfortable for the patient, to obtain these reflexes by electrical stimulation. Several patients were tested with a Sanborn stimulator, with which various frequencies and pulse widths to the reflexogenous area through bipolar skin electrodes were applied. The optimum pulse duration was one millisecond.

The optimum frequency of seventy per second corresponds favorably with that of the test vibrator and with optimum frequencies for direct electrical stimulation of muscle ⁷.

Electromyographic recordings were made on a Grass eight-channel oscillograph with bipolar surface electrodes in preference to needle electrodes, whenever possible. Action potentials from various combinations of as many as seven muscles were recorded simultaneously while the reflexes were being elicited and

while the patient was standing, balancing, and walking. Three paraplegics, twenty-two children with cerebral palsy, and six normal children and adults were studied electromyographically. Subcutaneous temperature readings were obtained with a needle thermistor and recorded on a tele-thermometer (model 44 TA).

OBSERVATIONS

Reflexogenous Areas

The size of the skin areas wherein these reflexes may be elicited (Fig. 2) is extensive at birth, but gradually diminishes as the reflex disappears during maturation. The reflexogenous areas are not circumscribed, there being a gradation of sensitivity from the central area to the periphery. If a reflex remains active for several years, which frequently occurs in children with cerebral palsy, there is often an unexplained spread of the reflexogenous area, with the result that it occasionally includes the entire foot. Persistence of extensive reflexogenous areas becomes an ominous sign, suggestive of delayed cortical maturation.

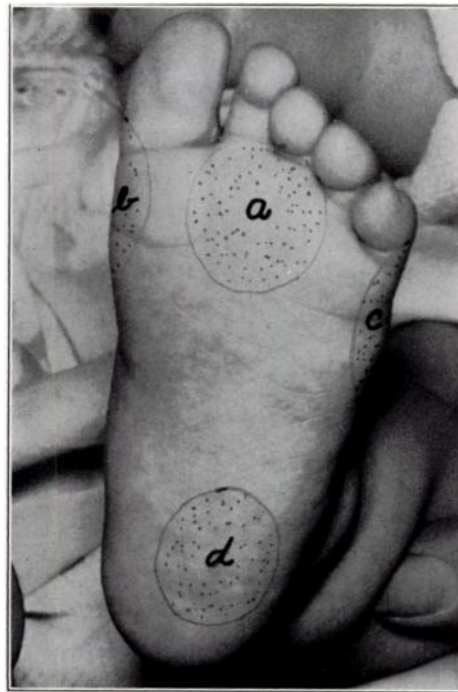


FIG. 2

Typical reflexogenous areas: *a* = toe-grasping reflex; *b* = inversion reflex; *c* = eversion reflex; *d* = dorsiflexion reflex.

Sensory Receptors

It seemed important to determine whether these reflexes were mediated through skin receptors or deep proprioceptive receptors, or both. In the monkey, the toe grasp can be elicited even when the entire plantar skin is anesthetized with novocain². In man, somewhat to the contrary, it has been reported¹⁴ that stimulation of both skin and subcutaneous tissue is necessary to elicit a true instinctive grasp reaction because skin stimulation was considered necessary to initiate the reflex and stimulation of the deep stretch receptors that are necessary to reinforce the strength (holding phase) of the movement. In the present studies it was possible to abolish each of the four tonic reflexes of the foot by local infiltration of procaine into the appropriate reflexogenous areas. The effectiveness of the block was confirmed electromyographically (Fig. 3). Since it is difficult, if not impossible,

to limit the infiltration to the skin alone, the experiments were repeated using ethyl-chloride spray. This was equally effective. To exclude the possibility that the nerve receptors in the subcutaneous tissues were also being cooled by the spray, a needle thermistor was inserted immediately under the skin, with proper insulation of the hilt of the needle, and the skin surface was again sprayed with ethyl chloride. With this technique it was possible to block the reflexogenous area without a measurable drop in the temperature of the subcutaneous tissue. Thus, it seems conclusive that these reflexes are mediated through skin receptors. As observed in palmar grasping², if only a portion of the reflexogenous area was anesthetized, the reflex could still be elicited from the non-anesthetized area. Deep tendon reflexes (Rossolimo) could be obtained by tapping of the anesthetized skin.

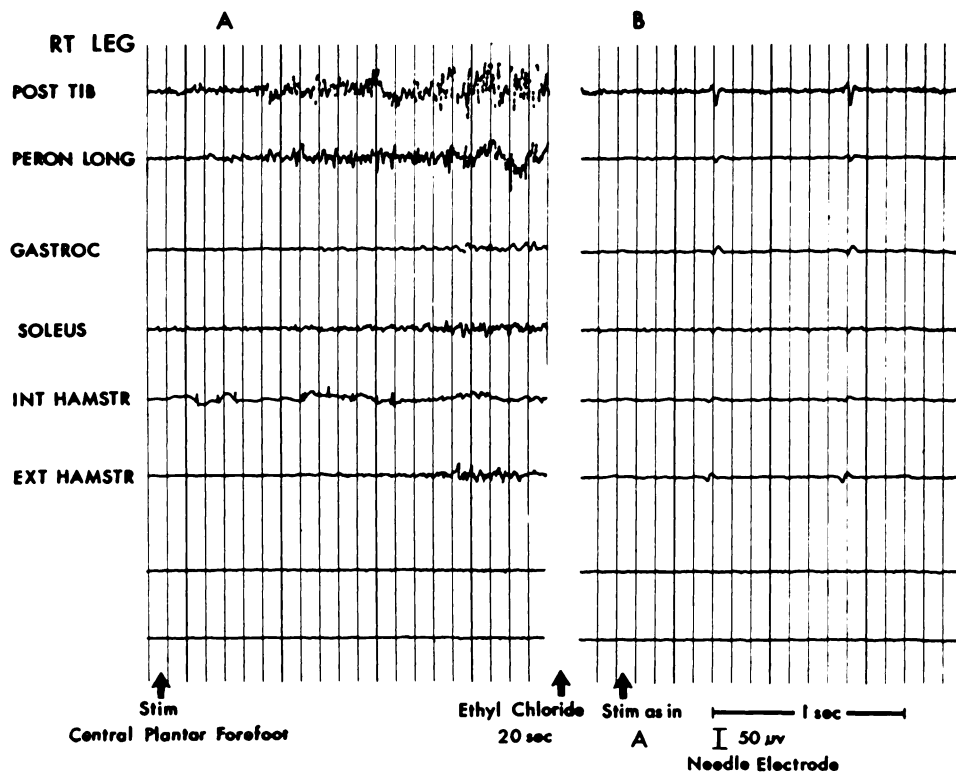


FIG. 3

Electromyographic recordings during elicitation of toe-grasping reflex. Note absence of electrical activity in *B* after blocking of the reflexogenous area with ethyl-chloride spray.

Reflex Arc

It appears certain that tonic reflexes of the foot are spinal reflexes, in that they can be elicited in patients who had surgically demonstrated transection of the upper thoracic spinal cord. Of the eight patients with spinal paraplegia who were studied, three had proved transections of the cord; all eight patients showed reflex activity. The reflexes in these paraplegics were extremely active, forceful movements, occurring through a maximum range after a noticeably shorter latent period than that observed in the other patients studied. The reflexogenous areas were extensive. The level of the reflex arcs could not be established on the basis of information gained from paraplegics because the exact extent of the cord damage was unknown. In one patient with a proved transection at the level of the fourth thoracic vertebra, all four reflexes could be easily elicited. In two other patients with cord lesions at the level of eighth and ninth thoracic vertebrae,

respectively, only the toe-grasp and eversion reflexes could be obtained, and the eversion reflex was less active in the patient with the lesion at the ninth thoracic vertebra. The findings suggest that the reflex arcs are distributed below the level of the fourth thoracic segment. The dermatome distributions of the afferent and efferent pathways are too widely separated to consider these reflexes as simple segmental reflexes.

With the spinal cord intact, the reflex arcs are subject to modification by higher centers. In addition to the suppressive effect just mentioned, it has been shown that the grasp reflex in the monkey² and in the human infant¹⁰ can be intensified by postural changes, such as the turning of the patient from side to side. I was unable to modify any of the other three tonic reflexes of the foot by similar positioning. All four reflexes were intensified by the placing of the subject in the upright position, by the startle reaction, and by the waves of increased tension in the muscles of patients with athetosis. The reflexes were unobtainable during sleep and second-stage anesthesia; the toe grasp was the last to disappear.

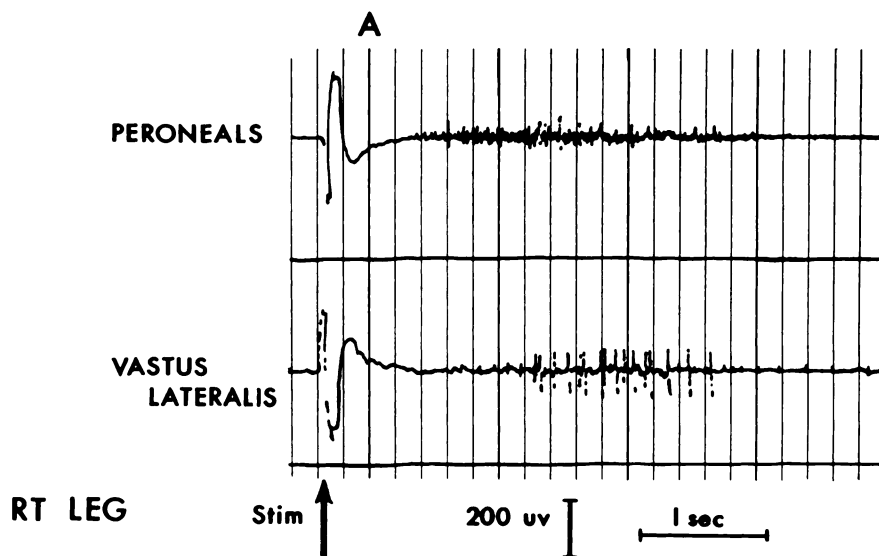


FIG. 4

Electromyographic recording (surface electrodes) of peroneal group and vastus lateralis during elicitation of eversion reflex. Initial deflection is artefact from mechanical application of the stimulator. Latent period (approximately one second) between application of stimulus and initial activity in peroneals. Additional latent period between onset of activity in peroneals (prime mover) and vastus lateralis (co-contractor).

Associated Movement

As each of these four reflexes was elicited, associated activity of a consistent pattern was repeatedly observed, palpated, or electrically recorded in other muscles of the responding extremity. The intensity of this simultaneous muscle contraction appeared to be proportional to the intensity of the reflex movement, being more evident in the young infant or in the patient with cerebral palsy. As the toe grasp was elicited, associated contraction could be observed in the hamstring, gastrocnemius, and soleus muscles. Clonus occasionally developed in the gastrocnemius and soleus muscles.

With the inversion reflex, associated activity occurred in the internal hamstring. The eversion reflex was usually accompanied by contraction of the vastus lateralis and tensor fascia femoris. On elicitation of the dorsiflexion reflex, contraction of the vastus medialis was often observed.

When the timing of this associated movement was studied electromyographically, a latent period of 0.1 to 0.3 second was demonstrated between the onset of

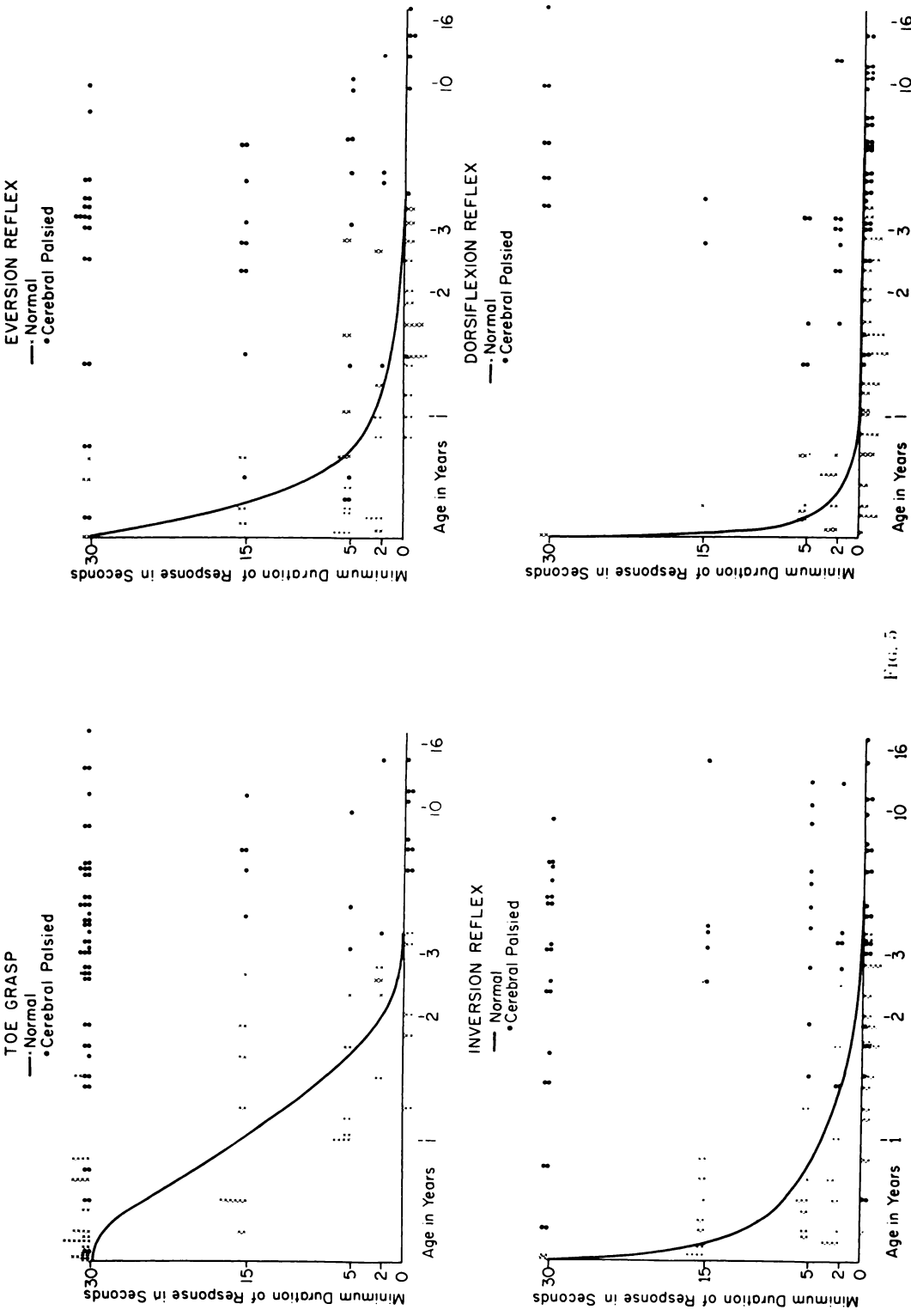


FIG. 5

Disappearance curves (idealized) for each of the four reflexes of the foot plotted from observations in forty normal children (each x represents one foot). Observations in children with cerebral palsy (•) indicate that in many instances the reflexes remain active throughout childhood.

electrical activity in the leg muscles (prime movers) and in the associated muscles (co-contractors) in the thigh (Fig. 4). This latent period far exceeded the transmission time (thirty to forty milliseconds) that would be required for an impulse to pass through a simple spinal reflex arc. This delay in activation of the co-contractor suggests that the associated movement is not part of the basic reflex but rather a separate event in some way dependent on the reflex itself. Further insight into this relationship was gained from a study of the effect of tenotomy of the prime mover on the associated movement. When a strong inversion reflex was present and was accompanied by associated contraction of the internal hamstrings, tenotomy of the posterior tibial muscle was observed to cause a complete cessation of the inversion reflex as well as of the previously associated co-contractors of the internal hamstrings. Thus, associated activity of the co-contractor is in some way dependent on the integrity of the tendon of the prime mover. It seems likely that the associated movement of the proximal muscle is elicited through proprioceptive receptors in the tendon of the distal muscle, so that, as the initial tonic reflex movement slowly develops, activation of the stretch receptors in the tendon of the prime mover gradually recruits increasing co-contraction of the associated muscles. The latent period just referred to is the time necessary for this recruitment.

Disappearance

In the normal infant, tonic reflexes of the foot gradually disappear during the first years of life. Prior to complete disappearance, there is a gradual lessening of the duration of the reflex movement in response to a continuous stimulus (vibrator). Since the disappearance of tonic reflexes seemed related to a suppressive effect of the maturing central nervous system, the duration of reflex movement when tested at any given age should be a useful index of the maturation of the central nervous system. For the establishment of normal values, forty healthy infants and young children were tested; the duration (seconds) of each reflex in response to a continuous stimulus was plotted against the age of the subject (Fig. 5). Based on these observations, idealized curves were plotted of the average age of disappearance of each reflex. Although not statistically significant, the general accuracy of these curves has been borne out by subsequent serial observations.

Deforming Effects

The deforming potential of the tonic reflexes arises out of the dominance of a single reflex, thus causing a dynamic muscle imbalance. The dominant reflex, triggered by environmental stimuli, repeatedly distorts the foot until, eventually, the position dictated by the reflex movement becomes fixed. Two types of dominant reflexes have been encountered:

The first is a reflex of normal intensity that is unopposed because other reflexes are prematurely suppressed as maturation progresses. For example, in an infant with a strong eversion reflex and a weak or absent inversion reflex, the foot will habitually be pulled into a valgus position in response to any general stimulation, such as handling of the foot or tugging on the sock. After several months, such a foot gradually becomes fixed in valgus, but when the dominant eversion reflex is eventually suppressed by the maturing central nervous system, the dynamic nature of the deformity disappears, and the fixed valgus deformity can then be easily corrected without fear of recurrence. Metatarsus varus, talipes valgus, and talipes calcaneus, as frequently seen in the normal infant, presumably fall into this same category of reflexly induced deformities. These deformities are seldom a problem after the first year of the child's life because by then reflex activity of this type has been largely suppressed.

In the second category of reflex-induced deformities, the dominant reflex is pathologically hyperactive. This situation is usually encountered in cerebral palsy. One or more of the reflexes may persist throughout childhood and, instead

of gradually disappearing, the reflex becomes more active as the years pass. At the same time, the reflexogenous area may spread to involve a large area of the foot. Under these circumstances the slightest stimulation evokes a violent movement, and permanent fixation in the deformed position usually occurs.

THERAPEUTIC CONSIDERATIONS

If the serial testing with a standardized stimulus (vibrator) shows no lessening of the duration and intensity of the deforming reflex, it may become desirable to artificially suppress the reflex by interruption of the reflex arc. There are three methods of altering a tonic reflex:

The first is temporary interruption by blocking of the reflexogenous area with ethyl-chloride spray or by infiltration with procaine. Although not practical for continued usage, local anesthesia is a useful diagnostic test to confirm the deforming effect of a reflex. Neurectomy of cutaneous nerves supplying the reflexogenous area, if feasible, affords a more permanent interruption of the reflex arc. This procedure results in a loss of epicritic sensation, but deep sensation adequate to protect the denervated area from trophic damage is retained. The toe grasp has been eliminated by deafferentation in three patients by sectioning of the cutaneous branches of the medial and lateral plantar nerves. The eversion reflex has been abolished in seven patients by section of the sural nerve. All patients, eight spastics and two athetoids, had severe reflex-induced deformities. They are mentioned here only to substantiate the fact that at least two of the reflexes can be interrupted conveniently by deafferentation. The patients have not been followed long enough to determine whether these effects will persist. The practical therapeutic value of the procedure remains to be proved—for the moment, the procedure must be considered entirely experimental.

The second method is counterstimulation of a reflex that is antagonistic to the deforming reflex, which was suggested early in the study. If a patient presented a varus-adduction deformity induced by an active inversion reflex, it seemed logical to methodically stimulate the eversion reflex in an effort to augment the eversion reflex and establish a more equal balance between the two reflexes. This method of treatment was carried out over a period of two years on fifteen selected patients. A vibratory stimulus was used by the parents three times a day for a period of twenty minutes, allowing time for rest when the reflex became fatigued. The results indicated that this procedure has no significant therapeutic value, but they did establish the interesting fact that in a patient with cerebral palsy the duration, ease of elicitation, and strength of a tonic reflex movement can be substantially increased by repeated stimulation over a long period of time.

The third method of altering a tonic reflex is to perform a tenotomy of the prime mover. After tenotomy of the posterior tibial tendon and healing of the elongated tendon, it has been observed repeatedly that there is a prolonged and often permanent disappearance of the inversion reflex. Likewise, tenotomy of the peroneus brevis will alter the eversion reflex. One possible explanation of this result is that during the immediate postoperative period, when the prime mover is temporarily ineffective, the supraspinal center is able to establish suppressive control.

DISCUSSION

The fact that these reflexes reappear in the patient with spinal paraplegia indicates that they have retained their organization even while clinically suppressed when the spinal cord was intact. The question naturally arises whether these reflexes serve any useful function in the normal adult. The grasp reflex has been considered to be a retained primitive prehensile movement by some workers¹⁴ and to be a postural righting reflex by others⁷. Tonic movements are too slow to be useful in prompt righting reactions, but, if, as has been suggested in the case of palmar grasping¹⁴, the tonic reflex movement in reality represents

the summation of a series of instantaneous reflex reactions, then the relation of this tonic movement to function becomes more evident, for the disappearance of the slow tonic movements with maturation could be explained as due to loss of the summing effect. The reflex would continue to function and to initiate contraction of its associated muscles but it would lack the necessary sensitivity to be summated into the slower, purposeless response observed in the newborn.

These reflexes are well arranged to facilitate balancing in stance and gait. If a person standing upright is displaced forward, pressure is produced on the ball of the foot, eliciting a toe grasp and co-contraction of the calf and hamstrings. In a like manner, displacement laterally causes pressure on the lateral aspect of the foot, evoking the eversion reflex and contraction of the peroneals, vastus lateralis, and tensor fascia femoris. Again, with displacement medially, the inversion reflex comes into effect, and with displacement backward the dorsiflexion reflex responds. In each instance displacement evokes the appropriate reflex muscle action to resist the displacement of the body from the upright position. Such an arrangement supports the concept that dynamic posture is a cascaded reflex system that, initiated by appropriate contact of the foot with the floor, proceeds proximally in a chainlike manner. The stretch loading of the tendon of the distal muscle (prime mover) recruits co-contraction of the proximal muscles. The speed and intensity of this chain reaction will, in part, be modified by the force of the initial contact with the floor, together with the degree of stretch loading applied to the distal tendons and, in part, by the inhibitory or facilitory effects of central postural reactions.

SUMMARY

1. Four tonic reflex movements of the foot can be elicited in normal infants and in some older children with cerebral palsy.
2. The disappearance of these tonic reflexes with growth appears related to maturation of the central nervous system.
3. Certain physiological features of these reflex movements are discussed, including the reflexogenous areas, sensory receptors, reflex arcs, associated movement, and disappearance.
4. These reflexes are of orthopaedic interest in that they may, by their occasional unopposed action, cause deformity.
5. It is suggested that these slow tonic movements represent a summation of many instantaneous reflexes, and that these instantaneous reflexes are distally located trigger mechanisms that initiate balancing reactions.

REFERENCES

1. BARRAQUER, L.: Contribution a l'étude du réflexe plantaire pathologique. *Rev. Neurol.*, **37**: 455-457, 1921.
2. BIEBER, I., and FULTON, J. F.: The Relation of the Cerebral Cortex to the Grasp Reflex and to Postural and Righting Reflexes. *Arch. Neurol. and Psychiat.*, **39**: 435-454, 1938.
3. BRAIN, W. R.: The Grasp Reflex of the Foot. *Med. Clínica*, **15**: 293-296, 1950.
4. BRAIN, W. R., and CURRAN, R. D.: The Grasp Reflex of the Foot. *Brain*, **55**: 347-356, 1932.
5. CHANEY, L. B., and MCGRAW, M. D.: Reflexes and Other Motor Activities in Newborn Infants. *Bull. Neurological Inst. New York*, **2**: 1-56, 1932.
6. FRADIS, A., and BOTEZ, M. I.: The Groping Phenomena of the Foot. *Brain*, **81**: 218-230, 1958.
7. FULTON, J. F.: *Physiology of the Nervous System*. Ed. 3, pp. 431-435. New York, Oxford University Press, 1949.
8. GERSTEN, J. W.; GILMORE, W. J., JR.; VIRTUE, R. W.; WOOD, CHARLES; and KAWASHIMA, ETSUKO: The Relation of Stimulus Frequency and Sensory Nerve Supply to Tension Developed in Normal and Denervated Muscles by Electrical Stimulation. *Arch. Phys. Med.*, **35**: 350-358, 1954.
9. GOLDSTEIN, K.: Tonic Foot Response to Stimulation of the Sole: Its Physiological Significance and Diagnostic Value. *Brain*, **61**: 269-283, 1938.
10. HALVERSON, H. M.: Studies of the Grasping Responses of Early Infancy: III. *J. Genet. Psychol.*, **51**: 425-449, 1937.
11. HOOKER, DAVENPORT: Fetal Reflexes and Instinctual Processes. *Psychosomat. Med.*, **4**: 199-205, 1942.
12. RICHTER, C. P., and HINES, MARION: Experimental Production of the Grasp Reflex in Adult Monkeys by Lesions of the Frontal Lobes. *Amer. J. Physiol.*, **101**: 87-88, 1932.

(Continued on page 874)

open reduction is to be continued, these catastrophes must be eliminated. Closed reduction should be revived, studied, and improved. The surgeon and the young trainee should be acquainted with the closed fracture of the long bones and its natural resources. Every closed fracture of the long bone should be given an honest trial at closed reduction. This step should be a prerequisite of every open reduction of a fracture of a long bone. Internal fixation should be only considered for unstable fractures and then only if conservative methods of external fixation have proved ineffective. A higher award should be offered for the successfully managed closed fracture than for the fracture treated by open reduction.

In closing may I make this appeal — Keep the closed fracture closed.

REFERENCES

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13. SCHUSTER, PAUL, and PINÉAS, HERMANN: Weitere Beobachtungen über Zwangsgreifen und Nachgreifen und deren Beziehungen zu ähnlichen Bewegungsstörungen. *Deutsche Zeitschr. f. Nervenheilk.*, **91**: 16-56, 1926.
14. SEYFFARTH, HENRIK, and DENNY-BROWN, D.: The Grasp Reflex and the Instinctive Grasp Reaction. *Brain*, **71**: 109-183, 1948.
15. WARTENBURG, ROBERT: The Examination of the Reflexes: A Simplification, p. 12. Chicago, The Yearbook Publishers, Inc., 1945.