Pronator teres rerouting transfer as an alternative to green's transfer in cerebral palsy patients

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Background
Hand function limitations are common in all types of cerebral palsy (CP) secondary to wrist-flexion deformity and forearm pronation. Flexion posture of the wrist decreases the mechanical advantage of digital flexor tendons, causing weak grip, weak pinch, and precluding a normal visual feedback of the hand. The Green's transfer using flexor carpi ulnaris to extensor carpi radialis brevis (ECRB) tendon transfer was a gold-standard procedure to correct the flexed position of the wrist and adding to supination power of the forearm, but after wide use of this procedure over the years, many cases with reversal of deformity were developed, but making any further help for those patients is very difficult. That arouses the need of other procedures to avoid this serious complication after Green's procedure.

Patients and methods
From 2008 to 2011 in 51 CP forearms in 37 patients (7–16 years old) with wrist flexion and ulnar deviation deformity and forearm pronation deformity, the authors assessed the results of PT tendon transfer to ECRB after rerouting of the muscle through the interosseous membrane according to hand function, improvement of daily activity, grip strength, and esthetics with at least 8 years of follow-up. Preoperatively, all patients are examined and only patients with at least a neutral wrist position and midprone position of the forearm passively can be reached and were included in the study.

Results
After a final assessment of all patients after a 8-year follow-up, we have comparable results to Green's procedure for wrist extension flexion range, active supination, hand function, and grip strength, with no reversal of deformity in any of the patients with a shorter procedure with a small single-forearm incision.

Conclusion
PT transfer to ECRB in CP patients with flexion and pronation deformity of the forearm can replace the Green procedure with avoidance of miserable complication of reversal of deformity, especially in skeletally immature patients.

Type of study/level of evidence
Therapeutic IV

Keywords:
cerebral palsy, pronator teres, rerouting transfer

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Introduction

Cerebral palsy (CP) is a nonprogressive injury in the developing fetal or infant brain that can involve either the upper limb only, the lower limb only, or both of them in mix pattern [1–3]. Although CP is static in nature, the limb deformity often changes with growth of the child and contractures usually worsen till adolescence [3]. Involvement of the upper extremity in CP often results in a typical pattern of spasticity, with elbow flexion, forearm pronation, ulnar deviation and flexion of the wrist, and a thumb in palm deformity.

A flexion deformity of the wrist frequently interferes with the digital grasp and release. A severely flexed posture of the wrist has both functional and esthetic implications to many patients and families. Transfer of flexor carpi ulnaris (FCU) to extensor carpi radialis brevis (ECRB) (the Green transfer) has been used for many years as the procedure of the choice to treat wrist-flexion deformity and improving supination in these patients [4–10]. Recent studies have shown that postoperative deformities after this tendon transfer occur in 13–69% of patients [6–8].

We believe that late deformities from length or tension changes occurring with growth or failure of stretching at the repair site may result when these transfers are performed in patients before skeletal maturity, especially if overtensioning is used during repair.

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The purpose of this study was to provide an alternative with less-frequent complication than that faced after Green transfer.

Patients and methods

From 2008 to 2011, 37 CP patients (7–16 years old) with 51 forearms with wrist flexion and ulnar deviation and forearm pronation deformity are enrolled in our study and followed till now. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Cairo University, Cairo, Egypt. Preoperatively, all patients are examined and only patients with at least passive neutral wrist position and midprone position of the forearm were included in the study

We assessed the results of PT tendon transfer to ECRB after rerouting of the muscle through the interosseous membrane, according to hand function, improvement of daily activity, grip strength, and esthetically with at least 5 years of follow-up.

Surgical technique

Under general anesthesia, a tourniquet is applied. A 4–5-cm-long incision centered over the radial aspect of the mid forearm was made.

PT tendon was harvested with a long periosteal sleeve and then transferred to ECRB but through the interosseous membrane.

Tension is in 45° of the extended wrist and fully supinated forearm and as far distal as the donor tendon allows. Nonabsorbable 4/0 rounded sutures are used. Skin closed and the forearm is put in the below elbow slab in 30° of extension for 4 weeks.

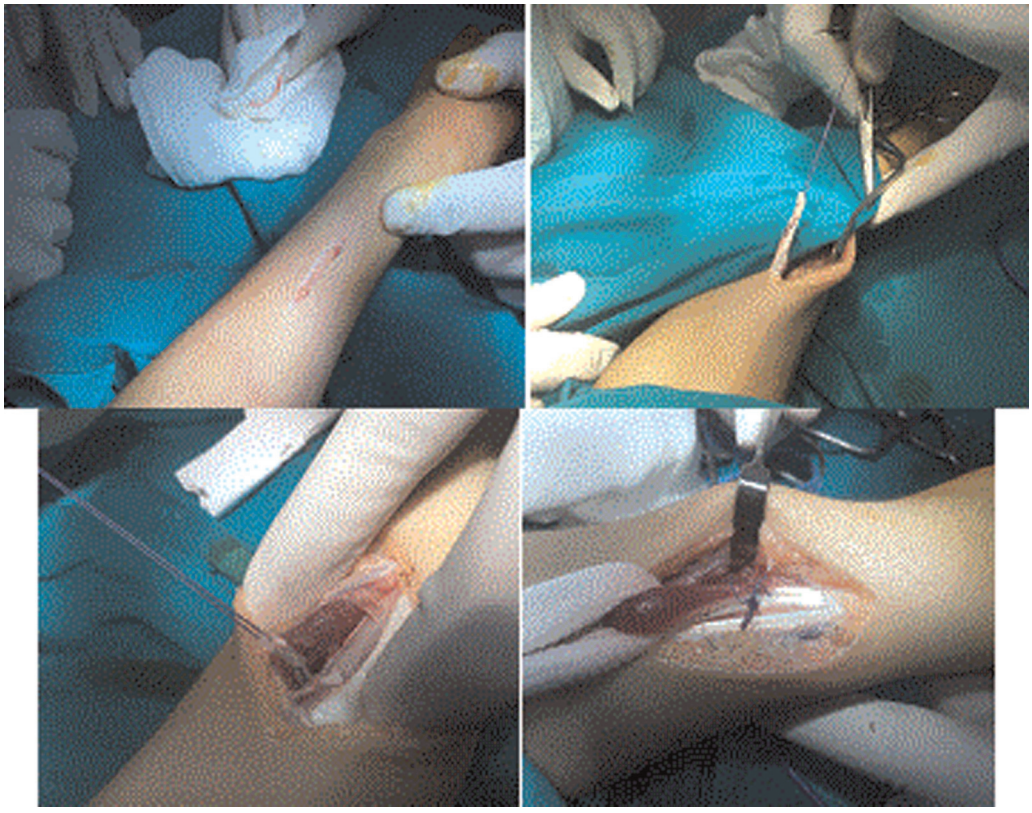
After 4 weeks, a slab is removed and gradual range-of-motion (ROM) exercises are started.

The patients are followed up at 2, 4, and 8 weeks, and then every 6 months, till the patients reach puberty, and every visit, the ROM, hand function, and grip strength are tested (Fig. 1).

Results

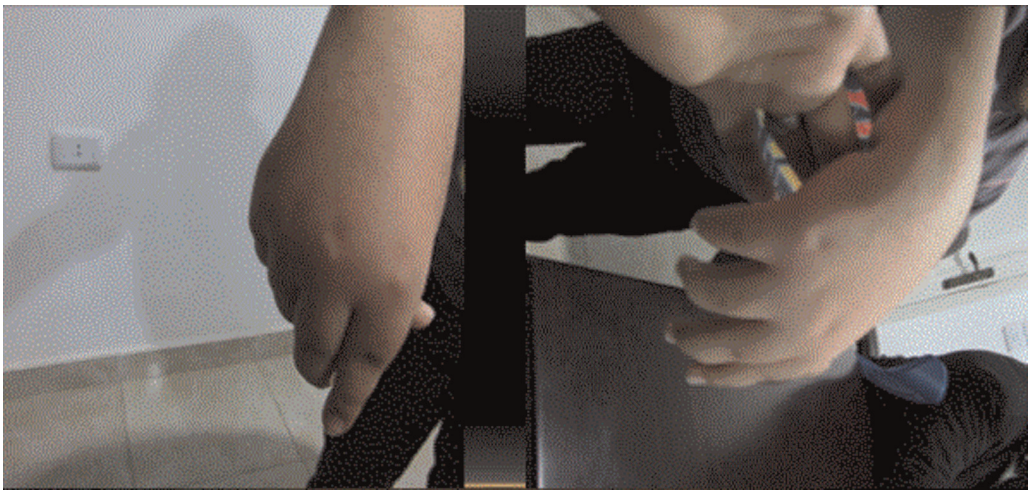
After a final assessment of all patients after a minimum of 8 years of follow-up, we have comparable results to Green's procedure for wrist extension, hand function, and grip strength with no reversal of deformity in any of the patients, with a shorter procedure and with a smaller single-forearm incision (Figs. 2 and 3).

Figure 1



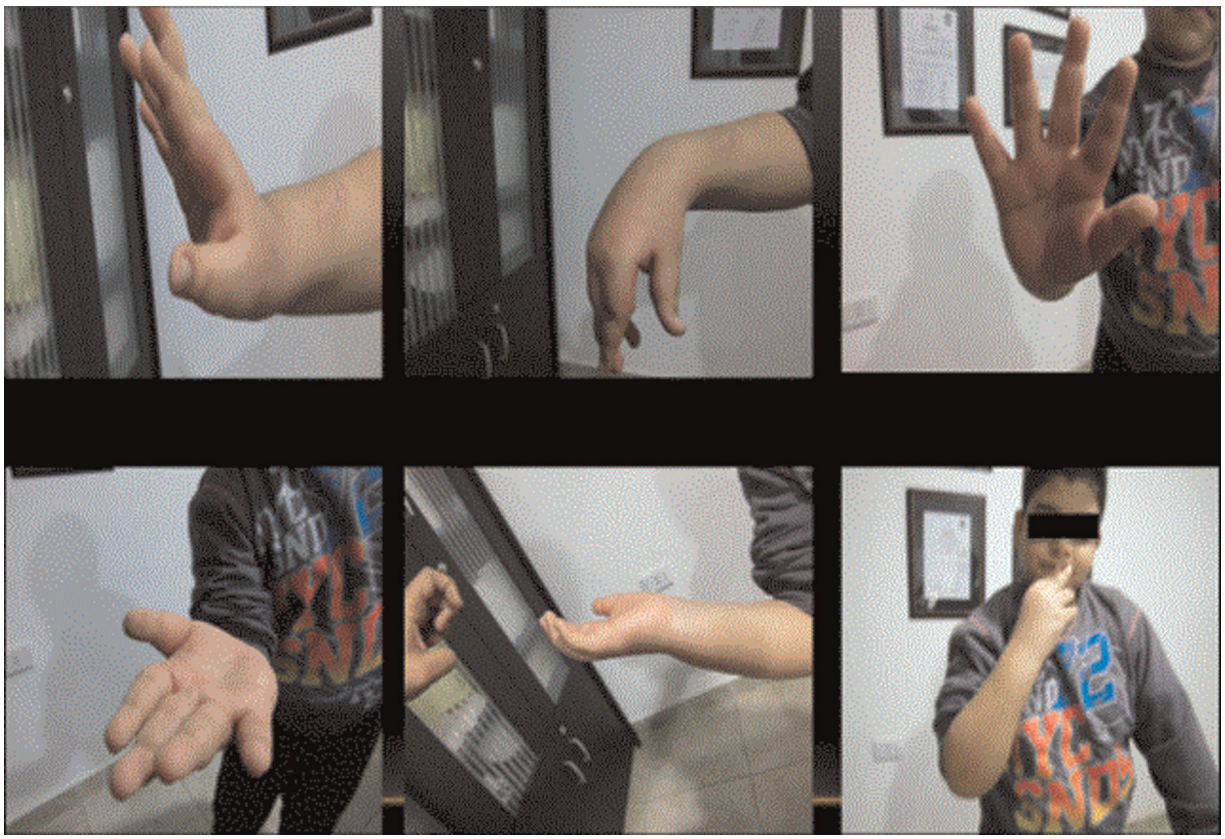
Surgical steps.

Figure 2



Preoperative, flexion, and pronation deformity.

Figure 3



Postoperative, 3 months later.

Discussion

Green's transfer has been used for many years to deal with wrist-flexion deformity commonly seen in patients with CP. An abnormal wrist ROM interferes with the ability to use the tenodesis effect for digital grasp and release. Transfer of FCU to ECRB is successful because it removes the deforming force (wrist flexion and forearm pronation) and augments the desired force (wrist extension and forearm supination).

Since Green's original description in 1942 of the FCU tendon transfer in patients with CP, many surgeons used it and evaluate its efficiency and document an early and later postoperative hyperextension deformity

that has been noticed [6–9,11,12]. Many causes have been implicated in the development of a postoperative hyperextension reversal of deformity, such as FCU spasticity, using wrong tension at which the transfer is placed, poor postoperative patient compliance to immobilization and physiotherapy, and failure of the repair site to stretch during growth.

Patterson *et al.* [13] performed 41 FCU to ECRB tendon transfers in children with CP between 1987 and 2005 and retrospectively reviewed them that late postoperative deformity occurred in 48% of patients, and the most common deformity that developed was an extension type.

Hoffer *et al.* [6] evaluated 38 patients with CP who had Green's transfer with a greater than 8-year follow-up, and found that 13% developed a postoperative hyperextension reversal of deformity. Thometz and Tachdjian [8] evaluated 25 patients with a minimum 4-year follow-up and found that nine patients developed a postoperative hyperextension deformity, although this was a functional problem with loss of tenodesis effect of wrist flexion for finger release that was used as a tricky movement to improve hand function.

Many studies have reported the incidence of late postoperative deformities, but a possible relationship between patients' age at the time of surgery and the likelihood of developing a deformity has not been well studied. The adolescent-growth spurt in normal children usually occurs between the ages of 10 and 14 in girls, and between the ages of 12 and 16 in boys [10,13–15]. Current studies in the literature that describes late postoperative hyperextension deformities evaluated patients who ranged in age from 4 to 23 years. However, these studies do not specify the ages of patients who developed a hyperextension deformity and when these deformities occurred.

Patterson and colleagues hypothesize that these late deformities occur when patients who underwent Green's tendon transfer at a young age enter the growth spurt, and the transferred musculotendinous unit does not stretch at the same rate as the skeleton does, and we also believe that sometimes improper planning of time and type of transfer or tension used is the main cause of reversal of deformity in early postoperative periods, while failure of scar stretch at the repair site is the cause for the lately developed deformity. It is recommended that surgery be delayed until motor patterns are established, the deformity is static, and patients are able to participate in postoperative therapy [2–4].

Beach *et al.* [9] evaluated 40 patients with CP who underwent Green's transfer with an average follow-up of 5 years, and found that the best results were seen in patients who underwent surgery between the ages of 7 and 12 years. In the study by Patterson and colleagues, they found that patients under the age of 13 at the time of tendon transfer were much more likely to develop a postoperative deformity than patients who had transfers when they were older than 13 years of age (82 vs. 25%). They believe that performing that transfer when the patient is young may be indicated to improve the function and esthetic appearance of the limb; however, it may place patients at a higher risk of postoperative hyperextension or supination deformity. This is especially true for patients with spastic quadriplegia because they found that these patients were more likely to develop a late postoperative deformity relative to patients with hemiplegic CP.

Of all transfers in our study, PT tendon was transferred to ECRB through the interosseous membrane tension that was in 45 degree of wrist extension and a fully supinated forearm and as far distal as the donor tendon allows; in that series, we reported that no patients developed an extension or supinated posture with more than 8 years follow-up, and regarding wrist extension flexion range, hand function, and grip strength, we have comparable results to Green's transfer with no reversal of deformity in any of the patients, with a shorter procedure and with a smaller single-forearm incision.

Conclusion

Based on our findings, we believe that although FCU to ECRB tendon transfer remains a viable option to address the wrist-flexion deformity commonly seen in patients with CP, its frequently faced complication may widen the options for more methods and types of transfer as we offer in our study, but care should be taken when selecting the patient as our transfer is not indicated in severe deformity in which we need more studies to additionally discuss the efficiency of FCU recession before doing our transfer to obtain the neutral wrist first.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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