SUMMARY
Spasticity of the rectus femoris (RF) is one of the possible causes of stiff knee gait (SKG) in cerebral palsy. Musculoskeletal studies have shown that in SKG, length and speed of the RF are perturbed. No evaluation had been made to quantify the modifications of those parameters after surgery. The effect of this surgery on the gait quality and on the RF kinematics is studied in order to identify some kinematic patterns that may aid its diagnosis. For 26 transfers, pre- and post-surgery clinical gait analysis was used to compute the Gait Deviation Index (GDI) and the Goldberg’s index. The kinematics of the Original RF path (ORFp) is studied before and after surgery. The expression ORFp was chosen to avoid any confusion between this modeling parameter, whose computation is unchanged, and the actual anatomic path that is modified by surgery. The timing of the maximum length and speed of the ORFp is improved (+18±12GDI) with an inverse interaction between the pre-operative GDI and its improvement. The Goldberg’s index is improved (88% of the cases). The surgery normalized the timings of maximum length and speed of the ORFp. Finally, the precocity of the ORFp peak length timing has been identified as a potentially prognosis factor of successful surgical outcome.

INTRODUCTION
Spasticity of the rectus femoris (RF) is considered as one of the possible causes of stiff knee gait in cerebral palsy [1]. The transfer of the rectus RF is one of its most common and validated treatments [2-5]. The transferred muscle, although always spastic, remains flexor of the hip, and would become flexor of the knee rather than extensor [6,7]. Nevertheless, this knee flexor mechanical effect is controversial [8-10]. And dynamic perturbations occurring before swing phase are also implicated in the stiff knee [11-14]. Musculoskeletal studies showed that in stiff knee gait, length and speed of the RF are altered [15,16]. No evaluation as been realized to quantify the modifications of those parameters after surgery as it has been done with hamstrings lengthening [17]. This one produced useful help to hamstrings surgery indications. Studying the modifications of RF kinematics parameters could provide predictive parameters to the indications of RF transfer which remains an actual question [18]. The kinematics of the Original RF path (ORFp) is studied before and after surgery. The expression ORFp was chosen to avoid any confusion between this modeling parameter, whose computation is unchanged, and the actual anatomic path that is modified by surgery.

The objective of this study is triple: Study the global effect of the surgical transfer of the RF; Study the effect of this surgery on the kinematics of the ORFp; Search for possible kinematic behavior which would contribute to surgical indications.

METHODS
Sixteen children took part in this study totaling 26 transfers conducted during multisite surgery. All these subjects were clinically examined before the surgical operation and had a complete gait analysis in pre and post-surgery (>1 year) conditions. The decision criteria having led to the RF transfer were based on a clinical examination (Duncan/Ely test), on an EMG examination (pathological activity during the oscillation), and on a kinematic examination with in particular the criterion of a delayed peak of maximal knee flexion and a deficit of maximum knee flexion during swing. Pre and post surgery clinical gait analysis was used retrospectively to compute the Gait Deviation Index (GDI) [19] and the Goldberg Score [20]. A musculoskeletal model was specifically developed to simulate the patella location and the ORFp during gait [21]. Patients ORFp kinematics was compared among the two conditions before and after surgery with respect to normative one. This one was computed from our asymptomatic gait database. A ORFp was considered as “short” if its maximum length was lower than the normal average maximum length minus two standard deviations. The timing of the maximum length peak was considered as “early” if it occurs earlier than the instant of the normal average maximum length peak minus two standard deviations. A ORFp is considered as “slow” if its maximal lengthening speed is lower than the normal average maximal speed minus two standard deviations. Finally the timing of the peak of maximal speed is considered as “early” if it occurs earlier than the instant of the normal average peak of maximal speed minus two standard deviations.

The times of the peaks of maximal length and maximal speed were measured from the instants of beginning of the oscillation phases.

RESULTS AND DISCUSSION
The gait quality is improved (±18 ±12 GDI) (Student T-test: F=2.06; p<0.05) with a negative interaction between the preoperative GDI and its improvement (Coefficient of Pearson -0.81; p<0.05) (Figure 1). The Golberg score is improved in 88% of the cases (Fisher exact test: p < 0.05). The surgery had a significant effect (Fisher exact test: p < 0.05) on the normalization of the timings of maximum length and speed of the ORFp. The improvement of the stiff knee is correlated with the normalization of the timing of maximum length of the ORFp (Fisher exact test: p < 0.05).

CONCLUSIONS
The global improvement of the gait quality and of the stiff knee was shown. Certain parameters of muscular kinematics were standardized, showing an effect of the transfer during the swing but also during the stance. Although the stiff knee is a complex phenomenon not reducible to the only RF kinematics it seems that the precocity of the RF peak length timing could be a prognostic factor of surgical success.

ACKNOWLEDGEMENTS
We are thankful to our subject and to all the members of the “Unité d’Analyse du Mouvement” (Motion Analysis Unit) at the Fondation Ellen Poidatz and to the “RoBioSS – Robotique, Biomécanique, Sport et Santé” team at the University of Poitiers. Funding for this work was provided by the University of Poitiers, the Centre National de la Recherche Scientifique (CNRS), the Fondation Ellen Poidatz and the “Société d’Etudes et de Soins pour les Enfants Paralysés et polymalformés”.

REFERENCES