

# How closely do surgeons follow gait analysis recommendations and why?

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Gait laboratory recommendations for surgery were compared with actual surgeries performed in 30 consecutive patients. The agreement between the procedures performed and those recommended by the gait laboratory averaged  $93.2 \pm 13.4\%$  overall and  $86.0 \pm 18.3\%$  excluding patients referred by the gait laboratory physician. For 23 patients (77%), the recommended surgeries exactly matched the surgeries ultimately performed. In the other patients, seven procedures that had not been recommended were performed, and seven procedures that had been recommended were not performed. Explanations for the differences included preoperative clinical or radiographic evaluation, intraoperative assessment, changes in function between gait analysis and surgery, and

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## Introduction

Use of computerized gait analysis by orthopaedic surgeons has become increasingly widespread for evaluating patients with abnormal gait patterns [1–4]. The results of gait analysis tests provide additional information for the physician to use in surgical planning [2,4]. Previous studies have shown that this information significantly impacts surgical decision-making and the surgeries that are ultimately performed [1,4]. However, studies have not been done to examine how surgeons incorporate gait analysis data into surgical decision-making before and during surgery.

DeLuca *et al.* [1] demonstrated that the addition of gait analysis information can alter treatment plans in children with cerebral palsy. They found that surgical plans were changed following the addition of gait analysis data in 52% of the 91 patients they studied. Kay *et al.* [3] also found that surgical plans change significantly after consideration of gait analysis data. Treatment plans developed before gait analysis were altered in 62 of 70 patients (89%) after gait analysis. One hundred and ten procedures (1.6 per patient) that had not been planned prior to gait analysis were performed, and 106 procedures (1.5 per patient) that had been planned were not performed. However, some discrepancy was noted between the gait laboratory recommendations and the actual procedures performed; in fact, the full gait laboratory recommendations were followed in only 51% of the cases in that study.

The purpose of the current study is to understand the reasons underlying discrepancies between the surgeries

recommended based on gait analysis data and the surgeries actually performed. Specifically, this study investigates how closely gait analysis recommendations are followed as well as why some treatment recommendations are not followed.

## Methods

Charts were retrospectively reviewed for 30 consecutive patients who underwent surgery from July 2002 to January 2003 following gait analysis within the prior 3 years at the authors institution. The mean age of these patients at surgery was  $9.3 \pm 3.1$  years (range 5.1–15.3 years). The mean time between gait analysis and surgery was  $5.5 \pm 4.6$  months (range 1.3–24.1 months). Twenty-nine patients had one gait study, and one had two gait studies, with only the later results being included in these data. Diagnoses of these patients included 23 with cerebral palsy, one with myelodysplasia, one with developmental delay, one with holoprosencephaly, one with a mitochondrial disorder, one with seizure disorder and autism, and two with bilateral clubfoot. The patients were referred for gait analysis by five different surgeons. The gait laboratory physician was the referring physician for 19 of the 30 patients.

Operative reports were compared with the preoperative gait laboratory reports to identify (a) any procedures that were performed but not recommended by the gait laboratory report and (b) any gait laboratory recommendations for surgery that were not performed by the surgeon. Procedures listed as possible recommendations on the gait analysis report were considered in agreement

with the surgeries performed whether or not they were ultimately done.

To calculate the agreement between the gait laboratory recommendations and the procedures actually performed, the number of procedures both recommended and performed was divided by the total number of procedures recommended or performed for each patient. For example, if hamstring lengthening and rectus femoris transfer were recommended but only hamstring lengthening was done, the agreement would be 50% (one half); if hamstring lengthening, rectus femoris transfer, and tendo-achilles lengthening were done the agreement would be 67% (two thirds). Procedures were counted per side, and bilateral procedures were counted as two separate procedures. The procedures included in the data were femoral derotation osteotomy, tibial derotation osteotomy, hip adductor lengthening, psoas lengthening, hamstring lengthening, rectus femoris transfer, gastrocnemius recession, tendo-achilles lengthening, posterior tibialis tendon lengthening, split posterior tibialis tendon transfer, split anterior tibialis tendon transfer, bony surgery of the foot and soft tissue surgery of the foot.

For those patients with discrepancies between the gait laboratory recommendations and the surgeries performed, a questionnaire was prepared asking the referring surgeon to comment on each individual procedure that was performed but not recommended or recommended but not performed. Questionnaires were sent to five surgeons and returned by all but one. The responses covered 10 of 14 discrepant procedures in six of seven patients.

Since the gait laboratory physician was also one of the referring surgeons, separate results for this surgeon and the other referring surgeons were considered in addition to the overall results. In addition, subjects who had surgery within 6 months of gait analysis were considered separately from subjects who had surgery more than 6 months after gait analysis. The non-parametric Fisher's exact test was used to examine whether either group had a significantly greater percentage of patients referred by the gait laboratory physician.

## Results

The agreement between the procedures performed by the referring surgeon and those recommended by the gait laboratory physician averaged  $93.2 \pm 13.4\%$  for the 30 patients, with exact agreement in 23 of 30 patients (77%). When the referring physician was the same as the gait laboratory physician, there was  $97.1 \pm 7.9\%$  agreement with 17 of 19 patients (89%) having exact matches. All other physicians had  $86.0 \pm 18.3\%$  agreement with exact matches in six of 11 patients (55%). In all, the procedures performed agreed with the recommendations in 153 of 167 procedures (91.6%).

Patients who had surgery within 6 months of their gait tests were found to have  $97.3 \pm 8.7\%$  agreement between the surgeries performed and the gait analysis recommendations, while those having surgery after longer than 6 months had elapsed had only  $81.8 \pm 19.7\%$  agreement. Fifty percent of the patients who underwent surgery within 6 months were referred by the gait laboratory physician, compared with 32% in the group operated on after 6 months. This difference was not statistically significant ( $P = 0.4172$ ).

Of the 30 patients, seven (23%) had some difference between the surgeries performed and the recommendations made by the gait laboratory physician. Four of 30 patients (13%) underwent a total of seven additional procedures that had not been recommended by the gait laboratory physician. In three of 30 patients (10%), a total of seven recommended procedures were not performed.

Of the seven additional procedures performed, four (two bilaterally) were explained by necessity based on preoperative clinical or radiographic examination of the patient before surgery. In one case, bilateral rectus femoris transfers were performed because the surgeon observed that the patient had stiff knees and positive rectus tests. The gait laboratory physician had noted the stiffness of both knees in swing phase in conjunction with rectus femoris overactivity in swing phase but had not recommended distal rectus transfers since the child had significant quadriceps weakness preoperatively. In the second instance, a child treated by the gait laboratory physician underwent bilateral hip adductor lengthenings which had not been recommended at the time of gait analysis. Based on preoperative radiographs, the decision was made to perform recommended femoral rotational osteotomies proximally in order to simultaneously correct the coxa valga (with resultant hip subluxation) and femoral anteversion. Due to the varus component of the osteotomies, hip adductor lengthenings were also performed.

For the other three additional procedures, an extensor hallucis longus lengthening was deemed necessary intraoperatively in the first case because the muscle was tight after the recommended procedures (split anterior tibialis tendon transfer, flexor hallucis longus transfer to first metatarsal, and medial cuneiform osteotomy) had been performed. In the second case, a bunion reconstruction was performed in addition to the gait laboratory recommendations at the family's request. In the final case, the surgeon reported performing hamstring lengthenings that had not been recommended since the patients hamstrings had progressively tightened in the 2 years between gait analysis and surgery.

**Table 1** Reasons for differences between gait laboratory recommendations and surgeries performed (*n*=30)

	Preoperative clinical decision	Intraoperative decision	Change in patient status	Request of patient/family	Other/unknown	Total
Procedures recommended but not performed	0	3	0	0	4	7
Procedures performed but not recommended	4	1	1	1	0	7
Total	4	4	1	1	4	14

Of the seven recommended procedures that were not done, three (including one bilaterally) were deemed unnecessary in the operating room after the other recommended procedures corrected the patients problems. In one patient, bilateral calcaneal slides were not performed after recommended claw toe surgery was done because the surgeon felt the patients cavovarus did not warrant osteotomy. In the other patient, a gastrocnemius recession was not performed because the surgeon was able to dorsiflex the patients foot to 10–15° with the knee extended after performing other soft tissue procedures. The other four procedures (two bilaterally) that were not done were in one patient for whom the questionnaire was not returned. These results are summarized in Table 1.

## Discussion

The gait laboratory recommendations were followed exactly in 23 of 30 patients (77%) in this study. This suggests that surgeons who refer patients for gait analysis at the authors institution seriously consider the gait data and treatment recommendations in surgical decision-making. A previous study at this institution found that gait laboratory recommendations were followed exactly in 51% of 70 preoperative patients [3]. The difference likely results from the higher proportion of subjects referred by the gait laboratory physician in the current study. Excluding patients referred by the gait laboratory physician, there were exact matches in 55% of patients, similar to the previous study. In either case, it is evident that the recommendations from gait analysis tests are often followed. When analyzed by individual procedure, there was greater than 90% agreement between the recommendation and the procedure performed.

The fact that recommendations of the gait physician were followed more than 85% of the time by physicians other than the gait laboratory physician in the current series is impressive. Though the gait data are objective, each physician applies subjective criteria in the assessment of the gait data. For example, some physicians may consider rotational osteotomies in children with cerebral palsy who have more than 10° of tibial torsion, while others may not unless there is 20° or more of torsion. Even when data for certain procedures are compelling, patients and their families may refuse the procedures because of their own beliefs or bias.

The current study demonstrates several additional reasons for discrepancies between the recommendations of the gait laboratory physician and the procedures ultimately performed. The most common reason for additional procedures being performed in the current study was the consideration of preoperative or intraoperative clinical findings by the referring physician. Four of seven additional surgeries in this study were attributed to clinical judgment based upon preoperative clinical or radiographic evaluation, and one additional surgery was performed based on intraoperative evaluation. This highlights the fact that gait analysis is one of a number of sources of information, including physical examination and medical imaging, that are used in preoperative surgical planning. The surgeon will ideally consider all available data, including gait analysis data, to provide a complete and comprehensive treatment approach.

The case in which a surgeon performed bilateral distal rectus femoris transfers, though these had not been recommended by the gait lab physician, merits discussion. The gait lab physician had noted the stiff knees in swing phase in conjunction with rectus femoris over-activity, but had felt that rectus transfers were not advisable given the significant quadriceps weakness present preoperatively. The child's surgeon, however, opined that the rectus transfers would not exacerbate the child's preoperative quadriceps weakness and crouch. Though both physicians evaluated the same objective gait data, each came to a different (though apparently reasonable) conclusion.

The gait lab physician performed bilateral hip adductor lengthenings which had not been recommended at the time of gait study. Since preoperative pelvis radiographs demonstrated bilateral coxa valga and hip subluxation, the planned femoral rotational osteotomies were performed proximally and a varus component was added. Due to the varus component of the osteotomies, concomitant hip adductor lengthenings were deemed necessary. Though this case represents a change in surgical plan, the change is clearly due to information not available through a gait study.

Another important reason given for an additional procedure was a change in the patients status between gait analysis and surgery. Patients who had surgery within

6 months of their gait tests had 97% agreement between the surgeries performed and the gait analysis recommendations, compared with 82% agreement for those having surgery after more than 6 months had elapsed. This reflects the fact that gait analysis captures a patient's gait deviations at one point in time and that gait may change with growth in both able-bodied and physically-challenged children. Repeat gait analysis may therefore be needed if significant time has elapsed or if a patient has grown significantly since his or her gait test. Currently, physicians at the authors institution most commonly operate on children within 12 months of gait analysis.

The most common reason given for procedures that were recommended by the gait laboratory not being performed was reassessment intraoperatively after completing some of the recommended surgeries. In these cases, it was determined that the procedures already performed had adequately corrected the patients problems. Since gait tests are typically used for patients in need of multilevel surgery, it is understandable that some surgeries may not be needed if other surgeries correct the problems they are meant to address.

The frequency with which treating physicians followed recommendations based on gait laboratory examination is

encouraging. This study points out potential reasons for discrepancies between recommended and actual treatment following gait analysis. Additional studies to further explore these reasons could be important in understanding how gait analysis tests impact the treatment of patients with gait problems. This study was limited by a small sample size; a prospective study could alleviate the dependency on the referring physicians memory of the surgeries performed, allowing more patients to be studied over a longer time period. Because this study was based on the gait analysis laboratory recommendations at one center and includes a majority of subjects operated on by the gait laboratory physician, it is not clear to what extent the findings can be generalized. Despite these limitations, this study is the first to demonstrate some important aspects of the decisions surgeons make when considering gait laboratory recommendations.

## References

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