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Original article

Physiolysis for correction of clinodactyly with delta phalanx: Early improvement

Physiolyse selon Vickers pour le traitement des clinodactylies par phalange delta : correction précoce

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ABSTRACT

Congenital clinodactyly known as "delta phalanx" is a congenital finger deviation caused by a middle phalanx abnormality. Progressive realignment can be achieved with normal growth through physiolysis according to Vickers. The purpose of this investigation was to identify the rate of correction in congenital clinodactyly following epiphyseal bar resection.We studied retrospectively 24 fingers in 14 patients aged from 14 months to 11 years old (y/o), operated on by two surgeons performing epiphyseal bar resection using a modified Vickers' method. Angle measurements were compared pre-operatively, at 1 year and at the final follow-up. The rate of correction was evaluated at each time point. The cohort was divided into two groups: surgery < 6 y/o and ≥ 6 y/o. Statistical analyses were conducted to compare the patient groups.The mean deviation decreased from 33° pre-operatively (20°–80°) to 17.2° (0°–40°) at 1 year after surgery. The deviation at the last follow-up decreased to 10.6° (0°–40°). Seventy percent of the operated fingers were completely corrected (angle $\leq 10°$) at the latest follow-up visit. No difference was found regarding the age at surgery. There were two cases of premature fusion of the epiphyseal plates. Regardless of the patient's age, Vickers' procedure is a simple and effective solution for treating delta phalanx with early correction. Our data suggest that physiolysis is a successful surgery in patients up to 11 years old.
Level of evidence: Level IV, therapeutic case series.

Mots clés :
Clinodactylie
Phalange delta
Physiolyse
Cartilage de croissance
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RÉSUMÉ

La clinodactylie par phalange delta est une déviation congénitale d'un doigt, liée le plus souvent à une anomalie de forme de la phalange intermédiaire. La physiolyse selon Vickers utilise la croissance comme moteur, afin de permettre une réaxation progressive à long terme. L'objectif de cette série était d'évaluer le taux de correction des clinodactylies après physiolyse. Nous avons étudié rétrospectivement 24 doigts chez 14 patients âgés de 14 mois à 11 ans, traités par physiolyse selon la technique de Vickers modifiée. La déviation des doigts a été mesurée sur des radiographies standards en préopératoire, en post-opératoire à 1 an et en post-opératoire en fin de suivi. Le taux de correction est également évalué à chaque étape du suivi. La cohorte a été divisée en deux sous-groupes : chirurgie avant l'âge de 6 ans et chirurgie après l'âge de 6 ans. La déformation moyenne préopératoire était de 33° (20°– 80°), avec une diminution à 17,2° (0°–40°) à un an post-opératoire et à 10,6° (0°–40) en fin de suivi. On objectivait une correction complète (angulation $< 10°$) pour 70% des doigts opérés lors du dernier contrôle radiographique. Nous n'avons trouvé aucune différence de correction en fonction de l'âge. Deux cas d'épiphysiodèse précoce de la physe proximale de la phalange sont rapportés. La physiolyse selon Vickers est une intervention simple et efficace pour le traitement des phalanges delta; nos données suggèrent que cette chirurgie permet une correction précoce en post-opératoire quel que soit l'âge des patients jusque 11 ans.

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1. Introduction

Clinodactyly is the congenital deviation of a finger in the coronal plane. Usually, it is caused by an abnormal middle phalanx, and more rarely an abnormality of the proximal phalanx or the metacarpal bone. This benign malformation most often affects the little finger. Prevalence varies widely from country to country, up to 5% in the Japanese population [1].

Described for the first time by Jones in 1964 [2], clinodactyly caused by delta phalanx is rarer. The phalanx has a triangular shape and it is most often associated with complex hand deformities (polydactyly, complete duplications, medial clefts) that are often part of syndromic forms (Cenani-Lenz syndrome, Rubinstein-Taybi syndrome, Apert syndrome). According to Light and Ogden [3], this malformation is caused by a longitudinal epiphyseal bracket disrupting the longitudinal growth of the phalanx. Using microscopy, they showed that proximal and distal secondary epiphyseal ossifications centers are separated by a cartilaginous bar in delta phalanx, which disrupts phalanx growth. The C-shape epiphysis interferes with growth unilaterally and, on the other side of the phalanx, growth takes place normally. With growth not being uniform, the phalanx has a trapezoidal shape. This sporadic or familial imbalance [4] causes a functional discomfort beyond 40° of angulation; when mild, only the appearance is problematic.

Therapeutic options are known and standardized [5]. Simple monitoring is advised if appearance is the only complaint. Surgical indications are functional impairment and/or considerable shortening of the finger. Osteotomies are the primary surgical option: opening wedge osteotomy [2,6], closing wedge osteotomy [7] or reverse osteotomy [8].

An attractive alternative is Vickers' procedure or physiolysis [9]. Resection of the epiphyseal bar releases the proximal and distal epiphyseal plates with greater growth kinetics. Theoretically, physiolysis allows slow and progressive correction of the finger's alignment due to a rebound in growth. However, in our experience, we found that a large part of the correction was achieved during the first post-operative year.

The purpose of this investigation was to identify the rate of correction in congenital clinodactyly following epiphyseal bar resection. We also sought to determine whether the age at surgery impacted the correction.

2. Methods

We performed a retrospective study on 24 fingers in 14 children with delta phalanx operated using Vickers' method between January 2010 and September 2016. All patients were reviewed to assess the deviation angle immediately after surgery, at 1 year and 2 years minimum.

The average duration of follow-up was 54 months (21–90). The average age at surgery was 4 years and 3 months (14 months–11 years). All our patients had isolated delta phalanx. Children presenting with multiple anomalies of the hand were excluded. All patients' families gave written consent for disclosing protected health information for scientific purposes.

Surgery was indicated if there was an authentic triangular phalanx and if the deviation increased with age. Although the literature does not agree on an angle from which surgery is indicated [9], we have chosen 20 degrees minimum to perform surgery.

The pre-operative and post-operative angles at 1 year and at the final follow-up were measured on radiographs of the finger using the Skvarilova and Smahel technique [10]. Complications such as premature epiphyseal closure were detected on the X-ray.

To optimize the age at surgery, we also compared the deviation angle between the patients less than 6 years of age (n = 18 fingers) and those 6 years old or more (n = 6 fingers). The subgroup analysis allowed us to determine whether age influenced the outcome of surgery.

Carried out by two surgeons, the procedure was similar to Vickers' technique [9], but with some added modifications. Under general anesthesia, with a tourniquet, each surgeon performed either a Z-plasty or a dorsolateral curved approach (Fig. 1a). The central part of the epiphysis was resected with a scalpel up to see cancellous bone (Fig. 1b). Unlike the initial technique, we did not perform fat interposition into the bone defect. The post-operative care was simple without post-operative immobilization. An ANOVA test was used to compare the pre-operative and post-operative angles.

3. Results

All results are summarized in Table 1 and Fig. 2. The mean deviation decreased from 33° pre-operatively (20°–80°) to 17.2°

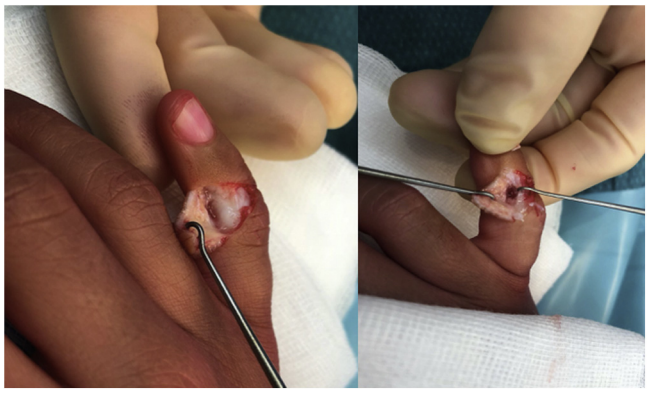

Fig. 1. Intra-operative view showing the dorsolateral approach and the longitudinal epiphyseal bracket (a); cancellous bone after resection (b).

Table 1
Results of the 24 operated fingers.

Fingers	Age at surgery (years)	Pre-operative angle	1-year post-operative angle	Final post-operative angle
#1	3	40°	40°	40°
#2	3	50°	40°	40°
#3	1	80°	30°	0°
#4	4	20°	0°	0°
#5	4	20°	5°	5°
#6	4	40°	10°	10°
#7	11	30°	20°	5°
#8	11	35°	25°	0°
#9	3	30°	15°	0°
#10	3	30°	20°	10°
#11	9	40°	5°	5°
#12	9	30°	15°	15°
#13	3	25°	20°	20°
#14	3	25°	25°	10°
#15	1	25°	15°	5°
#16	2	35°	35°	20°
#17	3	30°	25°	10°
#18	4	25°	10°	10°
#19	6	35°	5°	5°
#20	6	25°	0°	0°
#21	3	30°	25°	20°
#22	3	30°	20°	15°
#23	6	30°	5°	5°
#24	6	30°	5°	5°

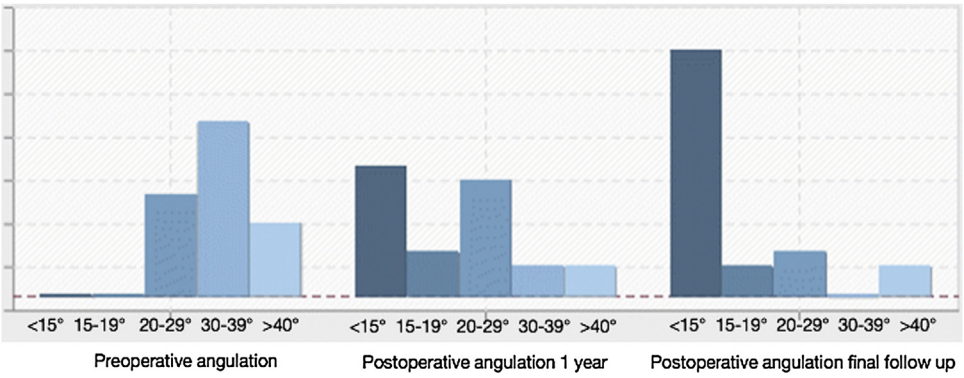

Fig. 2. Pre-operative angulation, post-operative angulation at 1 year and post-operative angulation at the final follow-up.

(0°–40°) at 1 year after surgery. The reduction in deviation at 1 year post-operative was statistically significant ($P < 0.00004$). The deviation at the last follow-up had decreased to 10.6° (0°–40°). The reduction in deviation at the last follow-up was statistically significant ($P < 0.00003$). The mean correction rate at 1 year is 49% and 70% at the last review. Seventy percent of the operated fingers were completely corrected (angulation ≤ 10°) at the last clinical and radiological review.

In the group "surgery before 6 years of age" (n = 16 fingers), the mean pre-operative deviation was 33.4° (20°–80°). At 1 year post-operative, the mean angle was 20.9° (0°–40°) and 13.4° (0°–40°) at the last follow-up. For the group "surgery after 6 years of age" (n = 8 fingers), the mean pre-operative angle decreased from 31.8° (25°–40°) to 10° (0°–25°) at 1 year post-operatively and to 5° (0°–15°) at the last follow-up.

While the post-operative deviation decreased markedly in both groups, there was no statistically significant difference between the two groups (P = 0.03 at 1 year and P = 0.03 at the last review) (Fig. 3).

No patients were lost to follow-up. The little finger was affected in 70% of cases. No stiffness was observed after this operation.

Two cases of premature growth plate closure were diagnosed at the end of growth. Only one patient had a second correction procedure; osteotomy was carried out 3 years after physiolysis.

4. Discussion

Vickers' physiolysis allows a gradual change in the angle of a finger using growth as a correction tool [9]. One year after surgery, almost 50% of the initial deformity was corrected. Our study aimed to prove that a large part of the correction occurs during the first year. Medina et al. [11] also suggested this hypothesis: the rate of correction is conditioned by the child's growth rate and correction is observed clearly at 1 year after surgery. But no data on corrective kinetics was found in the literature.

Fig. 3. X-ray showing the progression of the oldest patient: post-operative X-ray after 2 years (a) and at the final follow-up (b).

Vickers' physiolysis seems to be the first option before considering osteotomy and avoids having to perform invasive techniques and pinning. Among the numerous surgical treatments for clinodactyly, Jones described an opening wedge osteotomy with bone graft [9]. This procedure allows an immediate correction but often requires a Z-plasty for the skin tightness. In 1979, Wood and Flatt [6] proposed a closing wedge osteotomy but those osteotomies lead to shortened fingers. Carstam and Theander [8] described a reverse-wedge osteotomy with a certain improvement of angulation.

All those options require pinning and may have complications like nonunion, PIP joint stiffness [12], growth plate injury and infection. Goldfarb and Wall [13] found no increase of infection. Other authors consider delayed or nonunion [7] as a hypothetical risk.

Taking into account the risk–benefit balance, simple physiolysis is preferred to osteotomy with pinning which has more potential risks because of the fixation devices.

In the original Vickers' article, the incision is longitudinal close to the apex of the phalanx. We performed two types of approach: a dorsolateral approach for about half of our patients and a short Z-plasty for the remaining patients. Z-plasty is recommended by many authors because it reduces tension on the soft tissues in case of skin tightness [12].

All our measurements were carried out by a single observer and repeated twice at each time point. A measurement bias is possible in our study because the Skvarilova and Smahel method [10] has some inaccuracies. It does not take into account the rotational disturbances which can worsen or improve the deviation. In the future, MRI measurement of phalanx angulation may reduce irradiation and could be a useful diagnostic tool in patients under 3 or 4 years before growth plates appear, and to obviate a longitudinal epiphyseal bracket [14]. Ultrasound imaging also provides a good early analysis of the phalanx shape. Because it is an accessible imaging tool, we prefer using ultrasound in our daily practice if the longitudinal epiphyseal bracket is not visible on X-rays and if the diagnosis is uncertain.Two cases of premature growth plate closure were observed in our cohort. This complication was reported also by Vickers [9], Caouette-Laberge et al. [12] and Winckler et al. [15]. To limit the risk of epiphyseal closure, Medina et al. recommend not performing a second physiolysis after the first attempt fails [11]. Osteotomies should be the second line of treatment after failure of physiolysis.

According to Vickers, physiolysis allows a spontaneous correction of the angulation while restoring the finger's length. In his study, the average age at surgery was 9 years old which contrasts with Vickers' recommendations. In fact, the optimum age for physiolysis has not been established, but Vickers suggests performing physiolysis around the age of 3 to increase the chances of correction. Some authors recommend not performing this surgery beyond 12 years of age because correcting the angulation is uncertain [3]. Other authors are more restrictive about the age at surgery, arguing that surgery should be carried out before 6 years of age for better results [13].

The correction was not influenced by age in our series, as in the Winckler et al. study [15] who did not find any age-related difference. The latter found a similar average angulation of 17° post-operative in < 3 y/o and > 3 y/o patients. On the other hand, a correction made before the age of 6 is encouraged by Caouette-Laberge et al. [12]. Results showed an average correction almost three times greater before 6 years of age.

We believe that correction kinetics, which are faster in the first post-operative year, may explain the absence of correlation between the age at surgery and the deviation correction in our cohort. Vickers' physiolysis can therefore be proposed to slightly older children because of its rapid action. The results are as satisfactory as in younger children. The lack of homogeneity between the two subgroups is one of the limitations of our study. Despite this flaw, there is no difference in correction between the two groups.

5. Conclusion

Our review shows that physiolysis can be an effective technique for correcting clinodactyly in patients up to 11 years old. Indeed, since physiolysis corrects much of the deviation in the first year post-operative, it can be performed in older children or adolescents who still have growth potential marked by the presence of growth cartilage. Vickers' procedure is an attractive alternative to osteotomy. Possible early and late, it offers satisfactory results with often complete correction. The problem is not correcting the delta phalanx but detecting it.

Disclosure of interest

The authors declare that they have no competing interest.

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