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Age, sex, and Osteotomy Site effects on bone formation in 370 cases of bilateral tibial lengthening

Abstract

Limb shortness is one of the most common orthopedic referrals, and in the past, the most common cause was polio. In these cases, equalizing the length of the two lower limbs is a necessity, which can be done with methods such as osteotomy. Various factors can affect the success of this method. In this study, we want to investigate the relationship between age, sex, and osteotomy site with bone formation and growth. The current study is an analytical-cross-sectional study in which 370 patients with indications for limb lengthening were selected for 18 years and underwent lengthening using the LON method. Data collection after surgery and during height gain was done with the help of a questionnaire. Finally, to analyze the data using descriptive statistics and determine the significance of the statistics, SPSS version 20 software was used. Examining the relationship between the amount of ossification and the osteotomy site in men and women showed that, unlike men, there is a significant inverse relationship between the ossification site and the osteotomy site in both the left and right legs. Also, according to the data of this research, the role of the age variable was statistically significant in such a way that the higher the age, the less bone formation in people. Finally, our findings showed that bone growth rate after height correction surgery can be affected by factors such as age, gender, and osteotomy site. Therefore, checking and controlling these cases before height correction surgery can effectively improve the operation results.

Keywords: *Osteotomy, Tibial lengthening, Bone formation, Limb shortness*

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Introduction

Short limb length may be caused by various causes, including congenital, traumatic, and paralytic causes. However, bringing this disease under control with prevention methods has reduced its prevalence significantly. Although rarely indicated, tibial lengthening is a widely accepted technique to correct length differences in the lower limbs. Success relies on thoroughly considering the various contributing factors, strict conformance to the indications and requirements, and meticulous care of every surgery detail. Limb lengthening continues to be among the most challenging procedures encountered in pediatric orthopedic surgery (1, 2). Equalizing the length of the two lower limbs is considered a necessity, which can be achieved with different methods These methods include epiphysiodesis of longer limbs at appropriate ages, shortening the length of longer limbs, and lengthening the length of shorter limbs (3). Most patients prefer the method of lengthening the length of shorter limbs. However, it is better if the doctor chooses the appropriate method after examining all aspects and explaining them to the patient (4). Today, there are various well-known methods to increase the length of organs. Applying most of these methods requires much experience (5). Osteotomy is a type of surgery in which the patient's bone is cut by surgery in a controlled manner by the surgeon and with special tools. Osteotomy is used to correct bone length or distraction (6). After cutting, the bone is divided into two parts. After these two parts are placed in the desired position and length, they are kept in a suitable position with special devices until they are fixed again. Limb lengthening requires a good quality of experience (7).

To increase height, bilateral leg or thigh osteotomies have been used for many years, and there are various methods to increase the length of the tibia, including the Wagner method, the Ilizarov method, the De Bastiani method, and the most famous one, the LON method (8). Evaluation of bone repair after osteotomies is relatively insensitive in plain radiography with visual assessment and does not detect the amount of new bone produced to a significant extent (9).

We need special software to measure the amount of ossification in the bone-lengthening area. The Iranian Quick Densitometer Program (IQD) was designed by the experts of the Limb Lengthening Center of Iran (LLCI) team (10). The purpose of increasing bone length is to improve the functional mobility of patients with limb length differences or to solve the mental and social problems of people with short stature (11). Therefore, in this article, we want to investigate the relationship between age, sex, osteotomy site, and bone formation and growth.

Method

We conducted an analytical, cross-sectional study using a census to select the patients. Among the patients who were referred to Dr. Nader Motallebizadeh's clinic due to short

stature, 370 patients who had an indication to increase the length of the limbs and had undergone LON surgery in a period of 18 years from 2001 to 2019 in several private and public hospitals in Tehran to increase height were included in the study.

In this operation, the leg bone is first osteotomized, then fixed from the inside with a nail. Of course, only the proximal screws are placed before the increase, and the distal screws are not placed inside the bone to possibly increase the leg's length. Then, in the presence of the nail inside the bone canal, the external fixator is installed to make the lengthening possible. 5 to 10 days after the operation, how to work with the external device is taught so that the person's bone can regularly increase by about three-quarters of a millimeter per day. After the required distance is created in the osteotomy site, the lengthening is stopped, the distal nail screws are placed in the operating room to maintain the increase, and the external fixator is removed. After this stage, consolidation begins, and in this study, its amount is investigated in different cases in terms of age, sex, and the distance between the bone cut and the proximal end of the Tibia.

Data was collected by preparing a questionnaire filled out during and after bone lengthening, using the patients' files, and then their final examination to complete the required information and estimate the patients' satisfaction with the surgery. Finally, to analyze the data, descriptive statistics (prevalence, frequency percentage, mean, and standard deviation) were used, and to determine the significance of inferential statistics (chi-square, Fisher's exact test, independent and paired t, and regression), SPSS software version 20 was used. Using the Kolmogorov-Smirnov and Shapiro-Wilk tests, the normality of the data distribution was shown. According to the p-value, none of the variables were less than 0.05. Therefore, the said tests did not reject the hypothesis of normality, and the data was normal. Parametric methods should be used to check statistical tests.

Result

Comparing the bone formation rate of the left and right leg between women and men according to the osteotomy site referring to Table 1, we found no significant difference in the ossification rate of the left and right leg between women and men ($P<0.05$). However, the growth rate at the osteotomy site (the distance between the osteotomy and the proximal tibia) in the left and right legs was significantly higher in men than in women ($P<0.05$). Next, the ossification of the right and left leg were compared according to gender. According to the results of the study in Table 2, it was found that the average amount of ossification was slightly higher among men in the left leg than among women in the right leg. However, no significant difference was observed between the genders ($P<0.05$). Other factors besides gender can affect the amount of bone formation. This study investigated the effect of the osteotomy site and the patient's age on the bone formation rate. The results of the regression model in Table 3 showed that the ossification in the left and right legs was not significantly different ($P<0.05$). However, according to the data of this research, the role of the age variable was statistically significant, so the older the age, the less bone formation in people ($P<0.05$).

According to Table 4, the examination of the relationship between the amount of ossification and the osteotomy site in men and women showed that in women, there is no significant inverse relationship between the osteotomy site and the ossification in both the left and right legs. However, there was no significant relationship between the osteotomy site and the amount of ossification in men ($P<0.05$). The investigations in this study showed that the osteotomy site and age are significantly related to the amount of ossification in the samples.

Discussion

Limb shortness is one of the more common orthopedic referrals, and in the past, the most common cause was polio (12). In recent years, due to the expansion of vaccination coverage, the number of polio patients has decreased, and the common causes of limb shortness are congenital disorders, traumas, and bone infections (13). In many cases, limb shortness is accompanied by other deforming disorders such as bone deviations and joint instabilities, which, depending on the type of treatment selected, can be treated separately at the same time as shortness treatment for lengthening (14). Various techniques have been proposed for the short limb for many years, including external annular or one-sided fixators and the combined use of these devices on the internal guides of the bone canal. However, presently, Wagner's external fixator, Orthofix, or Ilizarov's method is practically used comprehensively (15).

The study's findings show no significant difference in the ossification of the left and right leg between men and women. However, the distance between the left and right leg osteotomy sites was greater in men than in women. In the study of Nazem et al., which was carried out under the title “Lengthening the limb by the Wagner method,” it was also observed that the shortness of the limb was more significant in men, which is consistent with the findings of this study (16). Although the previous studies were less focused on age and gender, the mentioned variables were investigated in this study, and the findings showed a relationship between the mentioned variables in some cases. The average duration of having an external frame was eight months (four to 14 months). The average index of healing was 48 days/cm (18-110 days/cm),

with younger individuals experiencing a more rapid healing process (17).

The results of the regression model showed that according to the data of this research, the role of the age variable was statistically significant, and the higher the age, the less bone formation in people. In Herman et al.'s study entitled "Complications of tibial eminence and diaphyseal fractures in children: prevention and treatment," which investigated the relationship between age and limb length difference, their findings showed that with increasing age, the difference in the length of the lower limbs also decreased, which was not observed according to the findings of the study (18). There was no significant relationship between the osteotomy site of the right leg and the ossification rate in the right leg, as well as between the osteotomy site of the left leg and the ossification rate of the left leg in men and women. The limb lengthening process tends to be invasive, complicated, and time-consuming, necessitating specific psychological considerations for the patient and their family. To correct leg length discrepancy leg lengthening is the best choice (19).

The method can be used for several objectives, such as obtaining the union and soft tissue reattachment, readjusting deviations in the limb axis, and resolving length discrepancies while facilitating the recovery of function. Since this surgery requires time and frequent examinations, all people who are interested in surgery are not considered suitable cases (20). While doctors can perform the surgery on people of all ages, this surgery is usually more successful for younger people. Therefore, according to the general findings of the study, it can be said that the average ossification of the right leg and left leg in men and women did not have a statistically significant difference. However, the amount of ossification in men's left leg and women's right leg was slightly higher.

Overall, patients reported an improvement in life quality following the treatment. We informed them and their parents of the risks, prompting them to proceed with their treatment judiciously. Finally, our findings showed that bone growth rate after height correction surgery can be influenced by factors such as age, gender, and osteotomy site. Therefore, checking and controlling these cases before height correction surgery can effectively improve the operation results.

Consent for publication

Not applicable.

Availability of data and material

The datasets generated and/or analyzed during the current study are not publicly available since they belong to a hospital database, and their public availability could compromise the confidentiality of participants and other patients registered in the database. However, this data can be made available from the corresponding author on reasonably serious request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All three authors were involved in the design and formulation of the argument.

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Conflicts of Interest

The authors declare no potential conflicts of interest.

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Table 1: Comparison of the ossification rate of the left and right leg as well as the site of the osteotomy in women and men

		Mean	Standard Deviation	t	P-value
Ossification rate of the left leg	Male	0.43	0.194	0.596	0.55
	Female	0.41	0.193		
Ossification rate of the right leg	Male	0.41	0.18	0.229	0.81
	Female	0.42	0.16		
Left leg osteotomy site	Male	8.68	1.12	3.73	0.001>
	Female	7.89	1.5		