Acta Orthop. Belg., 2021, **87 e-supplement** 1, 65-84

ORIGINAL STUDY

Can bone chips block the flipping of the continuous loop button?

Ugur Haklar, Ozgur Erdogan, Mikail Ozdemir, Erdinc Genç, Anıl Yavuz, Rüçhan Ozgocmen

From the Bahcesehir University Department of Orthopaedics, Istanbul, Turkey

The aim for the study is to provide sufficient bone-graft contact in anterior cruciate ligament (ACL) reconstruction, the shortest loop should be used. However, the more loop length decreases, the more difficult it is to flip the loop. Our aim was to investigate the possible cause of this problem.

Between January 2013 and August 2015, 29 knees from 29 patients with primary anatomic ACL reconstruction due to ACL rupture were included in the study. Transtibial reconstructions, revision cases, deformities, and fixations with adjustable-loop systems were excluded. The tunnel depth was measured through the dilator, and at the same time the bone chips were stacked on the tunnel base consciously. Following the second measurement, the bone chips were removed by irrigation inside of the tunnel with the aid of a shaver, and the measurement was made. In order to prove the effectiveness of the washing effect on the flipping margin, ratio between these two numbers was calculated and analyzed by the Mann-Whitney U test between the 15 mm and 20 mm groups.

The average flipping margin was 0.46 ± 0.24 for the 15 mm group and 5.3 ± 0.30 mm for the 20 mm group. According to this, the mean flipping margin in the 20 mm group was found to be significantly higher than 15 mm one (p=0,001). When the ratio of the washing effect to flipping margin was examined, it was significantly higher in the 15 mm group (median : 4.07 mm) than in the 20 mm group (median : 0.30 mm) (p =0.001)

Irrigation inside of the socket must be performed for the 15 mm loop length, however, this is not a requirement for >20 mm.

Level of Evidence : Level IV ; Case series.

Keywords : anterior cruciate ligament, ; ACL tear ; reconstruction ; loop ; bone chips, ; complication.

INTRODUCTION

Anterior cruciate ligament (ACL) anatomical reconstruction methods with short femoral tunnels are extensively used. To provide sufficient bone-graft contact with a continuous loop length button,

■ Ugur Haklar[1],
■ Ozgur Erdogan[2],
■ Mikail Ozdemir[3],
■ Erdinc Genç[4],
■ Anıl Yavuz[5],
■ Rüçhan Ozgocmen[5].

[1]*Professor in Bahcesehir University Department of Orthopaedics, Istanbul, Turkey.*

[2]*Consultant in Haydarpasa Numune Education and Research Hospital, Orthopaedics and Traumatology Clinic, Istanbul, Turkey.*

[3]*MD, Public Health Specialist, Oguzeli District Health Directorate, Gaziantep, Turkey.*

[4]*Consultant in Bagcilar Education and Research Hospital, Orthopaedics and Traumatology Clinic, Istanbul, Turkey.*

[5]*Student in Bahcesehir University Faculty of Medicine, Istanbul, Turkey.*

Correspondence : Ugur Haklar, Bahcesehir University, Department of Orthopaedics, Istanbul, Turkey. GSM : +90 532 217 30 80.

Email : ugur.haklar@kneeclinic.com.tr

Conflicts of interest: none

the shortest one should be used. However, the more loop length decreases, the more difficult it is to flip the loop. Adjustable-loop systems have been developed to solve this, but recent biomechanical studies have shown that the tensile forces of adjustable-loop systems are lower than those of continuous loop length systems *(1)*. Furthermore, it was shown that the stretch margins of continuous loops were significantly lower than adjustable-loop systems *(2)*. According to the literature, it is not clear why short loops can not been flipped. Our aim was to investigate the possible cause for the lack of flipping and examine whether the bone chips that appear during drilling block the button. Our hypothesis is that the bone chips block the flipping of the button and the washing effect would prevent that complication.

MATERIALS AND METHODS

Between January 2013 and August 2015, 29 knees from 29 patients with primary anatomic ACL reconstruction due to ACL rupture were included in the study. Transtibial reconstructions, revision cases, deformities, and fixations with adjustable-loop systems were excluded. Twenty-five cases were male, and 4 were female. The mean age was 31(SD : 10). The femoral tunnel was drilled by using an accessory anteromedial portal in all cases.

Reconstructive events were divided into two groups : 1.) those using 15 mm (n = 11) and 2.) those using 20 mm (n = 18) loop length implants. First, the tunnel depth was measured on the guide reamer. After completing this measurement, the tunnel walls were straightened with a dilator before the tunnel was washed. The tunnel depth was measured again through the dilator, and at the same time the bone chips were stacked on the tunnel base consciously. Following the second measurement, the bone chips were removed by irrigation inside of the tunnel with the aid of a shaver, and the third measurement was made. All of the measurements were made via the anteromedial portal. In addition, the diameter of the graft in each case and the implant loop lengths were recorded.

In our study, when the button came to an upright position at which point it could flip onto the lateral

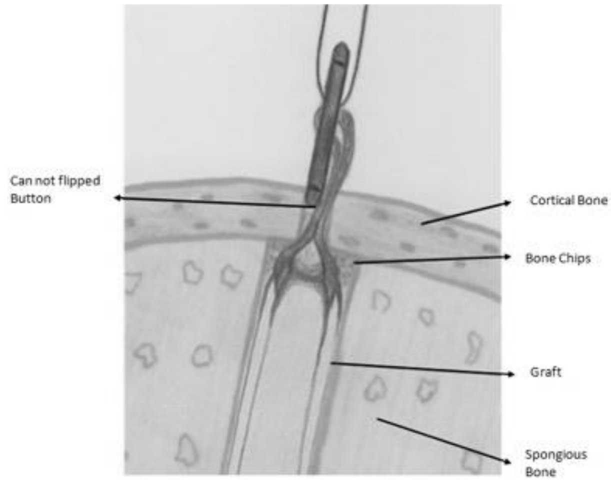

Figure 1. — Drawing represents how the bone chips block flipping.

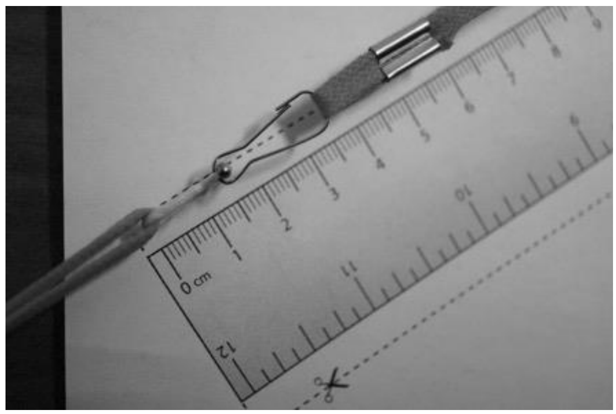

Figure 2a. — 15 mm loop length implant. Retrobutton (Arthrex, Inc., Naples, Florida).

femur cortex, the distance between the top hole that the loop was passing through and the bottom edge of the button was measured at 8 mm in the 15 mm loop length implant (Figure 1). Accordingly, 8 mm of the 15 mm loop length was used by the button, and 7 mm length was remaining. It was also found that there was a continuous distance of 4 mm between the guide and the socket reamers, which had been left by the manufacturer (Figure 2).

This margin is equivalent to the cortex thickness and must be left to prevent cortical impaction of the graft. The 8 and 4 mm length margins are constant for both 15 and 20 mm loop length buttons, respectively. Thus, the loop margin that has the main role in flipping is only 3 mm for a 15 mm implant. Also, the graft will occupy a place that will change

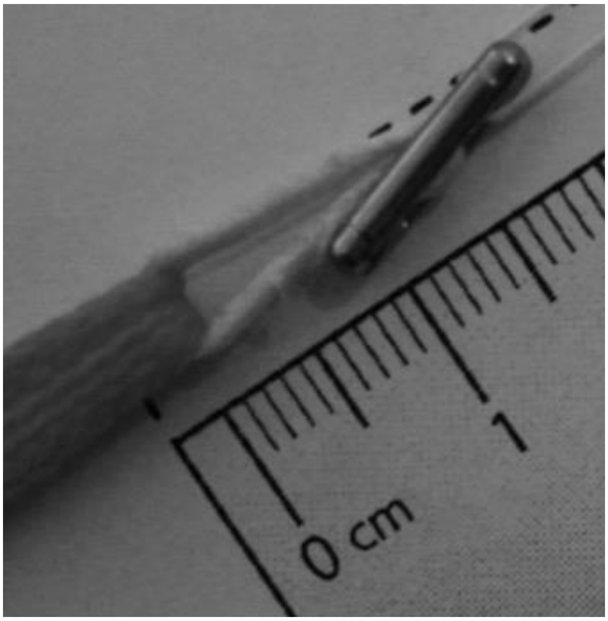

Figure 2b. — When the implant is in the upright position, the remaining loop length is 7 mm.

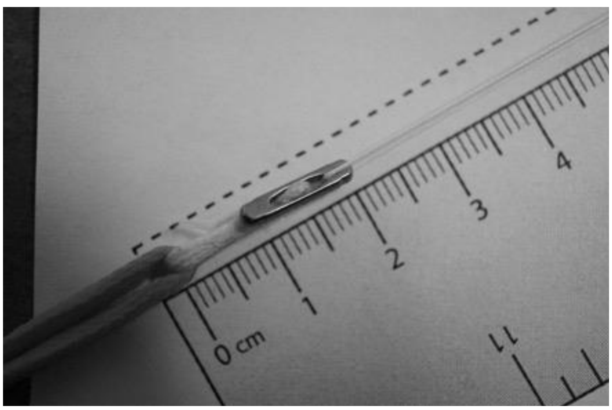

Figure 2c. — When the implant is in the upright position, the remaining loop length is 7 mm.

according to graft thickness in the loop. When the graft thickness is described in the literature, the graft section is regarded as a circle and the diameter values are given. However, the graft section is more similar to the oval instead of a circle (Figure 3). In addition, the distance taken up by the graft will be further reduced with the traction of the system (Figure 4). The length taken up by the graft in the loop was measured with calipers under normal tension and traction (Figure 4). According to this, a graft of 8 mm thickness was found to occupy a

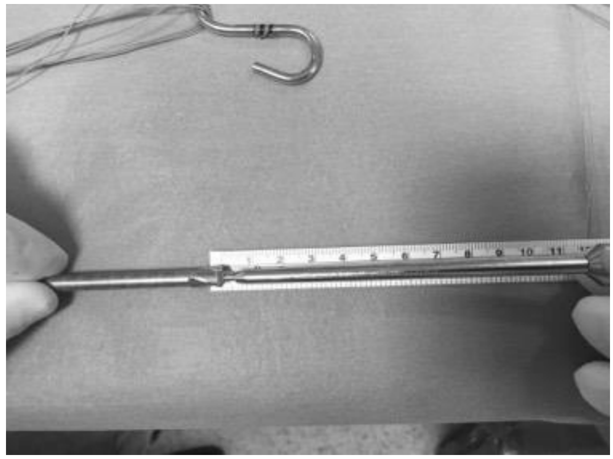

Figure 3. — A guide wire and drill bit, which leaves 4 mm cortex margin as the standard.

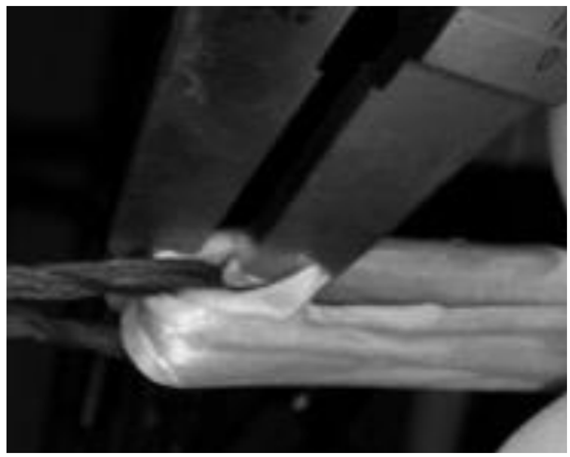

Figure 4. — Measurement of graft thickness under traction with the caliper.

2.8 mm place with the compression. All the grafts used in our study were measured by this method and these values were named as the graft margin (Table I).

In addition, the difference between socket depths after washing and after dilator application is defined as the washing effect, and the 3 mm graft margin distance is defined as the flipping margin (which provides flipping).

Statistical methods : In order to prove the effectiveness of the washing effect on the flipping margin, ratio between these two numbers was calculated and analyzed by the Mann-Whitney U test between the 15 mm and 20 mm groups since

Table I. — Graft thickness and graft margin

Graft Thickness (mm)	Graft Margin (mm.)
8.5	2.9
8	2.8
7.5	2.6
7	2.4
6.5	2.2

Table II. — Correlation between graft and the flipping margins according to loop lengths

Loop length			The flipping margin
15 mm.	The graft margin	r	-1.000
		p	p=0.0004
		N	11
20 mm.	The graft margin	r	-1.000
		p	p=0.0007
		N	18

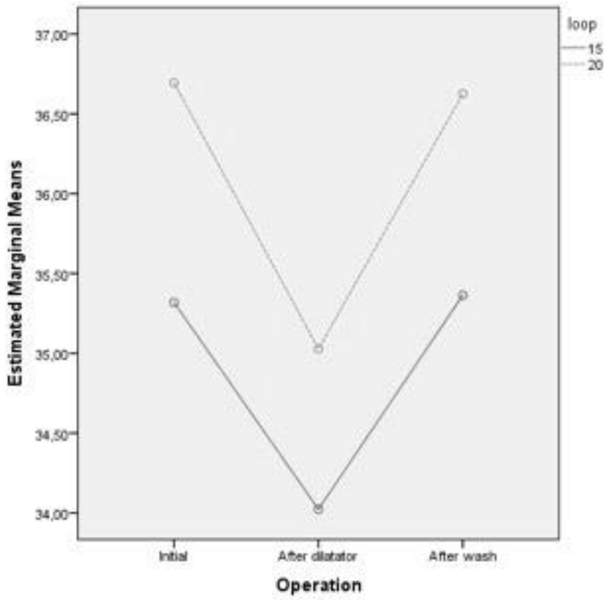

Figure 5. — Guide reamer length after the dilator and after washing lengths.

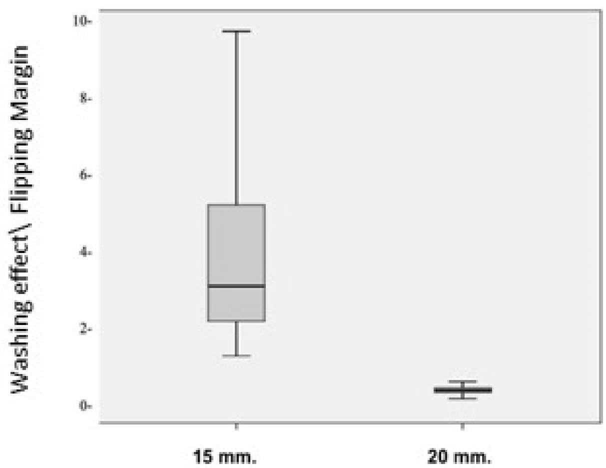

Figure 6. — The importance of the washing effect on the flipping margin according to the loop lengths.

the reamer size after dilation and washing and the tunnel-graft contact measurements did not show normal distribution in the analysis performed by the Shapiro Wilk test. The tunnel diameter and graft margin were analyzed by an independent t-test because of their normal distribution. The Wilcoxon test was used to compare the after dilation and after washing lengths with the initial reamer size. In addition, Spearman's correlation test was used for the correlation between the graft and flipping margin. In repeated measures, Mauchly's test of sphericity value was <0.05 when the analysis of variance (ANOVA) test was performed, so the Greenhouse-Geisser test was used for repeated measures among the groups.

RESULTS

The average flipping margin was 0.46 ± 0.24 for the 15 mm group and 5.3 ± 0.30 mm for the 20 mm group. According to this, the mean flipping margin in the 20 mm group was found to be significantly higher than 15 mm one (p=0.0005). When the ratio of the washing effect to flipping margin was examined, it was significantly higher in the 15 mm group (median : 4.07 mm) than in the 20 mm group (median : 0.30 mm) (p=0.0003) (Table II, Figure 5).

The mean guide reamer length was 36.17 ± 1.47, mm and after dilator mean tunnel length decreased to 34.64 ± 1.26 mm. There was a 1.52 ± 0.49 mm reduction after dilation. After the washing mean tunnel length was increased back to 36.14 ± 1.44 mm. There was a 1.50 ± 0.45 mm increase after washing. In the 15 mm group, the mean graft margin was 2.54 ± 0.46 mm, and in the 20 mm group it was 2.69 ± 0.30 (Figure 6). The mean graft-bone contact

Table III. — The mean, standard deviation, and p values of data according to loop lengths

	15 mm		20 mm		
	Mean	Standard Deviation	Mean	Standard Deviation	p
The guide reamer length	35.32	1.59	36.69	1.16	0.01
After the dilatator	34.02	1.33	35.03	1.09	0.03
After washing	35.36	1.57	36.63	1.15	0.03
Tunnel diameter	7.36	0.64	7.78	0.83	0.24
Graft margin	2.54	0.24	2.69	0.3	0.24
Flipping margin	0.46	0.24	5.31	0.3	p=0.0005
Graft-bone contact	29.9	1.55	31.31	1.24	0.01
Washing effect/flipping margin	4.07	2.78	0.3	0.11	p=0.0001

Table IV. — The analysis between the guide reamer lengths after dilator and washing lengths. Paired differences

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		
				Lower	Upper	p
The guide reamer length – After dilator length	1.52	0.5	0.09	1.34	1.71	p=0.00 03
The guide reamer length – After washing length	0.02	0.2	0.04	-5183	0.1	0.5
After dilator length – After washing length	-1.5	0.46	0.09	-1.67	-1.33	p=0.00 04

length was 29.9 ± 1.54 mm in the 15 mm group, and 26.87 ± 2.09 mm was measured in the 20 mm group. When the tunnel length was <35 mm, only 15 mm loop length implants were used. There was a highly significant correlation with the negative direction between the graft and flipping margins in both groups (respectively p=0.0004, p=0.0007, for both r : -1.000) (Table III).

While the ANOVA test was performed for repetitive measurements, the Greenhouse-Geisser test is preferred due to the value obtained from the Mauchly’s test of sphericity value was <0.05 in repetitive measurements among the groups. There were no significant differences between the 15 and 20 mm groups according to guide reamer lengths, after dilator and washing lengths (p = 0.073). Generally, however, there were significant differences between the guide reamer lengths after the dilator and washing lengths (p=0.06) (Table IV).

DISCUSSION

In this paper, we have determined that accumulated bone chips have a huge effect on flipping of the button and there was a reverse correlation between the graft thickness and washing effect. Also, the rates of the washing effect/flipping margins were significantly different (p=0.0001). Both results support the hypothesis.

Adjustable-loop systems allowed the socket to fill with graft and provide wider contact area.

Implant size does not change according to tunnel size and no need for loop length calculation *(3)*. According to some biomechanical studies, although their mentioned advantages above, adjustable-loop systems may cause stretching and laxation in the early postoperative period *(4-6)*. They have more tensile strength and less significant stretch margins than continuous loop length systems *(1-2)*. Stretching of the graft decreases graft tension and widens the tunnel so that the consolidation process is disrupted in the early postoperative period *(5,7)*. The required time for consolidation is approximately 6-12 weeks *(7,8)*. It is estimated that the implants can be exposed to 500 N force in the early rehabilitation period *(9)*. Petre et al., however, highlighted that the elongation amount with sinusoidal pressure (formed by 1000 cycles with only 250 N force) is <2 mm for adjustable-loop systems and 2.74-3.34 mm for continuous loop length systems *(6)*. Boyle et al. did not mention any significant differences between continuous loop length and adjustable-loop systems for graft stability and survival rates in their 188 cases *(3)*. This research, however, had a retrospective design. One may argue that adjustable-loop systems are more practical, but this system may cause some technical difficulties and also some complications that have been described with fixation. However, the device has been associated with the same complications that have been described with continuous loop fixation. The button of the adjustable-loop system may remain in the femoral tunnel rather than flipping outside of and resting on the lateral femoral cortex, or it may become jammed inside the femoral canal. Conversely, the button may be pulled too far off of the femoral cortex into the overlying soft tissue and flip in the substance of the vastus lateralis *(10)*.

As a result, in the 15 mm group, the mean flipping margin was 3 mm less than the 20 mm group. This revealed the effect of the flipping margin in the 15 mm loop length for the continuous loop length systems. The ratio of washing effect to flipping margin was 14 times higher in the 15 mm group. This result shows the effectiveness of the irrigation for the 15 mm loop length. If the socket is deepened through the cortex and if the inside of the tunnel is washed effectively, even the 9 mm thickness graft could be hung with the 15 mm loop length button.

Someone might suggest not using a dilator, but the graft will carry the bone chips toward the socket base-like dilator.

Producing a new loop length between the 15 mm and 20 mm should be considered. In conclusion, we are convinced that the irrigation inside of the socket must be performed for the 15 mm loop length, however, this is not a requirement for >20 mm. After considering this technical detail, the continuous loop length systems may be preferred over the adjustable-loop systems.

REFERENCES

1. **Eguchi A, Ochi M, Adachi N, Deie M, Nakamae A, Usman MA.** Mechanical properties of suspensory fixation devices for anterior cruciate ligament reconstruction : Comparison of the fixed-length loop device versus the adjustable-length loop device. *Knee*. 2014 ; 21(3) : 743-748.
2. **Barrow AE, Pilia M, Guda T, Kadrmas WR, Burns TC.** Femoral suspension devices for anterior cruciate ligament reconstruction : Do adjustable loops lengthen? *Am J Sports Med*. 2014 ; 42(2) : 343-349.
3. **Boyle MJ, Vovos TJ, Walker CG, Stabile KJ, Roth JM, Garrett WE.** Does adjustable-loop femoral cortical suspension loosen after anterior cruciate ligament reconstruction? A retrospective comparative study. *Knee*. 2015 ; 22(4) : 304-308.
4. **Kamelger FS, Onder U, Schmoelz W, Tecklenburg K, Arora R, Fink C.** Suspensory fixation of grafts in anterior cruciate ligament reconstruction : a biomechanical comparison of 3 implants. *Arthroscopy*. 2009 ; 25(7) : 767-776.
5. **Kousa P, Järvinen TL, Vihavainen M, Kannus P, Järvinen M.** The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction : Part I : Femoral site. *Am J Sports Med.* 2003 ; 31(2) : 174-181.
6. **Petre BM, Smith SD, Jansson KS, de Meijer P-P, Hackett TR, LaPrade RF, *et al.*** Femoral cortical suspension devices for soft tissue anterior cruciate ligament reconstruction : a comparative biomechanical study. *Am J Sports Med*. 2013 ; 41(2) : 416-422.
7. **Rodeo SA, Arnoczky SP, Torzilli PA, Hidaka C, Warren RF.** Tendon-healing in a bone tunnel. A biomechanical and histological study in the dog. *JBJS.* 1993 ; 75(12) : 1795-1803.
8. **Goradia VK, Rochat MC, Grana WA, Rohrer MD, Prasad HS.** Tendon-to-bone healing of a semitendinosus tendon autograft used for ACL reconstruction in a sheep model. *Am J Sports Med.* 2000 ; 13(3) : 143-151.

9. **West RV, Harner CD.** Graft selection in anterior cruciate ligament reconstruction. *J Am Acad Orthop Surg.* 2005 ; 13(3) : 197-207.

10. **Sonnery-Cottet B, Rezende FC, Neto AM, Fayard JM,** Thaunat M, Kader DF. Arthroscopically confirmed femoral button deployment. *Arthrosc Tech.* 2014 ; 3(3) : e309-e12.