

# The effects of immobilization subsequent to the repair of clean-cut tendon injuries on distal radius bone mineral content

## Tendon tamiri sonrası immobilizasyonun distal radius kemik mineral içeriğine etkisi

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### BACKGROUND

We investigated the changes of bone mineral density at distal radius and ulna in patients with volar wrist clean-cut tendon(s) injuries that were treated by early primary repair and passive mobilization.

### METHODS

Fifteen patients with non-dominant hand injury (group I), 12 patients with dominant hand injury (group II) and 15 healthy volunteers serving as the control group (group III) were enrolled into this study. Side to side bone mineral component differences (SSD) of the proximal, middle and ultradistal radius that were obtained at 6th week and 4th month after operation were statistically compared.

### RESULTS

In comparison with the control group, SSD measurements of the middle and proximal subregions of group II at the 6th week were significantly decreased ( $p<0.01$  and  $p<0.001$ ). The decreases were 8.9 and 8.6% respectively. Similarly, the 4th month SSD measurements of the middle and proximal subregions of group II were also significantly decreased compared to group III ( $p<0.001$ ). The decreases were 10.2% and 7.7%, respectively. In group I, except a 7.4% decrease at the middle subregion of the radius at 4th month, there was no significant difference in SSD measurements as compared with the control group.

### CONCLUSION

Results of our study indicate that there is a considerable bone loss of distal radius in patients who are surgically treated for acute clean-cut tendon(s) injuries at the volar wrist level.

**Key Words:** Immobilization; osteoporosis; radius, bone mineral density; tendon injuries.

### AMAÇ

Önkol voler yüzde düzgün tendon yaralanması olan olgularda erken primer tamir ve pasif hareket sonrası distal radius ta meydana gelen kemik mineral yoğunluğ undaki değişimin araştırılması.

### GEREÇ VE YÖNTEM

On beş dominant olmayan el yaralanması olan hasta (grup I), 12 dominant el yaralanması olan hasta (grup II) ve sağlıklı gönüllülerden oluşan 15 kişilik kontrol grubu (grup III) çalışmaya alındı. Ameliyattan sonra 6. haftada ve 4. ayda elde edilen önkol proksimal, orta ve ultradistal bölgelerin yan-yana kemik mineral içeriğindeki değişimler (SSD) istatistiksel yöntemlerle karşılaştırıldı.

### BULGULAR

Kontrol grubu ile kıyaslandığında, grup II olgularda altıncı haftada radiusun proksimal ve orta bölgelerindeki SSD ölçümleri anlamlı derecede azaldı ( $p<0,01$  ve  $p<0,001$ ). Bu azalma sırayla %8,9 ve %8,6 oranındaydı. Benzer şekilde, kontrol grubu ile kıyaslandığında, grup II olgularda dördüncü ay radiusun proksimal ve orta bölgelerindeki SSD ölçümleri anlamlı derecede azaldı ( $p<0,001$ ). Bu azalma sırayla %10,2 ve %7,7 olduğu kaydedildi. Grup I'de 4. aydaki radius orta kısım SSD ölçümündeki %7,4 azalma hariç tutulursa, kontrol grubuna kıyaslandığında SSD ölçümlerinin anlamlı farklılığı yoktu.

### SONUÇ

Önkol voler yüzde düzgün tendon yaralanması olan olgularda erken primer tamir ve pasif hareket sonrası distal radius ta meydana gelen kemik mineral yoğunluğ unda anlamlı derecede azalma olabilmektedir.

**Anahtar Sözcükler:** Immobilizasyon; osteoporoz; radius, kemik mineral yoğunluğ u; tendon yaralanmaları.

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Experimental and clinical studies demonstrate that immobilization leads to a rapid loss of bone. Immobilization-induced changes in bone vary depending on factors such as the location, age, severity of the injury and especially the type and duration of the immobilization. Additionally, a positive family history, increased age, white race, female gender, delayed puberty, various hormonal disturbances and nutritional deficiencies, low body weight, a number of diseases and drugs and smoking are well recognized risk factors for generalized osteoporosis.<sup>[1-4]</sup> Bone loss induced by disuse or immobilization are reported to be generalized in patients with prolonged bed rest<sup>[4]</sup> and localized due to immobilization and disuse of the limbs as shown in some experimental and clinical studies.<sup>[2,4-14]</sup>

Bone mineral density (BMD) measurements are commonly used as a surrogate for the assessment of the risk of fracture. One standard deviation decrease in bone-mineral density of an age-matched norm (an amount equivalent to approximately 10 to 15 percent of an individual's bone mass) is associated with a 50 to 100 percent increase in the risk of fracture.<sup>[3]</sup> There are a few studies dealing with the localized bone mass decrease that develop following injuries to tendons or ligaments.<sup>[2,15-18]</sup> In most clinical studies, authors emphasized the positive correlation between the increased risk for distal radius fracture incidence and low BMD or osteoporosis of the distal radius.<sup>[19,23]</sup>

Quantitative computed tomography and quantitative magnetic resonance imaging provide an accurate measurement of the three-dimensional geometry of bone and its trabecular bone compartment. However, their costs, required time and radiation dose are the limitations of these methods for routine use. On the other side, dual-energy X-ray absorptiometry (DEXA) is currently the most widely used tool for the measurement of bone mineral content because of its accuracy, precision, stability and low dose of radiation as well as the speed and ease of scanning.<sup>[3,24]</sup>

We examined whether there is a significant bone loss in patients with volar wrist clean-cut tendon(s) who were treated with early primary repair and passive mobilization.

## MATERIALS AND METHODS

Twenty-seven patients (7 females, 20 males, mean age  $30.8 \pm 9.9$  years, age range 15-50 years) and

fifteen healthy volunteers were enrolled in this study. All patients had acute clean-cut tendon(s) injuries at the wrist level of the volar side. The operated limbs of the patients were immobilized in long arm cast for thirty days and short arm cast for the following two weeks. After postoperative 4th day, according to Duran Method, all cases were encouraged for passive mobilization exercises for six weeks.

First group involved 15 patients operated for non-dominant hand injury (5 females, 10 males and mean age  $30.5 \pm 10.1$  years, age range 15-50 years). Second group involved 12 patients operated for dominant hand injury (2 females, 10 males and mean age  $31.3 \pm 10$  years, age range 18-44 years). The third group consisted of 15 healthy volunteers (2 females, 13 males, mean age  $32.9 \pm 7.6$  years, age range 21-48 years).

None of the patients and volunteers had any previous forearm fracture, bone and joint diseases and serious intercurrent diseases and none of them used any drugs known to affect bone metabolism such as estrogen, glucocorticoids, anticonvulsants, vitamin D or calcium supplements. Postmenopausal women and patients with secondary osteoporosis were not involved. Consent was obtained from all subjects and the study was conducted in accordance with the Helsinki Declaration and approved by the ethical committee of the İnönü University Faculty of Medicine.

Bone mineral component (BMC) of the dominant and non-dominant forearms were measured with dual-energy X-ray absorptiometry (DEXA) (QDR 4500/W, Hologic Inc., Bedford, MA, USA) and results were evaluated by the same examiner. DEXA equipment uses switched pulsed stable dual-energy radiation with 70 kV and 140 kV. Subregion analysis software was used to analyze the radius. Bone mineral density (BMD) was not preferred owing to limited forearm rotation during the first measurement that was at the postoperative 6th week. Three neighboring subregions (proximal, middle and ultradistal) were drawn at the distal radius, each measuring 20 mm starting from the tip of the styloid process (Fig. 1).

In the first and second groups, the bone mineral measurements of the bilateral forearms were performed twice. In group I, first and second measurements were performed at the 6th week (mean

6.1±0.8 week) and 4th month (mean 3.6±0.9 month). In group II, first and second measurements were performed at the 6th week (mean 6.8±1.7 week) and 4th month (mean 4.2±1.2 month). In group III, a single BMC measurement was obtained bilaterally.

Side to side bone mineral component differences<sup>[25,26]</sup> of the proximal, middle and ultradistal subregions of radius were statistically compared. Side to side bone mineral component difference (SSD) was calculated by the formula given below.

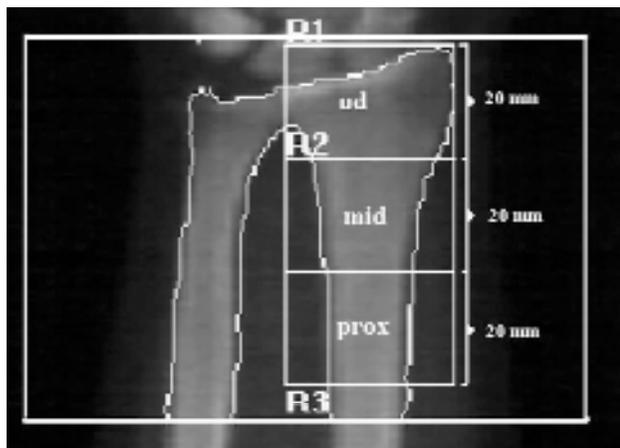
$$SSD = [(affected\ side\ BMC - unaffected\ side\ BMC) / unaffected\ side\ BMC] \times 100$$

When comparing the control group with group I, the measurements of the non-dominant limb of the control group was referred as the affected side BMC. In the same manner, the dominant limb of the control group was referred as the affected side BMC when comparing with group II.

For the comparison of side to side BMC differences, Wilcoxon signed-rank and Mann-Whitney U tests were used. All statistical analyses were performed with SPSS for Windows version 11.0 and p<0.05 was considered as statistically significant.

### RESULTS

In group III, the comparison of dominant and non-dominant sides revealed a significant difference regarding both the BMC values of the proximal and the middle subregions (p=0.023 and p=0.002, respectively). Bone mineral component values of proximal and middle subregions of the non-domi-



**Fig. 1.** Radius ultradistal (ud), middle (mid) and proximal (prox) regions on the forearm bone mineral density.

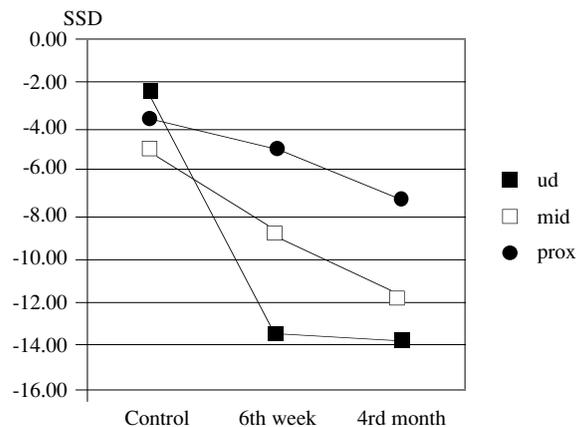
**Table 1.** SSD values of the 6th week and 4th month of group I and group III.

Region	SSD measurements		
	Group III (control)	Group I	
		6th week	4th month
Ultradistal	-2.36±7.23	-13.48±23.99	-13.78±23.32
Middle	-4.98±3.47	-8.88±7.47	-11.92±11.80
Proximal	-3.53±5.13	-4.96±6.44	-7.31±7.40

nant side were significantly lower than the dominant side, as 3.5% and 5%, respectively.

Regarding the middle subregion SSD values, there was a statistically significant decrease between 4th month measurements of group I in comparison to the control group (p<0.01). The amount of decrease was 7.4%. Although there was a decrease, the 6th week SSD measurements of group I did not show any statistical significance when compared with the 4th month measurements of group I and the control group (p>0.05). Side to side bone mineral component difference values of group I and group III are summarized on Table 1 and Fig. 2.

In comparison with the control group, SSD measurements of the middle and proximal subregions of group II at the 6th week were significantly decreased (p<0.01 and p<0.001). The decreases were 8.9% and 8.6%, respectively. The 4th month SSD measurements of middle and proximal subregions of group II were also significantly decreased in comparison group III (p<0.001). The decreases were 10.2% and



**Fig. 2.** Changes of SSD values at the 6th week and 4th month of group I and group III.

**Table 2.** SSD values of the 6th week and 4th month of group II and group III.

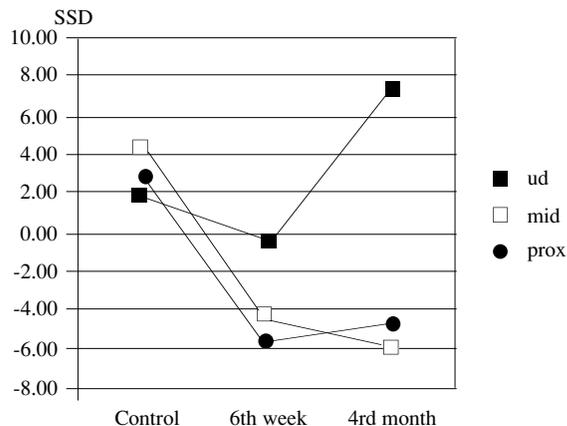
Region	SSD measurements		
	Group III (control)	Group II	
		6th week	4th month
Ultradistal	1.86±6.86	-0.46±8.52	7.37±9.04
Middle	4.64±3.21	-4.64±7.62	-5.98±5.49
Proximal	3.18±4.89	-5.66±4.94	-4.69±5.31

7.7%, respectively. In group II, we found a significant increase of SSD measurements in the ultradistal subregion between 6th week and 4th month values ( $p=0.004$ ). SSD values of the 6th week and 4th month of group II and group III are summarized on Table 2 and Fig. 3.

### DISCUSSION

In this study, we aimed to investigate whether there was a significant bone loss of distal radius due to early passive mobilization in patients surgically treated for acute clean-cut tendon-artery-nerve injuries at the wrist level.

When compared with the control group, the SSD measurements of group II have decreased by 8.9 and 8.6% at the middle and proximal subregions of the radius at the 6th week and by 10.0% and 7.7% at the



**Fig. 3.** Changes of SSD values at the 6th week and 4th month of group II and group III.

middle and proximal subregions at the 4th month. However, in group I, except a 7.4% decrease at the middle subregion at the 4th month, there was no significant difference of SSD measurements in comparison to the control group. This reduction which is more prominent in the injuries of the dominant side may be important for fracture risk, especially in patients with well-recognized risk factors for generalized osteoporosis.

Table 3 summarizes a number of comparative studies related to BMD changes due to immobiliza-

**Table 3.** Studies relating to immobilization induced bone loss

Author	Study	Location	Time of Immob.	Method	Time of BMD	Decrease BMD%
Kannus et al. <sup>[14]</sup>	Human, acute knee ligament injury	Surgery + Immob. in a plaster cast	6-7 weeks	DEXA	10-11th y	3-9
Kannus et al. <sup>[16]</sup>	Human, rotator cuff rupture of the dominant side shoulder	Surgery + Immobilization	-	DEXA	9th y	0.2 -3.5
Skerry et al. <sup>[4]</sup>	Sheep's calcaneus	From the tibia to the metatarsus immob. with external fixator	12 weeks	DPA	12th w	22
Kaneps et al. <sup>[7]</sup>	Dog's radius	Unilateral front limb immob. with bandage	16 weeks	DEXA	16th w	25
Alfredson et al. <sup>[15]</sup>	Human, achilles tendinosis	Surgery, immob. and weightbearing rehabilitation	2 weeks	DEXA	0-6 w 16th w 52th w	NS 11.5 16.4
Leppälä et al. <sup>[25]</sup>	Human, anterior cruciate ligament injury of knee	Surgery + Rehabilitation	-	DEXA	1st year	14-21
Silva et al. <sup>[18]</sup>	Canine's flexor tendon repair	Surgery + Immob. + Passive mobilization	10 day 42 day	CT	10th day 42th day	NS 17
Ditsios et al. <sup>[2]</sup>	Canine's flexor tendon repair in	Surgery + Immob. + Passive mobilization	6 week	CT	10th day 21th day 42th day	20 40 41
<b>Our study</b>	<b>Human, tendon repair</b>	<b>Surgery + Immob. + Passive mobilization</b>	<b>6 week</b>	<b>DEXA</b>	<b>6th w 3rd mo</b>	<b>&lt;8.9 7.4-10.2</b>

Immob.: Immobilization; CT: Computerized tomography; DPA: Dual photon absorptiometry; DEXA: Dual-energy X-ray absorptiometry; NS: Not significant.

tion. With respect to the SSD measurements of group I at the 6th month, our findings are in disagreement with the results of Alfredson, whereas they are concordant with the results of Silva and Ditsios.<sup>[2,5,18]</sup> Regarding the measurements at the 4th month, our findings support the studies of Skerry, Kaneps and Alfredson.<sup>[4,5,7]</sup> There are controversies about the period for the immobilized extremity to return to the normal BMD values. The recovery of decreased BMD was reported as 32 weeks by Kaneps and one year by Leppälä.<sup>[7,17]</sup> We will give the late results about the recovery of distal radius bone loss of our patients in our forthcoming studies.

Regarding the studies carried on patients with distal radius fractures, Tuck et al., Kanterewicz et al. and Wigderowitz et al. found a decreased BMD of distal radius at rates of 41.8%, 70% and 85%, respectively.<sup>[20,22,23]</sup> Morii et al. considered BMD as being one of the components of fracture risk that can be measured with reasonable accuracy and precision and emphasized this accuracy of BMD measurements in predicting fracture that was as good as blood pressure in predicting stroke.<sup>[24]</sup>

Results of our study indicate that there is a considerable bone loss of distal radius in patients surgically treated for acute clean-cut tendon-artery-nerve injuries at the volar wrist level.

In conclusion, results of this study suggest that at the postoperative 3rd month, there is a considerable bone loss developing a high fracture risk of distal radius and ulna in the patients operated for radial artery injury, patients operated for tendon and nerve injuries, in female patients and in patients operated for non-dominant left hand injury. Therefore, we suggest that these patients should be informed about the fracture risk at the distal radius and ulna and they should be encouraged for loading or resistive exercises of the involved extremity after the removal of the cast and anti-resorptive drugs may be recommended.

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