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ORIGINAL ARTICLE

Clinical differences between nasogastric tube and Hunter's rod for staged Zone II flexor tendon reconstruction

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Optimal outcomes are typically achieved, when tendon injuries undergo primary repair early within days of the injury. However, circumstances may prevent immediate intervention. In cases of missed injuries or unsuccessful primary repairs, two-stage reconstruction is recommended. When the digital sheath and a proximal motor tendon can be intact, the one-stage tendon graft reconstruction may be favored as the recommended approach. However, if there is impairment of the pulley system or the presence of adhesions, a two-stage tendon graft reconstruction may be required.

In the two-stage reconstruction method, first introduced by Hunter and Salisbury[1] in 1971, the initial phase involves the insertion of a tendon spacer following debridement and the creation

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ABSTRACT

Objectives: This study aims to compare the outcomes of two-stage flexor tendon reconstruction in Zone II of the hand and to evaluate the results of a nasogastric tube as a potential alternative to Hunter's rod.

Patients and methods: Between November 2012 and January 2022, a total of 45 patients (26 males, 19 females; median age: 31 years; range, 12 to 61 years) who underwent two-stage flexor tendon reconstruction were retrospectively analyzed. Of the patients 24 underwent nasogastric tube reconstruction (NT group) and 21 underwent Hunter's rod reconstruction (HR group). Patients' demographic and clinical characteristics, the number of surgeries, the occurrence of complications, the presence of infection during the procedure, and the range of motion of the finger joints at the final follow-up examination were recorded. The assessment of the cases was conducted using the total active motion system.

Results: Twenty-four digits underwent two-stage flexor tendon reconstruction with the nasogastric tube. Among these, three index fingers, nine middle fingers, seven ring fingers, and five little fingers were operated. Twenty-one digits underwent two-stage flexor tendon reconstruction using Hunter's rod. Among these, two index fingers, eight middle fingers, six ring fingers, and five little fingers were operated. In the NT group, excellent results were observed in 58.3% (14 digits), good results in 25% (six digits), fair results in 8.3% (two digits), and poor results in 8.3% (two digits). In the HR group, excellent results were seen in 57.1% (12 digits), good results in 33.3% (seven digits), fair results in 4.7% (one digit), and poor results in 4.7% (one digit).

Conclusion: The utilization of a nasogastric tube offers a convenient and cost-effective option to Hunter's rod in the two-stage flexor tendon reconstruction, leading to favorable outcomes characterized by high rates of excellence and improvement, while effectively minimizing the occurrence of complications.

Keywords: Finger, injuries, tendinopathies, tendon release, tendon.

of a pseudosheath around the silicone rod. In the subsequent stage, the silicone rod is removed, and the flexor tendon is reconstructed using a free tendon graft. This technique represents the most prevalent and widely accepted approach for flexor tendon reconstruction. However, alternative techniques have been documented in the literature due to economic burden and limited accessibility of Hunter's rod for staged tendon reconstruction.[2,3]

In the present study, we hypothesized that patients who underwent the nasogastric tube approach would achieve comparable outcomes with similar rates of complications compared to those who utilized Hunter's rod. We, therefore, aimed to compare the results of the nasogastric tube versus Hunter's rod in two-stage flexor tendon reconstruction within Zone II of the hand.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Medicine Faculty of Selçuk University, Department of Orthopedics and Traumatology between November 2012 and January 2022. A total of 45 patients (26 males, 19 females; median age: 31 years; range, 12 to 61 years) who underwent two-stage flexor tendon reconstruction in our clinic were included. All patients experienced injuries of the affected digit in Zone II of the hand, accompanied by significant scarring and a non-functional flexor remnant. Patients lost to follow-up and those who underwent multiple tendon reconstruction surgeries, irrespective of the method employed, were excluded from the study. Additionally, patients who failed to adhere to the prescribed physical therapy protocol were excluded. Furthermore, individuals who were unable to undergo two-stage surgery due to factors such as patient unsuitability or the presence of significant joint contracture were not included in the study. In addition, all patients with isolated flexor digitorum profundus (FDP) incision were mentioned as a conservative treatment option, but patients who received conservative treatment were not included in the study. Following the exclusion of patients, a total of 24 patients who underwent nasogastric tube reconstruction (NT group) and 21 patients who underwent Hunter's rod reconstruction (HR group) were included in the study (Figure 1). Data were retrieved from patient files and clinical records. The patients were invited for a final follow-up evaluation, and their clinical condition was assessed through physical examination. One of the authors, who was responsible for the final evaluation, was blinded to the material utilized in the two-stage tendon reconstruction.

The patient's demographic data, the number of surgeries, complications, occurrence of infections during the procedure, and the range of motion (ROM) of the fingers were all assessed and analyzed.

Surgical technique

A total of 24 patients (NT group) underwent two-stage flexor tendon reconstruction with a nasogastric tube. A total of 24 digits were operated, consisting of three index fingers, nine middle fingers, seven ring fingers, and five little fingers. A total of 21 patients (HR group) underwent two-stage flexor tendon reconstruction using Hunter's rod. A total of 21 digits were operated, including two index fingers, eight middle fingers, six ring fingers, and five little fingers. The classification of patients' tendon injuries was determined according to the Boyes grading system,[4] which assesses the severity of the injury. The initial stage of reconstruction was carried out approximately five (range, 2 to 24) months after the injury, and there was a median duration of two months (range, 8 to 10) weeks between the two stages.

In the NT group, FDP lesions were concomitant with flexor digitorum superficialis (FDS) incision in five patients, while in the HR group, this combination was observed in four patients. In cases where the FDS showed adhesion, excision was performed. Moreover, nerve injury was present in five patients from the NT group and in four patients from the HR group. The identified nerve injuries were subsequently repaired.

All surgical procedures were conducted by a single surgeon. Surgical procedures were performed as described by Hunter and Salisbury.[1] In the first

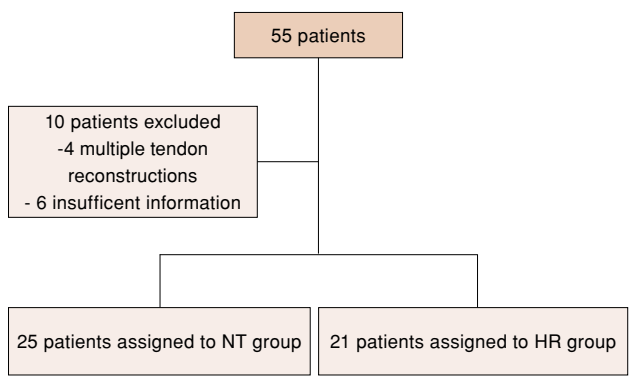

FIGURE 1. Study flowchart.
NT: Nasogastric tube; HR: Hunter's rod.

stage, the exploration was carried out using zig-zag skin incisions described by Bruner.[5] The Pulley system was evaluated and in case of defects and adhesions, two-stage tendon reconstruction was performed. The appropriately sized nasogastric tube that was made by silicone and 10-Fr in diameter (1-Fr= 1/3 mm) was secured to the stump of the FDP tendon at the distal phalanx level. The nasogastric tube or the Hunter's rod was released free at the level of flexor Zone III or Zone V region (Figure 2). At this stage, the proximal FDP tendon was marked with a polypropylene suture (Figures 3 and 4). The free end of the nasogastric tube or the Hunter's rod at Zone III/V was also marked with prolene suture so that it could be easily found in the second stage. In Stage 1, patients with additional injuries such as nerve injuries underwent nerve repair or reconstruction. Reconstruction or repair with the remaining pieces of pulley was performed according to the soft tissue condition in those who had loss of the pulley system. The residual pulleys were reconstructed using various techniques, including the utilization of existing remnants to create new pulleys when deemed suitable, employing excised tendon grafts for pulley grafting when deemed necessary, or using FDS remnants as grafts when deemed appropriate.[6-9] In the first stage, after the tip of the nasogastric tube or the Hunter's rod was sutured to the distal phalanx, finger flexion was controlled by pulling the silicone proximal in terms of possible bowstring deformity and pulley failure, and additional pulley repair or reconstruction was performed if necessary.

A splint was used for five to seven days after the first stage operation to assist in wound healing in all patients. After the splint removal, passive exercises were initiated and followed for at least eight weeks to prevent joint stiffness and ensure

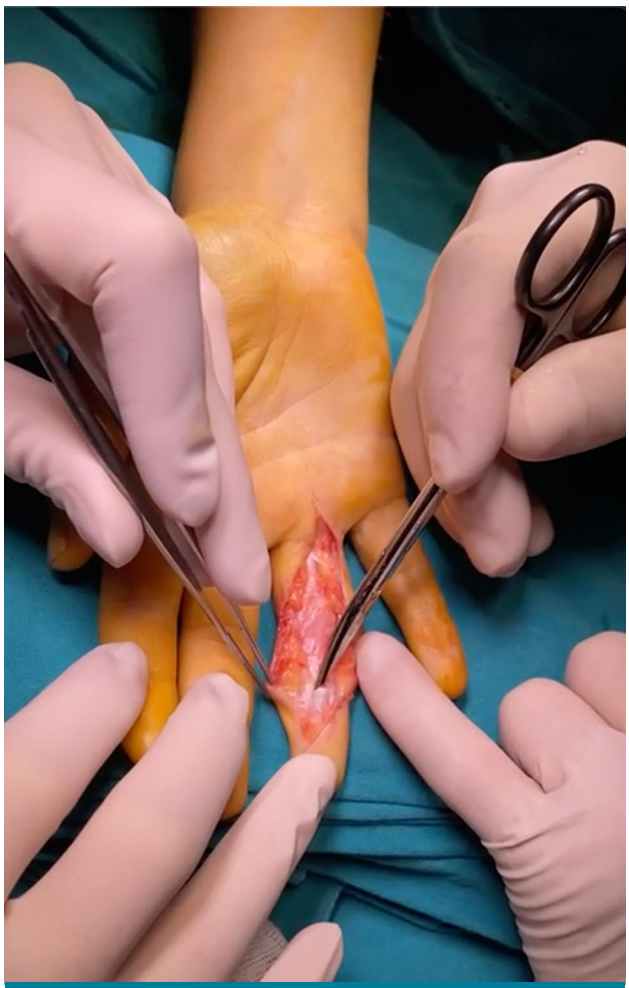

FIGURE 2. Pulling nasogastric tube.

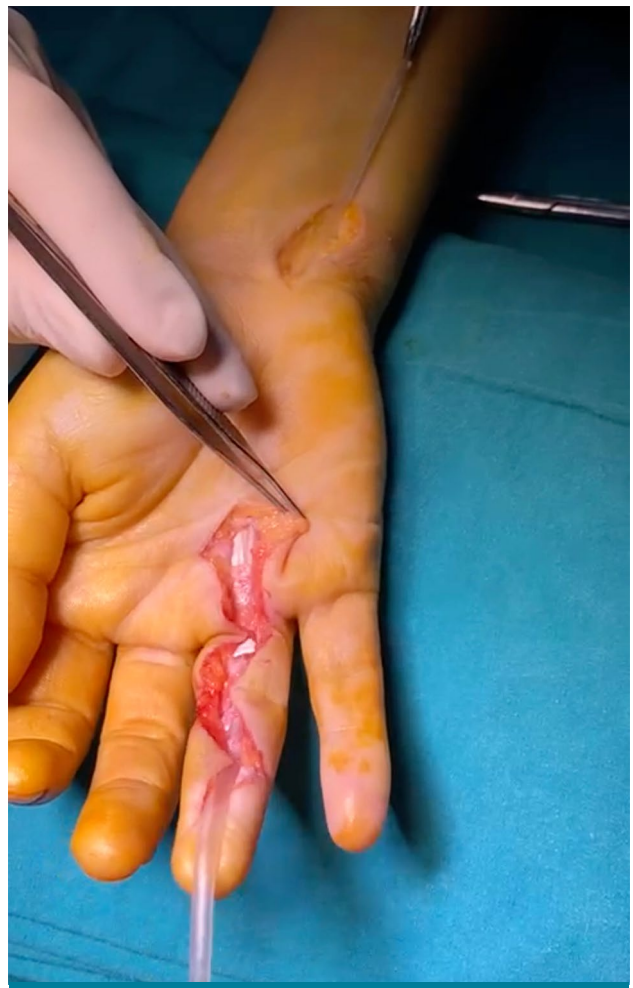

FIGURE 3. Marking of the flexor digitorum profundus tendon.

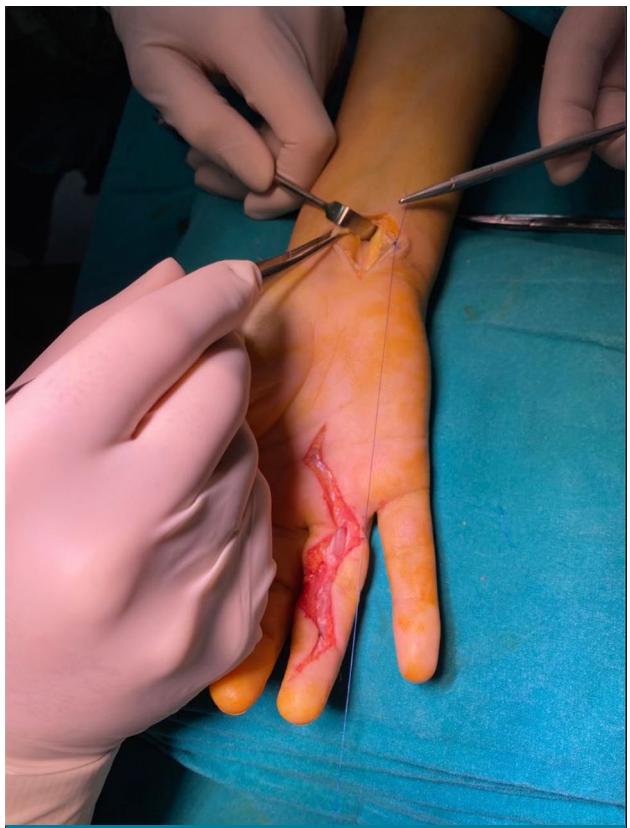

FIGURE 4. In the long-term follow-up, visualization of a patient's finger extension-flexion and full grasping movement.

the maximum joint ROM. At the end of a median of eight weeks (range, seven to nine weeks), the patients underwent second-stage surgery.

In the second stage, the palmaris longus tendon (PLT) graft was initially harvested from the same hand. If there was no PLT graft, a plantar tendon graft was harvested from the leg. The nasogastric tube or the Hunter's rod was primarily found in proximal and distal incisions. Subsequently, the tendon graft was attached to the distal end of either the nasogastric silicone tube or the Hunter's rod. The graft was, then, passed through this sheath with the help of this silicone tube or the Hunter's rod without damaging the formed membranous sheath. It was examined whether the tendon graft could move easily in this tunnel. In the beginning, the tendon graft was securely attached to the remaining portion of the FDP, specifically at the distal phalanx level. If there was no FDP tendon stump, the graft was fixed to the distal phalanx by pull-out procedure. The tendon graft was skillfully attached to the motor tendon proximally, ensuring appropriate tension, while adjusting the finger flexion-extension tonus through the passive tenodesis effect. In the NT group, the PLT was used as the tendon graft in 21 cases, while the plantaris tendon (PT) was used in three cases. In the HR group, the PLT was applied as the tendon graft to 20 cases, and the PT was applied to one case. A Kleinert splint was applied for at least one month after the operation. Postoperative rehabilitation was performed according to the Kleinert protocol (passive flexion, active extension). An average of one month after the second operation, active exercise was initiated. All rehabilitation program was carried out under the supervision of physiotherapists.

The evaluation of the cases was conducted using the total active motion (TAM) system assessment. The Strickland scale,[10] which utilizes the TAM, was employed to standardize and compare the outcomes. According to the evaluation, the results were categorized as follows: 75 to 100% as excellent, 50 to 74% as good, 25 to 49% as moderate, and 0 to 24% as poor.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in median (min-max) or number and frequency, where applicable. The normal distribution of the data was assessed using the Kolmogorov-Smirnov test. For non-normally distributed parameters, the Mann-Whitney U test was used to compare two groups. A p value of <0.05 was considered statistically significant.

RESULTS

Patient's demographic data, the number of surgeries, complications, occurrence of infections during the procedure, and the ROM of the fingers are presented in Table I.

A total of 24 digits underwent two-stage flexor tendon reconstruction applying the nasogastric tube and were evaluated. Among these, three index fingers, nine middle fingers, seven ring fingers, and five little fingers were operated. The distribution of patients based on Boyes grading was as follows: n=9 in Grade 1, n=3 in Grade 2, n=7 in Grade 3, and n=5 in Grade 4. Similarly, 21 digits underwent two-stage flexor tendon reconstruction using Hunter's rod, including two index fingers, eight middle fingers, six ring fingers, and five little fingers. The distribution of patients based on Boyes grading in this group was as follows: n=8 in Grade 1, n=2 in Grade 2, n=7 in Grade 3, and n=4 in Grade 4. There were no statistically significant differences between the two groups regarding the distribution of affected digits

TABLE I
Patients characteristics

	NT group			HR group			
	n	Median	Range	n	Median	Range	*p*
Age (year)		25.9	12-56		36.4	13-61	0.005
Sex							0.9
Male	14			12			
Female	10			9			

NT: Nasogastric tube; HR: Hunter's rod reconstruction.

TABLE II
Comparison of groups in terms of tendon injury

	NT group	HR group	
Boyes grade	n	p	*p* value
Grade 1	9	8	0.9
Grade 2	3	2	0.7
Grade 3	7	7	0.7
Grade 4	5	4	0.8

NT: Nasogastric tube; HR: Hunter's rod.

and tendon injury grades according to the Boyes classification (Table II).

In the NT group, excellent results were observed in 58.3% (14 digits), good in 25% (six digits), fair in 8.3% (two digits), and poor in 8.3% (two digits). Similarly, in the HR group, excellent results were seen in 57.1% (12 digits), good in 33.3% (seven digits), fair in 4.7% (one digit), and poor in 4.7% (one digit) (Table III). There were no significant differences between the two groups in terms of the outcomes using the Strickland scale (p=0.4).

In the NT group, one patient exhibited lumbrical plus finger. Following the initial stage of surgery, two patients experienced postoperative infection. Also, the nasogastric tube was exposed in same patients. The rod was replaced after removal in the given scenario in a patient who had infection after stage 1 operation and only removed in a patient and second-stage surgery was abandoned due to patient non-compliance. *Staphylococcus aureus* was cultured in both patients. In the NT group, one out of the two patients with unsatisfactory outcomes presented severe flexion contracture prior to the surgical intervention, while the other patient experienced tendon graft rupture during long-term follow-up. The patient who developed contracture after the initial stage had the tendon spacer removed and was subsequently excluded from the study. There were no occurrences of skin necrosis, rod buckling, and silicone synovitis in any of the patients.

In the HR group, two cases developed infection following the initial stage of the surgery. Debridement was performed and rod was changed in these cases. *Staphylococcus aureus* was cultured in one patient and *Staphylococcus epidermidis* in the other. The infection was managed using antibiotics, and the second stage of the surgery was conducted after an eight-week interval following the initial stage procedure. The Hunter's rod was exposed in one case. Since the exposure time was close to the second-stage operation, the rod was removed and the second-stage surgery was performed in the same session. Tenolysis was performed in three patients in the NT group and in one patient in the HR group. There was no significant difference in the complication rates between the groups (p=0.3).

TABLE III
Results obtained as per Strickland scale

	NT group		HR group		
Range of motion	n	%	n	%	*p* value
85°-100° (excellent)	14	58.3	12	57.1	0.4
70°-84° (good)	6	25	7	33.3	
50°-69° (fair)	2	8.3	1	4.7	
0°-49° (poor)	2	8.3	1	4.7	

NT: Nasogastric tube; HR: Hunter's rod.

DISCUSSION

In the present study, we compared the results of the nasogastric tube versus Hunter's rod in two-stage flexor tendon reconstruction within Zone II of the hand. Our study results showed that incorporating a nasogastric silicone tube in two-stage tendon reconstruction produced comparable outcomes to the use of a tendon spacer.[11] One of the two patients with poor outcomes had severe flexion contracture before surgery and the patient's compliance with physical therapy was limited due to pain sensitivity. In the other patient, a rupture of the tendon graft was observed in the long-term follow-up. The tip of the probe protruded into the skin of two patients who developed an infection. One of these patients was excluded from the study due to lost to follow-up for about six months after the first stage of surgery and non-compliance with the treatment. Our clinical experience in two-stage reconstruction is that this treatment should be applied to patients who are highly motivated and would be compatible with the treatment process.

The main disadvantages are that the nasogastric tube is more flexible than the Hunter's rod and that it less simulates the shape of the tendon compared to the Hunter's rod. The nasogastric tube is of the same thickness from proximal to distal, whereas the Hunter's rod tapers from proximal to distal.

Flexor tendon injuries represent a small proportion, accounting for less than 1%, of all hand injuries;[12] however, the treatment of flexor tendon injuries can be challenging. In particular, during and after surgery of Zone II injuries, microsurgery and rehabilitation protocols must be strictly followed. Implementing appropriate surgical techniques and early initiation of controlled movement can lead to favorable outcomes. However, chronic flexor tendon injuries, particularly in Zone II, often present complications including tendon end retraction, adhesion formation, and fibro-osseous canal collapse.

Two-stage tendon reconstruction is the preferred approach in secondary cases, when optimal outcomes cannot be achieved through primary repair. It is indicated for patients with severe damage to the tendon bed resulting from the primary injury and for delayed cases. The concept of two-stage tendon reconstruction was first introduced in an experimental study in 1914.[13] The method of utilizing silicone rods for two-stage tendon grafting was first outlined by Bassett and Carroll[14] in 1963 and subsequently established as a standardized technique by Hunter in 1971.[15]

Favorable outcomes have been documented in the scientific literature for cases treated with this technique.[16] However, the cost and limited accessibility of these silicone Hunter's rods posed significant challenges, particularly in developing countries. Due to these problems, it has led to studies on low-cost and effective alternatives. The presence of comparable inquiries in Türkiye has prompted us to conduct diverse investigations. In our local context, the nasogastric tube is priced at 20 cents, whereas the Hunter's rod spacer costs 500 USD. Given the similarity of clinical outcomes, the undeniable advantage lies in the cost-effectiveness of the nasogastric tube.

In a study conducted, two cases demonstrated successful outcomes by utilizing a silicone drainage tube that is flat and radiopaque in nature a substitute for Hunter's rod.[17] Similarly, in another study including 17 patients by Atik et al.,[18] comparable clinical outcomes and appropriate pseudosheaths for tendon grafting were achieved using a urinary catheter instead of a silicone rod. Additionally, Agarwal and Sharma[19] achieved satisfactory results by performing two-stage flexor reconstruction with a polyvinyl chloride feeding tube in Zone II injuries. Al-Qahtani[20] also published a case report demonstrating successful outcomes in a two-stage flexor tendon reconstruction performed applying a nasogastric tube. In a series of 11 cases using a Redon drain or nasogastric tube, similar satisfactory clinical results at less cost were achieved.[11,21]

Nonetheless, there are some limitations to this study. The single-center, retrospective design of the study introduces the potential for selection and information bias. Furthermore, the sample size of our cases is relatively small. In addition, the study lacks an objective cost analysis and the utilization of scores to assess functional outcomes.

In conclusion, the utilization of a nasogastric tube offers a convenient and cost-effective option to Hunter's rod in the two-stage flexor tendon reconstruction, leading to favorable outcomes characterized by high rates of excellence and improvement, while effectively minimizing the occurrence of complications. However, further multi-center, large-scale, prospective studies are needed to confirm these findings.

Ethics Committee Approval: The study protocol was approved by the Selcuk University Faculty of Medicine Local Ethics Committee (date: 24.05.2022, no: 2022/252). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from the patients and/or parents of the patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept: A.Ö., M.A.A.; Design, literature review: E.Ş., F.D.; Control/supervision: A.Ö., M.A.A.; Data collection and/or processing: E.Ş., F.D., M.E.; Analysis and/or interpretation: E.Ş., M.E.; Writing the article: E.Ş.; Critical review: A.Ö.; References and funding: F.D., M.E.; Materials: E.Ş., A.Ö., F.D., M.E., M.A.A.

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