

## ***Possibilities of improving the function and esthetic appearance of finger stumps using the method of osseointegration***

**A.A. Koriukov, A.V. Gubin, V.P. Kuznetsov<sup>1</sup>, D.Iu. Borzunov, A.V. Antipov<sup>2</sup>, E.N. Ovchinnikov, A.V. Reznik, A.A. Emanov, O.N. Vladimirova<sup>3</sup>**

FSBI Russian Ilizarov Scientific Center "Restorative Traumatology and Orthopaedics of the RF Ministry of Health, Kurgan

<sup>1</sup>Ural Federal University, Ekaterinburg

<sup>2</sup>Terra Closed Joint-Stock Company, St. Petersburg

<sup>3</sup>FSBEI APE St. Petersburg Institute for Advanced Training of Medical Professionals, St. Petersburg, Russia

**Relevance** The work deals with the challenging problems of improving the function and aesthetic appearance of the finger stumps using a surgical technology of osseointegration. **Purpose** To present preliminary results of osseointegration with the use of titanium implants and exoprostheses for finger stumps. **Material and methods** Osseointegration was performed in order to improve the function and aesthetic appearance of 17 phalangeal finger stumps in 8 patients at the age of 15 to 57 years who underwent treatment at the FSBI RISC for RTO of the RF ministry of health in 2014. **Results** Osseointegration that was assessed with clinical and radiographic methods, bench tests, and DASH scale resulted in positive short-term outcomes. **Conclusion** Osseointegrated finger prostheses for defects at the phalangeal level improve hand functions and appearance within a short period of time. The method of osseointegration is strategically important for management of large limb segment amputations and high levels of truncation. It is relevant to develop domestic implants that will optimize treatment terms, its results, and further prosthetic application.

**Keywords** Osseointegration, limb stump, hand stump, implant, patient, exoprosthesis

### INTRODUCTION

Osseointegration as the method of improving the function and appearance after partial amputation, including finger stumps, was first used in 1990 by Swedish and later by Italian specialists [10, 21, 23, 24]. Thus, in the period between 1990 and 2010, implants were applied into 37 upper limb stumps including 10 fingers, 10 forearms [27], and 16 humeral stumps. At a long-term follow-up, seven patients ceased to use osseointegrated prostheses due to various reasons [18]. The original technology was widely used not only for amputation defects of the humerus or forearm [17, 18] but also in the patients with lower limb stumps, predominantly at the level of the femur, including the ones that were bilateral [9, 15, 16, 20].

The traditional technology of osseointegration included two stages. At the first stage, a titanium implant was introduced into the bony part of the stump. Six months later, a metal rod or abutment was added in order to attach an external prosthesis to the limb [13, 22, 25, 26].

Osseointegration was morphologically studied in stomatological practice [11, 12, 14, 8]. It was discovered that the fibrous stage was absent when the implant interacted with the bone. Bone matrix directly covered the metal rod that was located in the bone canal in a rather short time. The studies [13, 25, 26, 28] confirmed the possibility to apply osseointegration as a method of choice in reconstructive surgery of limb stumps.

The available statistics proves the necessity in the method of osseointegration for hand defects. More than 20 % of patients that refer to emergency units sustain hand injuries [7]. They make between 30 and 50 % from the total of the injuries to the locomotor system and from 70 to 80 % from the total of upper extremity injuries [3, 4, 5]. Accidents at work are their most frequent cause [6]. The reported disability rates due to amputations of fingers from their tip to the level of the basic phalange are from 5 up to 20 %, respectively [2].

This work that was conducted at the Russian Ilizarov Centre for Restorative Traumatology and Orthopaedics (RISC for RTO) of the RF ministry of health presents preliminary results of using osseointegration after complete or partial amputation of fingers.

In the course of research, patients with acquired or congenital finger stumps and solitary or multiple defects were selected as candidates for length, shape, function, and appearance restoration in the affected fingers. The parameters of their stumps were examined both clinically and radiographically (length, shape, diameter, joint motion, colour, length and diameter of the bony finger stump part) in order to choose the size of the implant and exo-prosthesis. The authors (Kuznetsov VP, Gubin AV, Koriukov AA, Gorgots VG) obtained a patent № 15 25 58 for a utility model "tubular bone implant".

## MATERIAL AND METHODS

Since 2014, the method of osseointegration has been used in eight patients (6 males, 2 females) aged from 15 to 57 years for correction of 17 finger stumps of the right and left hands (**Table 1, Figs. 1-5**). Three individuals sustained accidents at work, and the others were injured during everyday activities. One 15-year old patient had a frostbite in the finger and in one of her feet when she was in preschool age. The injuries were from several months to three years old.

The patients in whom osteointegration was performed were mainly males of various professions (an unskilled worker, office manager, two students, and industry workers). Two of them were transferred to light labour after finger amputation. Females were a high school student and a librarian.

After surgeries and prosthesis applications, all the patients continue working on their previous jobs.

Quantitative analysis of the finger stumps in regard to the level of amputations revealed the damage to proximal phalanges in 11 cases, middle phalanges in 5 cases; the thumb was injured in one patient, and one patient had stumps of the distal phalanges.

In total, fingers of the injured hands were partially restored in those 8 patients (6 males, 2 females) with 17 implants that were from 10 mm to 18 mm long and 3.5 mm to 5 mm in diameter, and correspondingly with 28 exoprostheses of fingers. It improved several main types of grips such as tip, lateral, cylindrical, palmar, hook-like ones.

The manufacturer of titanium implants is ADINDental Implant Systems LTD (Israel). The exoprostheses are produced by domestic companies: Reutovskiy factory of prosthetic products (Moscow region, Reutovo) and JSC "Terra" (St. Petersburg).

**Table 1**

Characteristics of osseointegration variants in the patients with finger stumps

| No.      | Sex | Age (years) | Diagnosis                                                                                                                      | Implant and its parameters                            | Exoprosthesis    |
|----------|-----|-------------|--------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------------|
| 1        | m   | 57          | Middle phalange stump of the 2nd right hand finger                                                                             | 1 implant $\times$ 18 mm                              | 1 finger         |
| 2        | m   | 30          | Proximal phalanges stumps in the right hand fingers 1-4                                                                        | 3 implants $\times$ 18 mm<br>1 implant $\times$ 10 mm | 4 fingers        |
| 3        | m   | 25          | Right hand proximal phalanges stumps in finger 2 and 5                                                                         | 2 implants $\times$ 16 mm                             | 2 fingers        |
| 4        | f   | 35          | Middle phalange stump of finger 2 at the level of middle third                                                                 | 1 implant $\times$ 10 mm                              | 1 finger         |
| 5        | m   | 26          | Right hand thumb stump at the level of proximal phalange head                                                                  | 1 implant $\times$ 18 mm                              | 1 finger         |
| 6        | m   | 22          | Stumps of proximal and middle phalanges in finger 2, 3, 4 of the right hand                                                    | 1 implant $\times$ 12 mm<br>2 implants $\times$ 16 mm | 3 fingers        |
| 7        | m   | 19          | Right hand fingers 2 and 3 stumps at the level of proximal phalanges                                                           | 1 implant $\times$ 18 mm<br>1 implant $\times$ 16 mm  | 2-3 fingers      |
| 8        | f   | 15          | Right hand finger 2 stump at the level of proximal phalange and left hand finger 5 stump at the level of the proximal phalange | 2 implants $\times$ 16 mm                             | 2 fingers        |
| Total: 8 |     |             | Finger stumps at all the levels                                                                                                | 17 implants                                           | 17 exoprostheses |



**Fig. 1** Views of right hand stumps of fingers 2 and 5, and exoprostheses prior to osseointegration



**Fig. 2** Views of the hand (a) and its radiograph (b) after osseointegration. Metal abutments are seen to which finger exoprostheses are attached (a). Titanium implants were introduced into the bony part of the stump and connected with the abutments that are located outside the integument tissues (b)



**Fig. 3** View of the right hand with prostheses of fingers 2 and 5



**Fig. 4** Patient demonstrates initial functional capabilities of the hand after osseointegration

The design of the clinical evaluation was the following:

- Selection of the anesthesia technique, optimal for the operation of osseointegration;
- Selection of an implant of the corresponding size and diameter;
- Selection of exoprosthesis basing on medical and technical characteristics of the stump and prosthesis (length, sizes, colour panel, female or male);
- Osseointegration operation technique with the analysis of the character and time required for surgical intervention;
- Care in the postoperative period and observation of the treatment course in the conditions of osseointegration and functional adaptation by training the motions in the operated finger;
- Placement of an exoprosthesis in two options: directly on the operation table or after removal of stitching;
- Gradual training exercises for operated fingers with a choice of acceptable loads on the implant introduced into the fingers;
- Assessment of outcomes of surgical treatment and of using the prosthesis.

In general, the algorithm of treatment of the patients with finger stumps with the method of osseointegration was as follows:

- 1) Preparation for surgery, including clinical and radiographic analysis, and MRI diagnosis in several cases (2 patients);
- 2) Surgical intervention performed under conduction anesthesia;
- 3) Postoperative care, dressings of the distal stump parts of fingers;
- 4) Attachment of the exoprosthesis;
- 5) Education in using an exoprosthesis in a gradual regime;
- 6) Recommendations to patients at discharge from the

hospital after osseointegration with a focus on medical and social aspects.

1. Preparation for surgery Patients gave their informed consent for operation and filled in a required protocol. Then, the anthropometric measurements of the finger stump and hand followed and compared with the healthy hand. The measurements were performed with a ruler and a measurement tape. Radiographic parameters of the bony part of the stump were analyzed with “Samson” software that allows for assessment of the length and diameter of the stump bony parts. These measurements were required for a selection of an implant that would correspond to the finger stump sizes in length and diameter.

2. Before the introduction of the implant, a standard axillary conduction anesthesia was used and anesthesia of major nerve trunks in the lower third of the forearm. A 2 % solution of lidocaine and a 1 % solution of naropine in equal parts and in the quantity of 20 ml were used in the area of the axilla and in the hand.

Intervention technique After placement of a tourniquet in the area of the shoulder, a skin incision was made in the distal part of the stump. The bone of the truncated phalange was exposed and its end was processed with bone instruments. Then, the center of the bone marrow canal was marked for introduction of the implant and the canal was produced with a drill into which the entire implant was screwed. The implant was connected with the abutment and the skin on the stump was stitched. Dressing material soaked in a semi-alcohol was applied, and the exoprosthesis tester was attached. Then the upper limb was fixed with a palmar plaster cast from the tips of fingers to the upper third of the forearm. The patient was transferred to the ward.

3. In the postoperative period, the dressing care with regular techniques and solutions continued till sutures were removed. In order to decrease swelling of the finger stump, magnetic therapy was used (8 to 10 procedures).

4. Exoprosthesis was fitted on a patient. It was placed and fixed on the abutment (after removal of stitching).

5. Gradual movements with the exoprosthesis on and their control were conducted by a surgeon first, and then one or 2 days later by an exercise therapist. Further exercises used a special stand with objects for training everyday functions, mainly self-service (**Fig. 5**).

At the final treatment stage, the patient had a DASH scale test that includes 11 basic questions on the functional evaluation of the hand on which the prosthesis was applied and on assessment of sensations

by performing the main everyday tasks in the social medium. The answers suggest 5 levels of perception of osseointegration results: no difficulty by fulfilling a task (level 1), mild difficulty (2), moderate one (3), severe one (4), and unable to fulfill (5).

6. At discharge, the patient was recommended to perform everyday dressings by him/herself with a semi-alcoholic solution, to gradually start different types of manual activities and be in contact with the supervising surgeon for solving the problems that could arise. A radiographic checking of implant stability was advised after a month.



**Fig. 5** Patient trains different grips after osseointegration of the proximal phalange of finger 2 of the right hand

## RESULTS AND DISCUSSION

1. The anthropometric measurements of finger stumps and hand as well as the radiographic analysis of the bony part of the stump were sufficient for selection of implants of the required length and diameter. The first checking radiograph was taken on the third postoperative day. Stable position of the implant in the bone was confirmed by an absent shadow on its lateral surfaces. Further on, the radiographic checking was performed once a week in order to obtain information on the implant stability in the bone as the process of osseointegration continues in the period from 4 to 6 weeks, as reported by the operational Italian technology [10].

2. The quantity of anesthetic means was enough for exclusion of pain during the operation that generally continued 35 minutes.

3. Difficulties arose by drilling the bone canal for introduction of an implant in a 15-year old female patient that sustained amputation due to frostbite and had distraction lengthening of the stump of the proximal phalange that was sclerotic. It was recommended to start initial functional training of the operated hand 3 weeks after the intervention.

4. Two patients needed skin plasty with local tissues along with osseointegration for formation of the 1st (one case) and 3rd (other case) web-spaces and on the distal part of the finger stumps that improved the length, exoprosthesis mobility and hand appearance.

Wound healing after completion of skin plasty ran by primary intention and did not affect the healing process in general. However, the risk of possible infection that is able to impair the osseointegration process was taken by us into account [1, 28].

5. Frequency of dressings. Due to the peculiarities of a new treatment technique, some protrusion of an implant with an attached to it abutment out of the skin was considered. Therefore, dressings of the first 10 finger stumps were repeated daily up to suture removal (stitching was taken off on days 12 to 14). Further on, dressings were changed on every second day. Postoperative sutures were treated with a solution of hydrogen peroxide and alcohol. Then, the integument tissues of the stump were covered with narrow gauze pieces soaked in a semi-alcoholic solution. Patients were recommended to produce careful movements in the stump joints and healthy finger joints on the 3rd day but grasping of any object was not allowed.

There were no complications in the immediate postoperative period after osseointegration in the finger stump operated in all the cases. The inpatient stay was three weeks on average. No complications were noted from 6 to 8 months after osseointegration and the use of prosthesis such as inflammation, temperature rise, or infection in the area of implantation.

6. When sutures were removed, exoprosthesis was attached to the abutment. Liquid silicone was poured into the recipient cavity of the exoprosthesis. The abutment was

plunged into the composite and hardening took place. Then the prosthetic finger was fixed to the lower part of the stump with an adhesive plaster and positioned on a splint made of a thermoplastic material or plaster. Active but dozed movements of the operated fingers were allowed after suture removal.

Patients should report on any sensation by performance of various manipulations. During functional training, an effect of bone perception or bone conductivity was observed when sound oscillation transmitted a contact vibration to the bone by interaction of the prosthetic finger with objects. This positive effect demonstrated the presence of sensitivity along with functional and cosmetic improvements after osseointegration.

7. Assessment with DASH scale. All the patients had no difficulties when they fulfilled the tasks (evaluation level 1 out of 5 offered). They freely used the operated hand in the presence of roommates and reported an improvement in their psychological state. Once a statistically reliable number of clinical cases assessed with the DASH scale are collected, we plan to compare the functionality of finger stumps before and after osseointegration.

The use of osseointegration technique has revealed a number of clinical peculiarities. Thus, a 57-year old patient noted the “sensibility” of the finger exoprosthesis tip 6 months after osseointegration of the 2<sup>nd</sup> finger stump at the level of the distal part of the middle phalange. His new “finger” got frozen at the temperature that did not exceed 0 degrees of C. It was supposed that there was a technical incompatibility between the titanium implant and stainless steel abutment that distorted thermal conductivity. However, the “cold” tests conducted in 3 patients at similar temperature and even lower (down to -5 degrees C) for 15-20 minutes did not reveal any “freezing” feeling in their finger stumps.

The preliminary results of osseointegration that was

performed in 17 finger stumps due to various injuries in 8 patients showed a sufficient level of functionality and esthetic improvement.

One should acknowledge a perspective use of current additive technologies for manufacturing of osseointegration implants [28] that are based on selective laser melting of powder materials. The particle size of the powder used for laser melting ranges from 5 to 45 mcm and there is a possibility of obtaining a porous surface with different sizes of the pores.

Additive technologies of implant manufacturing have the following advantages:

- provide an optimal surface porosity for intensive osteosynthesis and osseointegration;
- allow for creation of implants with a complex geometry for a closer contact in the intramedullary canal;
- are able to form canals of a random shape for delivery of medicines into the bone and to form thick wall elements with the walls and internal cross walls that measure 100 mcm;
- allow the thread of any profile and any number of filaments, including the thread with altering diameter and step;
- enable to produce connection surfaces of a random shape for a rapid change of abutments;
- allow transition surfaces with a specified geometry and porosity for creation of conditions that hinder penetration of infection into the area that contacts with patient’s soft tissues and skin.

Any changes that were meant to introduce into the osseointegration technology were trialed experimentally on animals. Such studies that are held at RISC for RTO helped reveal specific peculiarities of surgical manipulations with implants by their introduction into rabbit’s legs and of osseointegration control both manually and by imaging techniques such as radiographs and MRI.

## CONCLUSION

Early functional loading following osseointegration should be gradual and starts with grasping and pinching of objects of small sizes and weight. Both osseointegrated fingers and healthy fingers should be loaded for psychological confidence and for functional stability of exoprosthesis by patient’ self-service. The development and use of implants

that are designed by domestic companies as well as an optimization of the osseointegration technology in regard to time are perspective trends. It is expedient to cooperate with the institutions of social protection and social insurance funds in order to search for financial sources for purchasing exoprosthesis used after osseointegration.

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## REFERENCES

1. Gubin A.V., Borzunov D.Iu. Paradigma Ilizarova [Ilizarov's paradigm]. *Genij Ortop.* 2012. N 4. pp. 3-8
2. *Kompendium po khirurgii kisti* [Compendium on the hand surgery]. Ed. Prof. V.F. Baitingera. Tomsk: Izd-vo Tomskogo gos. un-ta sistem upravleniia i radioelektroniki, 2004. 236 p.
3. Koriukov A.A. Reabilitatsiia detei s defektami kisti [Rehabilitation of children with the hand defects]. SPb.: Gippokrat, 2010. 268 p.
4. Koriukov A.A., Gubin A.V., V Kuznetsov P., Borzunov D.Iu., Ovchinnikov E.N., Emanov A.A., Vladimirova O.N. Osseointegratsiia kak variant osteosinteza v vosstanovlenii funktsii i estetiki kul'tei pal'tsev kisti [Osseointegration as a variant of osteosynthesis in the recovery of the function and aesthetics of the hand finger stumps]. *Sovremennye printsipy i tekhnologii osteosinteza kostei konechnostei, tazy i pozvonochnika: Materialy vseros. nauch.-prakt. konf. s mezhdunar. uchastiem* [Modern principles and technologies of osteosynthesis of the limb, pelvis and spine bones: Materials of All-Russian Scientific-Practical Conference with international involvement]. SPb., 2015. p. 58
5. Makarenko I.S., Koriukov A.A. Amputatsii pal'tsev kisti i protezirovanie [Amputations of the hand fingers and prosthetics]. *Vestn. Vseros. Gil'dii Protezistov-ortopedov.* SPb., 2013. N 1(51). pp. 7-11
6. Shikhaleva N.G. Lechenie bol'nykh s otkrytoi travmoi kisti i miagkikh tkanei distal'noi treti predplech'ia s ispol'zovaniem metoda chreskostnogo osteosinteza [Treatment of patients with open injuries of the hand and the forearm distal third soft tissues using transosseous osteosynthesis method]: [avtoref. dis... d-ra med. nauk]. FSBI RISC "RTO" of the RF Ministry of Health. Kurgan, 2013. 43 p.
7. Warwick D., Dann R., Melikyan E., Vadher J. Hand Surgery: Oxford University Press, Oxford. 2009, 630 p. (Russ. ed. Rodomanova L.A. *Khirurgiia kisti: spetsializir. oksford. ruk.* M.: BINOM: Izd-vo Panfilova, 2013. 704 p.)
8. Abuhussein H., Pagni G., Rebaudi A., Wang H.L. The effect of thread pattern upon implant osseointegration. *Clin. Oral Implants Res.* 2010. Vol. 21, N 2. pp. 129-136
9. Aschoff H.H., Clausen A., Tsoumpris K., Hoffmeister T. Implantation of the endo-exo femur prosthesis to improve the mobility of amputees. *Oper. Orthop. Traumatol.* 2011. Vol. 23, N 5. pp. 462-472
10. Bicchieri M., Sacchetti R., Pilla G., Grassi S., Davalli A., Orlandini D. Osseointegration in the treatment of digits amputees. Submitted to: *Orthopädie Technik*, 2004. URL: [http://www.inail.it/cms/Medicina\\_Riabilitazione/Riabilitazione\\_e\\_reinserimento/Centro\\_Protesi/Osseointegrazione0 T. pdf](http://www.inail.it/cms/Medicina_Riabilitazione/Riabilitazione_e_reinserimento/Centro_Protesi/Osseointegrazione0 T. pdf). (cited on page 131)
11. Brånemark P.I., Adell R., Breine U., Hansson B.O., Lindström J., Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand. J. Plast. Reconstr. Surg.* 1969. Vol. 3, N 2. pp. 81-100
12. Brånemark P.I., Hansson B.O., Adell R., Breine U., Lindström J., Hallén O., Ohman A. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand. J. Plast. Reconstr. Surg.* 1977. Vol. 16. pp. 1-132
13. Brånemark R., Brånemark P.I., Rydevik B., Myers R.R. Osseointegration in skeletal reconstruction and rehabilitation: a review. *J. Rehabil. Res. Dev.* 2001. Vol. 38, N 2. pp. 175-181
14. Chun H.J., Cheong S.Y., Han J.H., Heo S.J., Chung J.P., Rhyu I.C., Choi Y.C., Baik H.K., Ku Y., Kim M.H. Evaluation of design parameters osseointegrated dental implants using finite element analysis. *J. Oral Rehabil.* 2002. Vol. 29, N 6. pp. 565-574
15. Hagberg K., Häggström E., Uden M., Brånemark R. Socket versus bone-anchored trans-femoral prostheses: hip range of motion and sitting comfort. *Prosthet. Orthot. Int.* 2005. Vol. 29, N 2. pp. 153-163
16. Hagberg K., Brånemark R. One hundred patients treated with osseointegrated transfemoral amputation prostheses – rehabilitation perspective. *J. Rehabil. Res. Dev.* 2009. Vol. 46, N 3. pp. 331-344
17. Isaacson B.M., Jeyapalina S. Osseointegration: a review of the fundamentals for assuring cementless skeletal fixation. *Orthopedic Research & Reviews.* 2014. Vol. 6. pp. 55-65
18. Jönsson S., Caine-Winterberger K., Brånemark R. Osseointegration amputation prostheses on the upper limbs: methods, prosthetics and rehabilitation. *Prosthet. Orthot. Int.* 2011. Vol. 35, N 2. pp. 190-200
19. Kang N.V., Pendegrass C., Marks L., Blunn G. Osseocutaneous integration of an intraosseus transcutaneous amputation prosthesis implant used for reconstruction of transhumeral amputee: case report. *J. Hand Surg. Am.* 2010. Vol. 35, N 7. pp. 1130-1134
20. Lundborg G., Brånemark P.I., Rosén B. Osseointegrated thumb prostheses: a concept for fixation of digit prosthetic devices. *J. Hand Surg. Am.* 1996. Vol. 21, N 2. pp. 216-221
21. Manurangsee P., Isariyawut C., Chatuthong V., Mekraksawanit S. Osseointegrated finger prosthesis: An alternative method for finger reconstruction. *J. Hand Surg. Am.* 2000. Vol. 25, N 1. pp. 86-92
22. Moscato, T.A., Orlandini D. Amputato di arto superiore e di arto inferiore. Terapia occupazionale: metodologia ed ausili. Ed. SOLEI Press, 1996. 14. pp. 245-264.
23. Sacchetti R. et al. Osseointegration in the treatment of digit amputees // Villa Lemmi Congress. Florence (Italy), 2001
24. Smith D.G., Michael J.W., Bowker J.H. Atlas of Amputations and Limb Deficiencies. 3rd Edition. American Academy of Orthopedic Surgeons (AAOS), 2004. 965 p.
25. Tillander J., Hagberg K., Hagberg L., Brånemark R. Osseointegrated titanium implants for limb prostheses attachments: infectious complications. *Clin. Orthop. Relat. Res.* 2010. Vol. 468, N 10. pp. 2781-2788
26. Palmquist A., Jarmar T., Emanuelsson L., Brånemark R., Engqvist H., Thomsen P. Forearm bone-anchored amputation prosthesis: a case study on the osseointegration. *Acta Orthop.* 2008. Vol. 79, N 1. pp. 78-85
27. Pendegrass C.J., Goodship A.E., Price J.S., Blunn G.W. Nature's answer to breaching the skin barrier: an innovative development of amputees. *J. Anat.* 2006. Vol. 209, N 1. pp. 59-67
28. Pitkin M., Pilling J., Raykhtsaum G. Mechanical properties of totally permeable titanium composite pylon for direct skeletal attachment. *J. Biomed. Mater. Res. B. Appl. Biomater.* 2012. Vol. 100, N 4. pp. 993-999

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**Information about the authors:**

1. Aleksandr A. Koriukov, M.D., Ph.D., Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Clinical and Experimental Laboratory of Reconstructive and Restorative Microsurgery and Surgery of the Hand
2. Aleksandr V. Gubin, M.D., Ph.D., Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Director; e-mail: Alexander@gubin.spb.ru
3. V.P. Kuznetsov, Ural Federal University, Ekaterinburg
4. Dmitrii I. Borzunov, M.D., Ph.D., Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Deputy Director for Science; e-mail: borzunov@bk.ru
5. A.V. Antipov, Terra Closed Joint-Stock Company, S. Petersburg
6. Evgenii N. Ovchinnikov, Ph.D. of Biological Sciences, Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Scientific Secretary
7. Artem V. Reznik, M.D., Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Clinical and Experimental Laboratory of Reconstructive and Restorative Microsurgery and Surgery of the Hand
8. Andrei A. Emanov, Ph.D. of Veterinary Sciences, Russian Ilizarov Scientific Centre for Restorative Traumatology and Orthopaedics, Kurgan, Scientific and Clinical Laboratory of Reconstructive Arthroplasty and Arthroscopy
9. O.N. Vladimirova, FSBEI APE St. Petersburg Institute of Advanced Training for Medical Experts, St. Petersburg