New approaches of classification of open fractures of long bones

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The open fractures of long bones are one of the heaviest damages of the locomotor system. Despite of large attention (1, 2, 3, 4, 5, 6 and others), paid to an open trauma for the last years, the various parties of the given problem demand a detailed study and further scientific development.

One of them is the classification of open fractures of long bones which has significant meaning for preventive maintenance of complications, statistics of open traumas, determination of tactics, and also for consequent study of outcomes of treatment.

Many various classifications of open fractures were offered, some of which have become outdated, and others have undergone an essential modification.

However, studying the indicated publications will convert attention to an incongruity in points of view on a main problem: whether existing classifications of open fractures of long bones reflect the dynamics in posttraumatic period and if it is possible to create certain tactics of treatment on the basis of this classification. To answer the question we reviewed 120 sources of information on Traumatology, Orthopedia and bones-articular surgery from all over the world for the last 68 years. Besides we studied 486 patients treatment results with open fracture of long bones. The following facts were established:

On territory of the former USSR etiological classification of open fractures was first offered by A.D. Oserov (1936) and V.V. Gorinevskaya (1936), which have allocated open fractures with a small zone of soft tissue damage (this category is described by the skin perforation by the bone from within), with a large zone of damage of soft tissue and an extremity crushing (7, 8).

Among the foreign contributors the first classification belongs to L. Bohler (1937), where the author distinguishes an open fracture adjoining with air with selection of fat droplets from a wound and open fracture with selection of blood only (9).

In their classifications M.O. Fridland (1938), L.I. Shulutko (1940), T.S. Grigoryeva (1946) and V.A. Chernavskiy (1958) do not pay any attention to dot wounds connecting with a place of a fracture, and offer to exclude such damages from the group of open fractures (citation by G.S. Yumashev and V.A. Yepifanov, 1983).

I.F. Byalik (1984) conditionally divide all classifications, existing in the literature on simple and complicated, under the judgment of the author (11) classifications by Vives (1971), Wehner (1973), Voorhoeve (1974), Ritter (1976), Knapp (1979), Widenfalk (1979) concern to simple, where the open fractures are subdivided into two or three groups by the means of severity of trauma:

1. Punching of skin by the bone from within;
2. Bruise of skin or punching it from the outside;
3. Rupture of skin and soft tissues with or without of vessels' and nerves' damage.
In an above-stated classifications the degree of soft and bone tissue damage, sizes of a skin wound and character of an open fracture were not described.
The classification of open fractures offered by P.P. Zhukov (1967) concerns to a category of complicated, which results five groups of wounds of soft tissues (12):
1. Wounds of soft tissues up to 1 cm and puncture from within - do not require a surgical processing;
2. Wound of average sizes from 1 up to 4 cm, always requiring a surgical processing;
3. Large sizes of wound from 4 up to 8 cm with significant contamination;
4. Wounds of more than 8 cm in size - extensive, with severe contamination;
5. Wound with violation of viability.

However on territory of CIS the broad distribution was received by a classification of Kaplan-Markova.
In due course A.V. Kaplan, O.N. Markova and V.M. Melnikova [13], have conducted a controversy and have discussed on pages of the « Orthopedia, traumatology and prosthesis » journal [14, 15, 16, 17, 18, 19 etc.] before introducing the classification in practical activity.
During a controversy some authors [20, 21, 22 etc.] have marked, that a classification by A.V. Kaplan and co-authors does not reflect all the variety of open fractures, in particular it does not fully take into account combined damage, fracture's degree of severity, degree of contamination and invasion of a wound, viability of the damaged organ as well.
Later authors agreed with this recommendation and:
« We suppose, that actually in our classification all diverse factors, defining severity of a fracture could not be taken into account, but it is essential to select leading factors from them, objectively and easily definable influencing to clinical current and to outcome of an open fracture treatment (localization, kind of a fracture, size of a wound and character of damage of soft tissues) » [23].

Besides one of the participants of a controversy A.F. Baturin (1968) has offered the classification of open fractures. By the author's opinion, the given variant of a classification was useful for evaluating the severity and choosing tactics of treatment of 240 patients with open fractures of tibia and fibula [24].

« Orthopedics, Traumatology and prosthesis » journal's redaction summarizing the controversies has also marked that an offered classification of open fractures of long tubular bones by A.V. Kaplan, O.N. Markova and V.M. Melnikova should be advanced in consequent [25].

Now classification by Kaplan-Markova is widely applied in professional activity of traumatologists [26].
Classification by G.N. Zhararova and N.P. Topilina (1974) can also be referred to complicated where primary open fractures are distinguished to: а) with small damage of soft tissues and skin wound of 3-10 cm; б) with extensive damage of soft tissues and skin wound more than 10 cm, secondary open fractures and crushing of extremities. Under the judgment of the authors [27] applications of the given classification in practical activity has justified itself, and at the same time authors mark that, as well as many other classifications, it is not perfect enough.

In a 1982 V.G. Ryndenko [29] has offered most optimal classification of open fractures. Apart from the determination of a degree of severity of an open trauma authors offer to indicate infectious complications depending on current pyo-inflammatory process. This classification is acceptable for a stale (old) open fracture complicated by an infection.
Classification of open fractures of long bones by I.F. Byalik (1984) essentially differs from that which offered above and the author considers that in practical work it is necessary to be guided not only by an anatomic type of fracture, but also by a degree and character of damage of soft tissues [11].
The given classification allows determining the tactics and volume of medical measures, to update the diagnosis and correctly approach to an evaluation of outcomes of treatment.
T. Zh. Sultanbayev and co-authors (1993) using Kaplan-Markova classification in practical work has supplemented it as follows. Outcomes of 85 patients' treatment indicated by the authors [30] specify that the classification is more applicable determining the degree of severity of neurovascular bundle damage. Knowing that 10% of open fractures are followed by damage of magistral vessels and 12.5% are followed by damage of peripheral nerves there is a necessity of further development of the given classification with the precise indication of vessel and nerve trauma type, only then it is possible to apply it for determining the combined open trauma [31, 32, 33, 34, 35, 36 etc.]. Outcomes of the research show that attempts of creation of new variants of classification in CIS and applying it in practical activity have not crowned by success. We think the main reason was that each author, creating and offering the variants of a classification of open fractures of long bones, tried to change an existing classification by A.V. Kaplan and O.N. Markova radically without consideration of a fact, that in several years it has rigidly come in professional activity, some generations of surgeons were brought up by this classification; in this connection, offering an absolutely new classification will not let us delete the old one from everyone's memory. In countries out of CIS [37] open fractures classification offered by R.B. Gustililio et all. (1976, 1984) is widely applied. The authors think that the given classification is more acceptable evaluating severity of open traumas and choice of rational methods of treatment. However R.J. Brumback and A.L. Jones (1994,1995) mark that there are doubts among the foreign contributors about expediency of application of the given classification in clinical practice, as quite often evaluating open fracture the diverse internal destructions of the damaged segment are insufficiently estimated in this classification. Authors think [38, 39] this is the main reason of criticism.

In Lorentz Baller's (Vienna) Schwarz N. clinic (1984) they use following classification of open traumas [40]. Undoubtedly such classification is not applicable in modern traumatology and requires a further development. J.W. May and co-authors (1989) analyzing the outcomes of 250 patients' treatment with posttraumatic osteomyelitis of tibia following open traumas has offered their own classification [41]. However it does not seem possible to decide a problem in this way. The classification even complicates the existing confusion; furthermore it is not easy to remember huge amount segment-related classifications of open traumas. Now traumatologists of all countries use the classification of open fractures offered by Maurice E. Muller et all. 1987, 1990 [42, 43]. Later M.E. Muller and co-authors [44, 45] considering a big set of various variants which should be taken into account when trying to create a classification of open and closed fractures have united the widespread classification of AO for long bones with soft tissues damage classification. The advantage of the given classification comparing with remaining (Gustililio R.B., et all., 1976, 1984, Schwarz N. 1984, Muller Е. et all., 1987,1990, May J.W. Et all., 1989 etc.) is the availability of a severity scale of damage in relation to a skin cover, muscular, tendon tissue and neurovascular damage scale. However, in a classification there is no severity scale concerning to bone tissue. It is well known that open fractures are followed by the damage of bone tissue which is not less than the damage of dermomuscular case and consequently the principle of a fracture treatment is not clear. Besides the given classification we think is not absolutely convenient in application, it is bulky, too detailed and presents difficulties in remembering. Clearly in and outside the CIS offered classifications mainly take into account the character and degree of soft tissue damage at the moment of patients' arrival to the hospital. It is well known, that traumatic disease current after an open fracture is very continuous and
often followed by complications of a various character demanding a purposeful medical measures applied by a competent traumatologist in correspondence with dynamics of posttraumatic period [46, 47, 48, 49, 50 etc.].

In accordance with peculiarities of long bones' open fractures forming mechanism, with an expansion and severity of damage, superficial and underlying soft and bone tissues we offer improved variant of a classification of open fractures of long bones of extremities. Developing this classification we tried to take into account sizes, severity of soft and bone damage and also the defeat of a neurovascular bundle which should be established according to expansion of internal damages revealed during or after the operation of wound Primary Surgical Cleaning».

The classification of open fractures of long bones of extremities is presented in table 2. In the present classification apart from well-known 10 main types of open fractures of long bones where sizes of a skin wound and the damages of soft tissues are indicated by various combinations of first three Roman numerals and first three letters of the alphabet, we distinguish deficits of a skin and muscular tissues, bone tissue defects and also damage of magistral vessels and nerves. The damage of skin and underlying soft tissues, bones, magistral vessels and nerves are designated by the large English letters - S, G, and M. The severity of damage is determined by a four-degree scale.

To eliminate some kinds of questions during the discussion, we would like to explain, that in a four-degree scale of damage severity the sizes of a probable deficit of skin cover, soft tissues and bone defects are not accidentally taken. According to the literature data of the [51, 52, 53, 54 etc.] frequency of posttraumatic soft tissue deficits is at the range of 18.0 – 44.1%. The first degree of soft tissue deficit of 2 cm is taken from those reasons that the edges of such wound of soft tissues are pliable and superposition of seams after surgical processing of a wound is possible. If the deficit of soft tissues is more than 2 cm, in our variant from 2 up to 6, from 6 up to 10 and more than 10 cm the defect substitution in different ways of skin plastics is necessary.

In clinical practice posttraumatic (shedding of bone fragments at the moment of a trauma, resection of the polluted ends of bones, after deleting of freely lying polluted or sequestered fragments of a various cross-sections) the bone defects will be obtained in 60 % [55, 56, 57, 58, 59, 60 etc.]. The bone defect is conventionally considered when the absence of bone tissue is present on a stretch of more than 2 cm. Though, V.I. Shevtsov and co-authors (1996) think that bone defect is to be considered when any absence of bone is present despite of magnitude and size of defect. In any case to apply a certain tactics of treatment having a fresh open fracture of long bones it is desirable to know the true magnitude of the bone defect. As it was indicated above open fractures of long bones combine with damage of magistral vessels and nervous trunks in 10.0 % and 12.0 % accordingly. Therefore four-degree scale with the indication of a concrete kind of damage of neurovascular bundle of an extremity is easily applicable and is convenient for traumatologist [61, 62].

For the readers convenience we offer various ways of the classification usage and treatment methods on open fractures of long bones.

Fig. 1. Appearance of the wound of soft tissues of the open fracture of the patient A., 16 years old at time of admission to hospital. By the time of admission to hospital patient A. has been settled with diagnosis of open oblique fracture of middle one-third of both bones of left shank II types.

Fig. 2. X-ray of the damaged extremity of the patient A., 16 years old, ordinary oblique fracture of the shin bone.

After carrying out the first surgical operation the clinical diagnosis has been made as “Open II S3G2M2 degrees slanting crisis of average of third both bones of the left shin with bone’s fragments displacement bone. Posttraumatic rupture of peroneal nerve. After excision of devitalized tissues the patient got deficiency of coverlet and muscles more then 10 centimeters
and defect of shin-bone up to 10 centimeters with rupture of peroneal nerve.
Fig. 3. The true sizes of the wounds of soft tissues and coagulation necrosis of the shin bone in 2 days after transosseous osteosynthesis of the left shin.
Fig. 4. X-ray after a resection of an osteomyelitis of a bone of the patient A., 16 years old, the bone defect was developed. After epineuralis suturing on peroneal nerve to replace defect of shin-bone monolocal compression –distraction Osteosynthesis by G. Ilizarov method has been made.
Fig. 5. X-ray after replacement of the bone defect of the patient A., 16 years old according to Ilizarov G.A. It is examined in 1 year after the transmit trauma. The postoperative wound has begun to secondary intention healing. Complaints are not present. Volume of movements in the left knee joint: unbending up to 180°, bending 45°, in an ankle joint in corpore. The peroneal nerve innervation rehabilitated in full.
Fig. 6. X-ray in 1 year after a undergone trauma and operation of the patient A., 18 years old, the bone defect was wholly rectified, the bone was knitted.
Fig. 7. Cosmetic appearance of extremity of the patient A., 18 years old after recovery.
Fig. 8. X-ray of the right shin of the patient P., 19 years old at time of admission to hospital, gunshot comminuted fracture of both bones of the right shin.
After first surgical processing of gunshot fracture the clinical diagnosis “Gunshot IIIS2G0M1 comminuted fracture of the bottom third both bones left shin with displacement of bone fragments has been settled. Posttraumatic full rupture of anterior tibia arteries of the left shin”.
Fig. 9. Angiography of the right tibial artery of the patient P., 19 years old, there is a rupture of the vessel.
After excision of devitalized tissues the patient got deficiency of coverlet and muscles up to 10 centimeters, with flawless of shin-bone but with complete separation of anterior tibia arteries of the left shin. By the reason of defect of anterior tibia arteries vascularity rehabilitation was unsuccessful. The broken ends of vessels were tixed up with hope on collaterally vasculature of limb. For the purpose of fragments stabilization the neutral transosseous osteosynthesis by Ilizarov method has been made.
Fig. 10. After transosseous osteosynthesis of the right shin of the patient P., 19 years old, the fracture was confronted.
The patient examined in six months after trauma. Complaint was not present. Functions of joints are rehabilitated completely. The fracture has grown together.
Fig. 11. X-ray in 8 months after a trauma of the patient P., 19 years old, healed fracture of both bones of the right shin.
Fig. 12. Cosmetic appearance of extremity of the patient P., 19 years old, the rugged changes of skin and bone deformation is absent.
Fig. 13. X-ray of the damaged extremity of the patient K., 46 years old, comminuted fracture of both bones of the left shin.
Fig. 14. The true sizes of the wounds of soft tissues and denudation of the open fracture in 4 days and after transosseous osteosynthesis of the patient K., 46 years old. Because of development of a suppuration, for 4 day secondary surgical processing of open fracture made and the basic diagnosis “open IIIS3G3M0 degrees comminute fracture of the top third both bones of the left shin with displacement bone fragments is exposed. Complications: a sharp posttraumatic osteomyelitis of the left tibia bones, fistula form, acute condition. The deficiency of coverlet and muscles up to 10 centimeters has been replaced with the dermo-plastic manipulations, formed after a resection of osteomyelitis foci. The defect of shine-bones more than 10 centimeters eliminated by bilocal osteosynthesis on G.A. Ilizarov. The damages of the main vessels and nerves is not revealed.
Fig. 15. X-ray osteotomy of the lower third of the shin bone and a resection of an osteomyelitis of a bone.
Fig. 16. X-ray after replacement of defect of the shin bone of the patient K., 46 years old according to Ilizarov G.A.
The patient examined in 6 months after trauma. Complaints are not present. Functions of joints are restored completely. On control X-ray defect is replaced also fracture of a bone has grown together.

Fig 1. X-ray in 1.5 years after a trauma and operation of the patient K., 47 years old, intercalated fragment of the bone is fully healed.

To all patients for the favorable outcome of complex treatment of the open fracture is applied primary and if necessary secondary surgical processing. This processing goes with draining of anatomic structures of defective segment (intramedullary canal, paraosseous, intramuscular, hypodermic cellular tissue), flowing and out-flow system, endoarterialae conducting antibacterial preparations taking into account sensitivity of micro flora, with normalization of blood circulation and a metabolism of the damaged muscles of the abacterial environment. Also it’s goes with suppression of an infection and increase of protective forces of an organism by endolymphatic inject of Roncoleukinum, transfusion of preparations of blood and medical products which improve on rheological properties of blood of damaged limb and desintoxication preparations.

Thus, the experience of usage of offered classification in a clinical practice demonstrate, that it reflects dynamics of course of the open fracture of long bones and is useful in a choice of the optimal tactics of treatment.

We think the offered classification has a real advantage reflecting the dynamics of current of an open fracture of long bones of extremities. Therefore, it will be useful in choice of an optimal method of treatment.

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