

MAJOR REPLANTATION IN UPPER EXTREMITY: EVALUATION OF LATE RESULTS WITH QUANTITATIVE APPROACH TO SENSIBILITY AND MOTOR FUNCTION

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Abstract

Hand and Microsurgery Hospital in Izmir-Turkey has performed 105 major replantations and revascularisation during last eleven years and average survival rate were 84%. 55 of them were complete and 50 of them were incomplete amputations. 11 of the 55 complete and 6 of the 50 patients were lower extremity amputations. The follow-up period more than 2 years to evaluate at the 62 upper and 5 lower extremity replantation and revascularisation with Chen's functional grading system. 56% upper extremity and all of the lowers were graded I and II. Complete major upper extremity have been correlated significantly with their type of injuries and level of injuries ($p=0.04$) and type of injuries and functional capacities ($r=0.85$ $p=0.00$) according to Chen's criteria.

7 of the 16 major upper extremity complete amputation proximal to the wrist were analysed with Millesi, Tamai and Chen's functional evaluation and compared each others statistically. The patients lose their hand function 42% according to Millesi scoring system (Table 4). The correlation of these, 7 patients with volumes, surfaces of the finger nail and the pulp region, the quantitative methods were used. Pulp volumes atrophy are 47%, pulp surfaces atrophy are 32% and finger nail atrophy is 22%. Color duplex ultrasonography and syntigraphic changes were significant and these seem to be close relations with motor functions. So the commonly pronounced indications of the major amputations are need to be reviewed. Psychological pathology were found 5 out of 6 patients according to CAPS, bech and Hamilton scales. The team knows that these is a multiple major problem for the patients and the physicians themselves.

Introduction

In Turkey, the modern hand surgery began by Ege and Eroplu after 1960 (1). The first hand surgery department was established by Eroplu, at University of Aegean, Department of Orthopaedic Surgery and Traumatology in Izmir in 1971 (2). The pioneer of the microsurgery in Turkey is Gülgönen who performed the first successfully replantation in Istanbul, 1978 (3). The first hand and Microsurgery Hospital were established by the authors of this article in Izmir in 1991 (4).

Now, there are 24 surgical teams and centers and one subspeciality hospital already perform routinely hand, micro and replantation surgery in Turkey. In our country, work and traffic accident are very frequent so that amputations are still a big problem (5).

Although, major amputations are very dangerous and life threatening surgery and the functional results are still far from the perfect, only few studies have long term follow up with detailed analyzed functional results (6,7,8,9,10,11,12,13,14,15).

The purpose of this article is to discuss the survival rate, the long term results of our major amputations and their functional results, as well as the volumetric quantification of the replanted extremities. Vascular status, and perfusion conditions of the replanted parts proximal to the wrist were examined comparing with their normal side. Last but more importantly, the psychiatrist within our team searched the psychiatric status of our patients

Patients and methods

Between the years 1988-1998 we had 105 major replanted and revascularized patients. 55 of them were complete and 50 of them were incomplete amputations. 11 out of 55 complete and 6 out of 50 incomplete amputations were in lower extremity. We hereby would like to give only the survival rates of this serie (Table 1).

There are 62 upper extremity amputations successfully replanted and followed more than 2 years (Table 2). Number of patients followed up more than 2 years with complete upper extremity replantation are 35 (Table 3). Their age range is 2 to 69 and average is 25 years. The follow up period was 2 to 11 years and in average 5 years and 7 months. To search the relationship of the type and level of injury, we have chosen 35 complete upper extremity replantations. However among the type of injury and functional results has been held on 30 succesful upper extremity replantations. The second serie is only for grading the functional results of the complete major amputations according to Chen's functional evaluation.

The third serie for more detailed examination and statistical analysis, we have seperated upper extremity replantations, proximal to the wrist at the level of musculetendinos

...s suitable for this parameters. 7 patients out
...but only the youngest patient accepted few
...At this moment, the age range was 9 to 39 and
...after the replantation surgery was 6 years and 3
...in arm one in elbow and 3 in forearm level. They have 4
...clean cut amputations at that time (Table 4). Functional
...trophic assessment, color duplex ultrasonography.
...were examined with both upper extremity, the uninjured side is
used for control manner only.

Functional Assessment

Range of motion of each joint of the hand and wrist powergrip, pinch grip, SWE monofilament test, two point discrimination with static and dynamic manner; Moberg pick up test. Object recognition, daily living activities and the measurement of the arm and forearm which is ten centimeters proximally and distally from the medial epicondyl, finger nail width and length at the beginning of the nail fold to the distal white line of the finger nail and both hand volumes measured distal to the radial styloid were measured by the same physiotherapist and the same physician, seperately.

The finger print and total pulp finger print have had by rolling the finger or the paper itself. The finger print we magnified seven times in computer and 4.5 times by loupe and with micrometer were measured ridge and groove at the side radially and ulnarly to the central halo of the each finger pulp print for the standartization of measurements (Figure 1). For the calculation of the pulp surface and pulp volume, we have considered the pulp as one quarter of an egg (elipsoid). Calculation of the finger volume starts from the margin at the proximal end of the nail perpendicular to the finger distally. The radius of the pulp (b) has been calculated from the width of the rolling finger print measurement. The formula $2\pi r$ and $b=2r$, the length of the finger nail give us the measurement of "a". The surface of the egg is $S=4\pi ab$ and the volume is $V=4/3\pi ab^2$ were calculated and divided by 4 for reaching the surfaces and volumes of each index fingers (Table 5).

Color Duplex Ultrasonography

This were made to see the arteries at the replantation region from proximally and distally up to digital artery in order to determine the occlusion and narrowing (Kretz Technik Voluson 530 D, Austria)

Radionuclide Imaging

Made by to 99 Pertechnatate radioisotope and counting by gamma camera (Siemens zic 370 s Germany). Three phase scanning were printed and Roi count distally from the replantation line and normal side at the same level were noted for the standartization of the test in mathematical order.

The Psychiatric Examinations

Were carried out one psychiatrist in our group. After short organic mental observation, the CAPS, Beck's hopelessness score and Hamilton's psychiatric scale for depression were evaluated too (16).

Statistical Analysis

Spirman rank correlation coefficient two tail test are given together with the correlation coefficient which is symbolised by the letter "r" and probability by tpe "p". Wilcoxon Matched Pair Signed Test is non-parametric, two tail and represented by the letter "p" only. If the statistical number with the letter "r" and "p" have been given together, that means Spirman Rank correlation coefficient test and if it is "p" only, that means Wilcoxon Matched Pair Signed Test.

Results

105 upper and lower extremity replantation or revascularisations were performed at Hand and Microsurgery Hospital, İzmir-Turkey, between the years 1988-1998 by this group of surgeon and 55 of them were complete amputations (Table-1) and 50 of them incomplete amputations and success rate were 82% and 86% respectively. 11 out of 17 complete lower extremity amputations the survival rate 55%.

The functional results of the 32 replantation could be seen in details at the table 2 which Chen's functional classification (7) were used. At this classification Grade I and II are are put together because it seems to be the patients put their replanted parts in their daily life. Opposites could be said for Grade III and IV. 56% of the successfully replanted and revascularised upper extremity were in Grade I and II (Figure 2). However all of the survived lower extremity replantations and revascularizations have had superior functional results (Table 2).

35 upper extremity complete amputation had been put into statistical analysis to gain clear and doubtless idea about the relationship between the age, level of amputation, type of amputation and the functional classification of Chen (Table 3). There was no relation between the age and the functional results, but strong relations should be seen statistically between type of amputation and the functional results $p=0.4102$. At type of injury and the level of injury was statistically correleated. Amputations which is proximal more likely to be avulsion type and more distal ones were clean cut ($r=0.8494$, $p=0.000$) (Picture 1).

The normal and replanted part of the upper extremity were analized in 7 patients by mathematical approach (Table 4).

The replanted part lost the hand volume 16.5% comparing to the normal hand

0.0277). The circumferential differences proximal 10 cm. from the medial epikondyl were 8% ($p=0.0431$) and distally 20% ($p=0.0277$). The length of forearm shortened 3.5 cm average, ranged (1-11.5 cm.). The finger nail width loss 13.5% ($p=0.277$) and the length were 89.5% of the normal side ($p=0.0679$). Circumferential length of the pulpa loss 28% at the nail fold region ($p=0.0277$). With all those measurements we could calculate the volume and surface of the index distally to the nail fold. The shape of the distal finger tip is same as one quarter of the egg which is elipsoid (Table 5). The volume difference of the finger tip gives us the atrophy measurements objectively. The average surface of the normal finger index nail were 1.56 cm² and replanted side 1.20 cm². The surface losses of the replanted index nail were 22.6%, pulpsurface losses were 32% and volume losses were 47% comparing to the normal side ($p=0.027$, $p=0.043$, $p=0.043$) (Table 5). Additionally, from the finger print of the both index finger, we could measure the ridge size 0.173 \pm 0.022 mm., at the normal side, 0.130 \pm 0.022 mm. at the replanted side. It means the replanted ridge of the index pulpa width decrease 25% and the grove 26% at the same time ($p=0.018$ ridge, $p=0.018$ groove). (Picture 2).

The sensibility examination were carried out at the otonom zone of the median and ulnar nerves by the same physiotherapist. 2 of the patients (no.5 and 6) have no discrimination, the others ranges are 10 to 15 mm.

Dynamic and static two point discrimination is statistically shows strong significance with the control side ($p=0.0277$) and the SWE monofilament ($p=0.431$ uln.) at the otonom zone of the median and ulnar nerves as well. Moberg pick up test only 8.51% of the normal side total active motion was 32.5%, grip strength was 14%, pinch strength was 15% of the normal side. Chen's functional classification are strongly related with grip and pinch strength-ratio and TAM ratio ($p=0.006$, $r=0.9380$, $p=0.003$ - $r=0.9535$, $p=0.000$ - $r=0.9852$) respectively. Tamai's daily living activity (8) (DLA) in average 6.5 point, range 1.5 to 16.5 comparing to 20 full point which is 32.5% of the normal side. There are statistically strong correlation between the Chen functional classification and the Millesi functional scoring system ($r=0.8827$, $p=0.02$), between Millesi FSS and Tamai DLA score ($r=0.9856$, $p=0.000$) and between Tamai DLA score and Chen's functional classification ($p=0.8956$, $r=0.016$) (Table 4). BHISS (19) has significant relationship with Millesi and Chen's grading system respectively ($r=0.8827$, $p=0.02$ and $r=0.9091$, $p=0.012$).

According to the Millesi functional scoring system (14,17), loss of the TAM 67.4%, sensibility 29% and strength 89% at the replanted extremity were determined. Cumulative functional losses average 42% comparing to the normal side. In other word, this 6 major replanted patient have lost nearly the half of their total functional capacity (Table 4).

All the patients have been examined by color duplex ultrasonography for the examina-

tion of the artery at the replantation level and distally (18). There were no occlusion found, but 5% to 17% narrowing in diameter of the artery comparing to the normal side at the different levels (Picture 2).

Three phase scintigraphic examination with T99 with both upper extremity were done (19). The Roi isotope counts, distal to the amputated zone were measured quantitatively. At the third phase (metabolic or osteoblastic phase), average of isotope count ratio at the replanted part is only half of the normal side (Picture 2). Scintigraphically the isotope count has relationship between the normal and replanted part ($p=0.0277$). The isotope difference were related significantly with hand volume differences ($r=0.9258$, $p=0.008$) and grasp strength difference ($r=0.9411$, $p=0.005$) and pinch strength difference ($r=0.9258$, $p=0.008$) and Millesi strength losses difference ($r=0.9411$, $p=0.005$), and TAM difference ($r=0.8986$, $p=0.015$), but were not any significance of the sensibility measurement.

Psychosocial conditions of the six patients were also examined and measured. Short organic mental examination were normal range 27 to 29 (Normal 20-30) Beck's hopelessness score were between 5 to 12 and average 9.5 (normal is less than 8) and the Hamilton depression scale between 10 to 30 average 20.3 (Table 4). There were 2 patients have no psychopathologic symptom, 3 patients have depression survey, 2 patients have dependency, 2 patients have incapacity and one patient has an idea of suicide. CAPS (clinical administered posttraumatic stress) disorder scale well known and respectable measurement for the PTSD (posttraumatic stress disorder). 5 of the six patients have psychiatric disorder, though not statically significant but evaluated phenomenonly at this time.

Discussion

For eleven years, we have had 105 patients. 88 of them were upper and 17 were lower extremity complete or incomplete amputations. Our philosophy, for the indication, every effort must be done unless the patient were under life. Threatening conditions. Even though, our overall success rate were 84%. There were higher (9,10,14,15) and lower success rates (12,13) mentioned in the medical literatures. Some of authors have considered to follow the strict indications important for gaining better results (9,14). On the other hand, some of authors mentioned that, most of the patients prefer the worst extremity to an artificial one (8,15).

After the major replantation surgery, the second step is a long lasting running to be held between patient and physiotherapist. To calculate the function, name is "evaluation" as accepted commonly. For the meaningful inspiration, the follow up period must be at least 2 years or more (6,7,9,10,14,15,17). There were high technological equipment and sophisticated computerised analysis (12,14,18,19) and also very simple methods for evaluation to determine the extremity functions. But the simplest is the best. That is why, the Chen's functional classification is the method most commonly

for evaluation of the function of the replanted part (4,6,7,9,10,14,15).

In this series, evaluation of the patients were seen at the table 2 according to the Chen's classification. 56% of the 62 patients of upper extremity replantation and revascularisation were in grade I or II. But all the survived lower extremities were grade I. Nevertheless, no method could explain the real function more accurately and as objectively as the patient's a himself. Though all of us remark this as "subjective". Besides patients evaluate their own functions more optimistic than all the well known methods (8,10,11,14).

Also, some studies and statistical analysis mention that: age (12), ischemic period (15), types (9) and level (14) of injuries influence the functional results. But the series done are neither pure nor large enough to clarify monitoring the real relationship definitely. Therefore, we have chosen complete major upper extremity replantation for better statistical sample. There are strong relationship between the type and level of injury and functional results of Chen influence the type of injury as well (Table 3).

For more detailed analysis, we have narrowed these series. We have chosen the complete upper limb amputations proximal to the wrist (proximal to the musculotendineous junction of the flexor tendons). On this narrowed series, the follow up range is 2.5 years to 11 years. We have 16 patients left according to this criterions. Seven patients accept more detailed examinations (Table 4).

With this purified series, we could have the opportunity to compare various functional evaluation methods statistically. Chen, Millesi and Tamai evaluation methods, all were statistically related with each others. Moreover, Chen and Millesi methods have close relationship with the sensibility, motor and functional parameters (Table 4).

According to the Millesi scores, this series of patients have only one third of their TAM, one tenth of their strength, and more than two third of their sensibility which is most commonly complained obstacles. So that, we have determined that the motor performance is worse than the sensibility. When the surgeon makes a decision on whether replantation or closing the amputation stump, the last parameter to be considered is sensibility, which is completely opposite of the common knowledge.

The volume difference of the hand, were %16.5 and statistically significant. The pulp region atrophy was not calculated quantitatively up to now. Nail surface and pulp surface losses and the volume loss of distal finger portion (from the beginning of nail fold to the tip of the finger) is called as "pulp atrophy". In these patients, comparing to the normal side, nail surface loss 22.6%, pulp surface loss 32% and volume loss, 47% in the replanted index finger (Table 5). At the same time, the finger prints which con-

tains ridge and grooves, loss their width 25% to 26% respectively ($r=-0.7928$, $p=0.033$) (Figure 2) The difference of the groove with difference of the pulp surface are statistically significant ($r=0.9000$, $p=0.037$), and with difference of pulp volumes has a tendency to be different ($r=0.800$, $p=0.0104$). Interestingly the differences of the ridge were negative correlations with the difference of 2PD median and ulnar nerves otonom zone ($r=-0.8000$, $p=0.2$). They are the representations of dermal papilla, which contains Meissner corpuscles and the other mechanoreceptors except Water-Passini corpuscles. So finger print atrophy may be the representation of the mechanoreceptor itself. But we couldn't find statistical relationship with the measured pulp atrophy of the finger and the sensibility status at this time. The difference of nail surface are statistically related with the differences of 2PD at the median otonom zone ($r=1.000$, $p=0.000$), and differences of SWE ulnar and median nerves otonom zone ($r=0.800$, $p=0.2$), and the differences of the Meissner corpuscle count ($r=0.700$, $p=0.2$). The differences of pulp surface are significant with difference of 2 PD ulnar nerves otonom zone ($r=1.000$, $p=0.000$), and pulp volume differences with 2PD ulnar nerves otonomie zone ($r=1.000$, $p=0.000$).

2.5 and 11 years, after the surgery, it is important to determine the arterial patency too. We have not found any arterial occlusion and minimum diameter losses of the artery ranging 5%.

injured according to the CAPS scale. Beck's hopllessness and Hamilton's depression scale were slightly beyond the normal. Although, there are many researches about the posttraumatic stress disorders, but there is a few, about the replanted patients psychological survey (20).

The team not only concern with treating the replanted extremity put also the life quality of the patient.

Conclusion

105 extremity replantations operations have 84% success rate. The functional results were acceptable in 56% of 62 patients followed more than two years. This study shows us it is possible to calculate the pulp atrophy quantitatively but couldn't get statistical relationship with sensibility at this time. Scintigraphic measurements related with motor functions. Chen's functional grading system is related with the type of injury. The evaluation methods have close relationship with each others. The sensibility results are more superior then the motors. That is why the commonly used indications of the major replantation is need to be reviewed.

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