First metatarsophalangeal joint endoprothesis replacement – alternative of arthroplastic resection by Shede- Brandeis in Hallux Rigidus treatment

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Abstract:

Not only high incidence and anatomical and functional foot disruption in Hallux Rigidus, but also imperfect existing treatment methods are the main reasons for patient's and physician's dissatisfaction. Accordingly, new and new optimal treatment methods for above-mentioned medical problem are being developed [4. the major treatment methods are the following: arthroplastic resection (Shede- Brandeis operation), first metatarsophalangeal joint arthrodesia, especially, first metatarsophalangeal joint endoprothesis replacement [4]. Evaluating the research results of ceramic implants in two groups- control and treatment, included the comparative results of both arthroplastic resection and first metatarsophalangeal joint endoprothesis replacement. Endoprothesis replacement demonstrated excellent functional results, but revealed significant number of complications.

Introduction

Davies- Colley was the first to describe this medical problem as *hallux flexus* in his report at London Clinical Association in 1887 [4]. However, 4 months later, Cotterill proposed the term *Hallux Rigidus* (further as *HR*). This term was considered to be more appropriate in defining deforming arthrosis of first metatarsophalangeal joint (further as first MTPS), in spite of the numerous existing synonyms, such as Hallux Limitus, Hallux Dolorosus, metatarsus non extensus, dorsal osteochondroma, wrinkled picker's disease and metatarsus primus elevatus. [4]. Finally, in 1965, the well-known medical researcher of diabetic foot, Kelikian summarized all background history and definitions [15]. According to ICD code-10, this disease is classified as “stiff big toe” and was identified M20.2 [1]. Epidemiological evidence vividly demonstrates: based on M.Jahss data incidence is significant- 1 out of 45 aged 50 or more, in addition to HR incidence in cases of systemic lesion, injury outcomes, etc. [4].

Most researchers indicate predominately men patient in the total number of incidents; and only one case of painfully degenerating affected metatarsophalangeal joint among 2-sided affected foot incidents.

The significant number of unfavorable results concerning both conservative and surgical HR treatment in advanced stages resulted in first MTPS endoprothesis replacement onset [4,10,16]. Different proposed implants and surgical techniques were estimated and rejected.

Both cement use and silicon structrure were proven to be entirely unacceptable for first MTPS endoprothesis replacement [17,19,20]. During the last few years, different materials, such as stainless steel, Co-Cr alloy, titanium and others were used for implants [5,6,7,8,9,]. However, today, the most prospective first MTPS material is dual-component press-fit implant with Ceramic-on-Ceramic [2].

Our application results were favorable , but one question still arose- which would be better: endoprothesis replacement or widely- applied arthroplastic resection by Shede-Brandeis (known as Keller operation) [12]. In the following retrospective study analysis we will attempt to answer this question.

Patients and methods

Long-term treatment results of 220 HR patients (100%) were analyzed. The study included patients of type III (corresponding to Kosinskaya type [3]): 79 men (35.7%) and 141 women (64.3%) who were operated at Novosibirsk Research Institute of Traumatology and Orthopedics from 2001 to 2015, and then surgical treatment in their Clinic. The patients were divided into two groups according to applied surgical treatment method. Patient treatment results were assessed in 1-1.5 years after operation period and maximal follow-up period- 7.5 years. Obligatory examination period was before and in 1.5 years after operation. The following factors were assessed: pain syndrome dynamics, joint range of motions in first metatarsophalangeal (measured by goniometer).

Control group of patients

Control group included 52 patients (100%): 31 women (60%) and 21 men (40%). Arthroplastic resection of first MTPS by Shede- Brandeis was conducted. Average age of patients-52±8.5; average disease period- 12.6±6.7 years before seeking medical advice.

Treatment group of patients

This group included 168 patients (100%): 104 women (62%) and 64 men (38%). First MTPS endoprothesis replacement with Ceramic-on-Ceramic. Average age of patients-49±1.5; average disease period- 12.6±6.5years before seeking medical advice.

X-ray method. Radiography of both feet in support position, frontal and lateral views (functional roentgenogram of first metatarsophalangeal was not conducted because of active and passive to-and-fro movements in first MTPS or total absence of such). To monitor correct position of implant components throughout the operation, perioperative radiographic (X-ray) control was conducted by electron-optical converter for 2D X-ray of the feet. In 12 months after the operation, X-ray of both feet in both support position and frontal and lateral views, as well as functional roentgenogram of first metatarsophalangeal on lateral view and flexion and extension position of one toe were conducted to evaluate the final treatment results.

Surgical method

The classical method-arthroplastic resection by Shede- Brandeis was applied in the control group for OP treatment; while first metatarsophalangeal joint endoprothesis replacement applying ceramic implants in the treatment group. In the after operation period the following procedures are recommended: orthopaedic therapy, excluding all possible burdens on the forefoot for 4 weeks; dressing change to complete operative wound healing; physiotherapy. In 5 weeks the patient continued the therapy with graduated weight bearing on the foot surface; therapeutic cycle exercise to recover the movement in MTPS. Vocational rehabilitation in 4-4.5 months.

Assessment of results

Assessment of results included clinical, X-ray and functional result analyses. The results were assessed in one year after the operation. Pain syndrome dynamics was studied to VAS and functional indexes- adapted AOFAS scale for forefoot. Motion range in first metatarsophalangeal jointwas measured by goniometer.

Statistical method

Obtained research results were processed by computing descriptive statistics and qualitative and quantitative factor comparison in studied patient groups. Descriptive statistics is an average (M) and its standard mean square error (m). Statistical significance of compared average studied parameter values in patient groups is assessed by Mann-Whitney U test. Statistical significance threshold level (p) equals 0.01. Analysis of qualitative parameters was conducted on the basis of Chi-squared test. Compared value difference is considered statistically reliable, not exceeding the determined threshold level of 0.01 ($p < 0.01$).

Results of treatment

All patients were examined and the results evaluated. Treatment group patients showed 151 (90%) good and satisfactory results. The patients experienced significant reducing pain syndrome, post-support recovery of medial foot and improving shoe wearing comfort (Fig. 1)

Figure 1 (a,b,c,d) X-ray of 50-year patient G. and 472\2009. Before operation (first metatarsophalangeal joint endoprothesis replacement)- X-ray of both feet (a, b) and after operation- in 7.5 years.

Good results. Increasing movement range in first metatarsophalangeal joint (Table 1 and 2). Good and satisfactory results were significantly less 30 (58.7%) in the treatment group (Table 1 and 2).

The reasons for poor results 18 (10.7%) in the treatment group involves the following complications (Table 3), the most severe complication 7(4.1%) involved surgical site infection. Specifically, 1 case – advanced infection; while in 6 cases- early infection. In 3 (1.8%) cases of poor results showed hallux varus. Implant instability was revealed in 3 (1.8%) patients requiring revision surgery. Poor results in the control group involved unavoidable complications after arthroplastic resection by Shede-Brandeis, i.e. fibrosis, stiffness of first metatarsophalangeal joint, pain syndrome (Fig.2).

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Figure 2 (a,b,c,) X-ray of 48-year patient G. and 472\2009. Before operation (arthroplastic resection by Shede-Brandeis) – direct radiography of both feet: (a) expressed HR, revealed by radiography of feet after arthroplastic resection by Shede-Brandeis; (b) results in 1.5 years; (c) revealed fibrosis, shortening of first toe. The results are considered as poor.
There were no severe complications in control group; however, nervus cutaneus dorsalis medialis was observed.

Table 1
CLINICAL AND FUNCTIONAL RESULTS OF HALLUS RIGIDUS SURGICAL TREATMENT IN CONTROL AND TREATMENT GROUPS

Patient groups	Follow-up period	Dorsal flexion, degrees	Plantar flexion, degrees	Motion range in MTPS, degrees	Evaluation by AOFAS scale, points	Evaluation by VAS scale, points
Treatment group (n=168)	Before operation	5.4 ± 6.2	¬0.2 ± 5.6	4.6 ± 3.8	34.0 ± 5.2	78.5 ± 7.1
	12 months after operation	25.6 ± 5.3*/**	12.4 ± 3.2*/**	37.2 ± 4.1*/**	80.2± 5.5*	29.3± 5.8*/**
Control group	Before operation	5.9 ± 4.3	0.6± 4.5	6.5± 1.8	43.7± 2.6	76.7± 6.9

(n=52)	12 months after operation	8.5 ± 3.7	6.2 ± 3.8	4.3 ± 1.8	67.7 ± 6.4	48.3 ± 4.5*

NOTE:
*- p<0.01 compared to c (n=120) (M±m).
values before surgery
** - p<0.01 compared to the control group values

Final assessment of clinical, X-ray and functional treatment results was summarized in Table 2, reflecting general patient treatment results.

Table 2
FINAL SURGERY RESULTS IN CONTROL GROUP

РЕЗУЛЬТАТ	TREATMENT GROUP (n=168)	CONTROL GROUP (n=52)
Good	109 (64.7%)	6 (11.5%)
Satisfactory	42 (25%)	24 (47.2%)
Poor	17 (10.3%)	22 (42.3%)
Total (n=120)	168 (100%)	52 (100%)

Complications- analysis in both patient groups. Surgery complications in treatment and control groups.

Table 3. Complication in control and treatment groups

	COMPLICATION TYPES	TREATMENT GROUP (n=168)	CONTROL GROUP (n=52)
1.	Surgical site infection	7 (4.1%)	0 (0 %)
2.	Hallux varus	3 (1.8 %)	0 (0%)
3.	Implant instability	3 (1.8 %)	0 (0%)
4.	Nervus cutaneus dorsalis medialis	5 (3 %)	4 (7.7 %)
	Total	18 (10.7%)	4 (7.7 %)

Discussion

Surgery methods for advanced HR significantly changed since the time when Davies-Kolley (1887) proposed resection of proximal phalanx base of great toe. Nowadays, the range of surgery methods has expanded, and new and new methods are being developed. Another important factor is the tendency towards differential approaches in surgery depending on

specific morphologically affected substrate. Thus, arthrodesis (joint fusion) of first metatarsophalangeal joint is recommended for young people with high movement level (especially, sportmen) [16]. Cuneiform osteotomy of proximal phalanx of great toe or neck of first instep bone is more attractive for adolescents [16]. Arthroplastic resection of first MTPS by Shede-Brandeis is the most common surgery method [12,16].

However, low method performance potential to recover the range of movement in first metatarsophalangeal joint (especially, arthroplastic resection of first metatarsophalangeal joint) resulted in further active research of more effective methods. Particularly promising method- first metatarsophalangeal joint endoprothesis replacement- was proposed in the 50s of the last century. Our experience revealed the positive potential of this method in improving the foot range of movement and its function. More and more representatives of the medical community confirmed this position [16]. However, numerous traumatologist-orthopaedists have apprehensive attitude concerning this type of endoprothesis replacement, due to the following anatomical site features- insufficiency of muscles which could cover the implant, external medium relation, etc.

Unjustified complications could be excluded. Negative attitude to the MTPS implant structure itself can also be suspended [15]. Ultimately, there were no severe complications in the control group, but there is an inappropriate number of poor results as a result of arthroplastic resection. First metatarsophalangeal joint arthrodesis is rather more beneficial [18]. However, further in-depth research could be that convincing evidence proving the significance of this method.

Conclusion

Retrospective study analysis showed that first metatarsophalangeal joint endoprothesis replacement comparable to arthroplastic resection has a more significant advantage. This fact is due to the significant number of positive results of the first method. endoprothesis replacement The main positive results are reducing pain syndrome and improved range of motion in the affected joint which is the target of this surgery method. Another factor should be mentioned- good cosmetic results after first MTPS endoprothesis replacement. Not one after-operation complication lead to the disability of a patient. It is not only the accumulated experience in endoprothesis replacement and further improvement of designed implants, but also the upgrading surgery methods that decrease any arising complications to minimum.

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