Evaluation of The Standard Procedure For Treatment of Periprosthetic Joint Infections of Total Knee and Hip Arthroplasty: A Comparison of The 2015 and 2020 Census in Total Joint Replacement Centres in Germany

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Research Article

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Abstract

Background

Since there are no national or international algorithms there are different procedures for both, the diagnosis and the therapy of a periprosthetic joint infection (PJI). Therefore, the present paper evaluates the respective protocols from different centres on the basis of an EndoCert questionnaire to treat PJI in certified total joint replacement centres (EPZ).

Materials and methods

A questionnaire was developed in cooperation with the EndoCert Certification Commission to survey the principles to treat septic revision arthroplasties in EPZ including questions on various treatment options: prosthesis preserving procedures (DAIR - Debridement, antibiotics, irrigation, and retention of the prosthesis), one-stage revision, two-stage revision, removal of the endoprosthesis and sampling prior to reimplantation. All certified EPZ were included (n = 504). The results of the current survey 2020 were compared to those of a previous analysis.

Results

The number of centres that performed DAIR up to a maximum of 4 weeks and more than 10 weeks after index surgery has clearly decreased since 2015, while the number of centres that provided a one-stage revision as a treatment option has increased (hip: +6.3%; knee: +6.6%). The majority of the centres (73.2%) indicated a 4-8 week period as the interval between prosthesis removal and reimplantation for two-stage replacement for both, hip and knee revisions. Amongst centres with a higher number of revision surgeries (>200 revisions/year), there were even more that opted for the 4-8 week period (92.3%). The Girdlestone situation, but also metal-based spacers with/without reinforcement with antibiotic-containing cement, are less frequently used. When exchanging knee replacements, there was a clear trend towards cemented anchoring, whereas cementless anchorage was preferred for hip replacements. Overall, the number of EPZ with a standardised protocol for the procedure continues to increase. In addition, more samples for microbiological testing are taken when removing the endoprosthesis, 72% of the centres take 5 or more samples.

Conclusion

While there was a trend towards standardised therapeutic algorithms for PJI with more uniform choices among the centres in 2020 compared to 2015, the treatment often remains an individual decision. However, since a consistent treatment regime is of vital importance with an expected rise of total numbers of revision arthroplasties, uniform definitions with regard to comparability and standardisation are necessary for the further development of the EndoCert system.

Summary

This study shows recent changes in therapy algorithms in EPZ's with respect to interval duration in two-stage revision, spacer selection, anchoring techniques, sampling and duration of antibiotic treatment. In the view of increasing number of revision arthroplasties, therapeutic algorithms and uniform definitions are missing.

Introduction

Periprosthetic joint infections (PJI) are considered to be some of the most serious complications of arthroplasties [1, 2]. PJI occur in 0.2 - 2% of patients who have undergone replacement of the knee or hip joint [3–5]. Septic diseases have social, economic, psychological and forensic aspects and implications [6]. The different approaches to diagnose a PJI [7–11] in itself is a major challenge, but there are also different therapeutic approaches once the diagnosis of PJI is confirmed. These therapies include prosthesis preserving procedures (DAIR - Debridement, antibiotics, irrigation, and retention of the prosthesis) or one- and two-stage revisions [2, 5]. To date, there is neither national nor international therapeutic algorithms for the treatment of PJI, although various recommendations have been published in recent years [5, 10, 12].

Within the framework of the EndoCert Certification System of the German Society for Orthopaedics and Orthopaedic Surgery (DGOOC) certified endoprosthesis centres (EPZ) are obliged to describe their procedure to treat PJI in a standardised documentation prior to an external audit [13, 14]. The evaluation of the centres' algorithms offers the possibility to map the therapy standards of all German certified EPZ where more than 56% of all knee and hip arthroplasties are preformed nationwide [15].

A first evaluation in 2015 already showed that there are differences between therapies depending on the size of the centre, i.e. the number of revision cases per centre per year, also having an influence on the procedure [16]. Among others, it was investigated whether a one- or two-stage procedure and which implant anchorage are preferred as well as the duration of the interval between two-stage revision.

We hypothesised that the therapeutic algorithms changed, especially in the view of the "Consensus Conference 2018" [10]. The previous analysis [16] is based on the data of the EndoCert system in the years 2013 and 2014. The aim of the current study was to investigate the development in the therapy of PJI in the certified centres since then. Therefore, the present results were compared to the previous survey.

Materials And Methods

The Certification Commission of EndoCert developed a standardised questionnaire to assess the treatment for PJI in EPZ [17]. The documentation form on the principles of treatment for PJI was hardly modified since the start of the pilot project in 2015, so that the results from the survey based on the data years 2013-2014 are comparable with the current analysis (2020) based on the data years 2018-2019. Every other year the questionnaire has to be completed by the EPZ and must be sent to the independent certification body ClarCert.

The number of cases of multi-site EPZ was summarised, as these centres usually submit just one questionnaire as they follow the same procedure. Only from one multi-site centre, two different questionnaires were available, so that these had to be considered separately in the evaluation.

In the current evaluation, all centres in Germany were included which were also included in the EndoCert Annual Report 2020 [18]. Accordingly, 504 certified EPZ's took part in the survey. The data of the evaluation regarding one-stage revision refer to the facilities that stated in the survey to principally perform one-stage revisions (the number of the centres are n = 277 for the hip and n = 255 for the knee). With respect to the question to perform two stage revisions, the number of the centres is n = 503, since only one centre indicated not to perform any two-stage revisions. This centre refers such cases directly to the cooperating high volume EPZ.

The questionnaire contains five superordinate categories of the different therapeutic options for PJI. These include DAIR, one-stage revision, two-stage revision, removal of the endoprostheses and sampling prior to reimplantation. The questions can be answered by single or multiple responses. Individual responses are also possible.

Statistical analysis

Descriptive statistics were performed using Microsoft Excel 2016. Quantitative characteristics were described, and absolute and percentage frequencies were given for qualitative parameters. Since all certified EPZ were included, this is a comprehensive survey.

For a differentiated evaluation of the results, additional groups were formed, and those were compared with each other. A distinction was made between EPZ and EPZmax (high volume centres), then the number of replacements was also categorised (centres with <50 revisions/year (n = 268), 50-100 revisions/year (n = 90), 101-200 revisions/year (n = 66) and >200 revisions/year (n = 26)).

Ethics approval

The study was approved by the local institutional ethical committee (A2015–0055).

Results

Prosthesis preserving procedures (DAIR)

In 2015, 503 centres (97.7%) used DAIR as a treatment option. In 2020, 9.5% of the centres (n=48) left this question unanswered. Figure 1 shows the comparison of the preferred time interval after index surgery when PJI is still treatable considering DAIR as an attempt to retain the endoprosthesis.

As part of DAIR almost all centres performed a partial exchange (2015: n=503 (97.7%), 2020: n=490 (97.2%)). 65.1% (n=328) of the centres currently use DAIR treatment in a time frame of 4-10 weeks. The evaluation of 2020 showed that centres with more than 200 joint replacements per year initiate implant-

preserving surgery only up to a maximum time of 10 weeks after initial implantation, whereas in 2015 still 4.5% of these high volume centres performed the method after more than 10 weeks. At the same time the percentage of these high volume centres that solely used DAIR within the first 4 weeks dropped from 41.0% (n=9) in 2015 to 23.1% (n=6) in the current evaluation. However, compared to 2015 7.7% (n=2) of the centres with the highest number of revisions individually decided, while 7.7% (n=2) of the centres left this question unanswered in the current survey.

One-stage revision

In the current survey, 255 (50.6%) and 277 (55.0%) centres reported one-stage revisions of total knee and hip arthroplasties, respectively. In 2015 the rate was still below 50% with 44.0% (n=213) and 48.7% (n=241) of centres carrying out one-stage revisions of the knee and hip joint, respectively. Thus, in 2020 this number was 6.6% higher for revisions of the knee and 6.3% higher for revisions of the hip joint than 5 years ago. The reasons for performing a total one-stage revision are shown in Table 1.

Table 1 Reasons for a one-step revision differentiated for joint and number of revisions per year 2020

	EPZ with PJI (n=277)* hip				EPZ with PJI (n=255)* knee			
	<50	50-100	101-200	>200	<50	50-100	101-200	>200
	n=135	n=90	n=38	n=14	n=125	n=81	n=36	n=13
Early Infection	80.7%	77.8%	86.8%	78.6%	79.2%	70.4%	80.6%	84.6%
depending on defect	44.4%	35.6%	26.3%	50.0%	42.4%	37.0%	25.0%	53.8%
depending on age	36.3%	26.7%	31.6%	50.0%	36.8%	28.4%	36.1%	53.8%
Depending on species of the causative pathogens	23.7%	28.9%	39.5%	28.6%	24.8%	28.4%	41.7%	30.8%
Others	14.1%	20.0%	18.4%	28.6%	12.0%	21.0%	16.7%	30.8%

*centres, that perform one-step revision at all

With respect to the preferred method of implant anchorage during one-stage exchange procedure, there are no obvious differences between 2020 and 2015. The trend for the knee joint is clearly towards the cemented anchorage (2020: n = 224 (87.8%), 2015: n = 196 (92%)), and for the hip joint there are no differences with respect to type of anchorage (2020: n = 120 (43.3%) cemented & n = 127 (45.8%) cementless, 2015: n = 115 (47.7%) cemented & n = 109 (45.2%) cementless).

Two-stage revision

Interestingly for two-stage procedures there was a clear change in the interval between prosthesis removal and reimplantation between 2020 and 2015. Overall, the duration of the intermediate interval varied widely among centres. However, there was a wider range in 2020 with a minimal duration of 4 days and a maximum duration of 270 days, while in 2015 the data for the duration between removal and reimplantation ranged from 4 to 120 days. While in 2015 only 61.2% (n=315) of the centres favoured the intermediate interval of 4-8 weeks, this number increased in the current survey to 73.2% (n=368) and 71.8% (n=361) for both hip and knee revisions. Nine to 11 weeks were now preferred by only 2.4% of the centres compared to 16.1% in 2015 and 12 weeks or more were applied only in 3.2% of the centres (2015: 8.3%). When differentiating between EPZ and EPZmax the focus on the 4-8 weeks interval becomes even more apparent (Table 2) and this also correlates with the number of revisions, i.e., the more revisions per year the more centres chose an interval of 4-8 weeks.

Table 2 Intermediate interval for two-stage revision differentiated by centre type 2020

	EPZ (n = 350)		EPZmax (n = 153)	
	hip	knee	hip	knee
< 4 weeks	13.1%	12.0%	4.6%	4.6%
4-8 weeks	69.1%	67.7%	82.4%	81.0%
9-11 weeks	2.6%	2.6%	2.0%	2.0%
≥12 weeks	4.0%	4.0%	1.3%	1.3%
individual/ individually	7.1%	7.4%	8.5%	8.5%
not specified	4.0%	6.3%	1.3%	2.6%

Major changes were also evident between 2015 and 2020 in the choice of spacer. In 2015, one-piece metal-based spacers with/without reinforcement with antibiotic-containing cement were used in 40.1% (n = 210) of the centres for the hip and in 39.6% (n = 204) of the centres for the knee. Five years later, one-piece metal spacers were only used in 8.7% (n = 44) of the centres for the hip and in 7.6% (n = 38) of the centres for the knee. A similar trend was observed for multi-part metal spacers with usage rates in 38.1% (n = 196) and 39.6% (n = 204) of the centres for hip and knee, respectively, in 2015, but with being used only in 8.0% (n = 40) of the centres for the hip and in 7.8% (n = 29) of the centres for the knee in 2020. The 2020 survey showed that 63.0% (2015: 61.6%) of the centres used individually shaped cement spacers for the hip and 76.7% (2015: 62.9%) for the knee. Moulded cement spacers are used in 54.7% (2015: 41.7%) of the centres in the hip and 50.3% (2015: 40.8%) in the knee. While in 2015 22.5% of the centres still use a sine-situation after removal of the knee prosthesis, this figure was down to 7.2% in 2020.

The comparison of Figures 2 and 3 shows that while 44.1% of centres chose a cementless knee endoprosthesis for reimplantation in 2015, this figure amounted only to 9.3% in 2020. Thus, a clear shift towards a cemented anchorage was detected.

In the current evaluation, 75.3% of the centres used a premixed cement for hips and 75.4% for knees (2015: 70.7%) if cement is used. A cement mixture, in which an individual antibiotic supplement is added to the cement, is used by 16.8% of the centres for the hip and 17.0% at the knee (2015: 19.6%). In 2015, 7.6% of the centres used both methods (2020: 5.8% for the hip & 5.2% for the knee).

The previous evaluation in 2015 showed that 75% (n = 384) of the centres treat PJI according to a special concept and that the more revision operations per year are carried out in an EPZ the more often a standardised algorithm (>200 revisions: 87% (n = 20)) was applied compared to centres with fewer revisions (<50 revisions: 72.3% (n = 204)) per year. In 2020, on the other hand, the number of centres with standardised concepts has considerably increased. For the hip 86.3% (n = 434) of the centres have a standardised concept and for the knee 84.5% (n = 425). Amongst centres with more than 200 revisions per year even 96.2% (n = 25) used standardised procedures for both joints, while 83.1% (n = 222) and 80.9% (n = 216) of centres with less than 50 interventions applied a standardised algorithm for the hip and knee joint, respectively.

Removal of the endoprosthesis and Sampling before reimplantation

In 2015, 37.9% of the centres took intraoperative 2-4 samples and 58.4% took 5 or more intraoperative samples for microbiological testing when removing the endoprosthesis. In the current study, only 14.9% of the centres reported taking 2-4 samples and 72.0% reported taking 5 or more samples.

The duration of antibiotics administered between removal and reimplantation were stated very differently by the centres. Some centres named distinct days, but many others listed a time span in the questionnaire, so that a direct comparison in days is only possible for a limited number of centres. For this reason, it was additionally considered whether or not a standard procedure was available. This comparison (Figure 4 and 5) showed no significant changes between 2015 and 2020.

In the current evaluation, it was also determined which of the known methods is used for the majority of the centres. Two hundred ten centres (21.8%) use postoperative antibiotics for 42 days and for 42 days after reimplantation of the new endoprosthesis. 3.2% (n = 16) of all certified EPZ chose 42 days after removal and 14 days after reimplantation and 7.5% (n = 38) of the centres selected 42 days after removal and individual therapy after reimplantation. Twenty seven centres (5.4%) prefer 14 days of antibiotic therapy after removal, but have no standardised timeline after reimplantation.

Sampling before reimplantation

While in 2015 only 12.4% (n = 64) of all centres did not take any biological material for infection diagnosis after removal and before reimplantation, this figure increased to 32.5% (n = 164) in 2020. 2015 315 centres (61.0%) were performing a puncture whereas in 2020 only 104 centres (20.6%) punctured before the second procedure.

Discussion

The care of patients with PJI requires close cooperation between medical and surgical specialists. Numerous factors, such as duration of the symptoms, age of the implant, causative pathogens, stability of the endoprosthesis, comorbidities of the patient, but also the expertise of the orthopaedic surgeon or the patient's expectation, influence the decision on the best possible therapy [5].

The definitions of PJI differ significantly and therefore lead to different therapeutic approaches. Nevertheless, in the last decade, various associations and expert groups have provided clear definitions that are internationally recognised. The most important definitions include those of the Musculoskeletal Infection Society (MSIS) [19], the International Consensus Meeting (ICM) [10, 20], the World Association against Infection in Orthopedics and Trauma (WAIOT) [6], the Infectious Diseases Society of America (IDSA) [5] or the European Bone and Joint Infection Society (EBJIS) [21]. Whereby, some of which have already been revised and updated.

There is still a lack of comprehensive prospective comparative multicentre studies regarding PJI therapy. As a result, no internationally established, scientifically proven guideline for the treatment of PJI has yet been established. Nevertheless, the results of this present study also reflect the efforts to establish standards. The comparison of the two survey periods shows a positive development with regard to an established standardised concept in dealing with septic revisions. Almost all centres that carry out more than 200 revisions per year have established a standardised procedure to treat PJI. This development makes it clear that standardised processes and procedures have become part of everyday hospital life as a consequence of the successful certification by EndoCert.

Prosthesis preserving procedures (DAIR)

Our current study shows that centres that performing more than 200 revision surgeries per year only perform prosthesis preserving procedures up to a maximum of 10 weeks after index surgery. The trend is clearly towards 4-10 weeks while the number of centres that performed prosthesis preserving procedures only up to a maximum of 4 weeks fell from 41% to 23% in this group. However, this trend contradicts the current recommendations from, for example, the 2018 consensus meeting [20] or those of the Trampuz working group [12], who recommend prosthesis preserving procedures up to 30 days after the index

surgery or 3 weeks after the onset of symptoms with, among others, stable endoprostheses and no sinus tract infection or compromised soft tissue [22]. Almost all centres (2020: 97.2%) carry out a partial exchange of prosthesis maintenance components. This corresponds to the consensus of the Philadelphia Meeting in 2018, where 94% of the delegates were of the opinion that a partial exchange prevents a relapse [23]. Finally, a limitation of our survey is that the documentation form did not consider any question toward acute late infection.

One-stage revision

The comparison of the two evaluation periods shows that over the last 5 years more centres have been using the one-stage revision procedure. This is more common in Europe, while the one-stage revision has hardly been considered in the USA [12]. The main reason for such an indication is early infection. However, there are different internationally recognised definitions of early infection leading to different interpretations [13, 14]. For future evaluations and consequently for a better interpretation of the results, it is therefore recommended to establish a uniform definition of early infection within the certification system.

The type of anchorage used for one-stage replacement did not changed over the past years. For the knee joint, cemented anchorage is mostly used and for the hip joint, both cementless and cemented anchoring techniques are used. During the 2018 consensus meeting 93% of delegates believed that there is no evidence to recommend either cemented or cementless anchorage for the successful treatment of infection. When choosing a cemented endoprosthesis, the incorporation of antibiotics in the cement should also be considered [24, 25]. This recommendation applies to both, the one-stage revision procedure and the two-stage procedure.

Two-stage revision

The two-stage revision is described in the literature as the gold standard in the treatment of PJI [12, 24]. This also applies to the results of our current survey. While only 277 centres perform the one-stage revision for the hip joint and 255 centres for the knee joint almost all centres (n = 503) perform the two-stage revision.

Li et al. [12] described a short interval of 2-4 weeks between both surgeries (removal and reimplantation) for patients with a known and easy to treat bacterial spectrum and no or less compromised soft tissue or sinus tract; or a long interval of 8 weeks for patients with a difficult-to-treat (DTT) bacteria and severely compromised soft tissue. Sukeik et al. [24] recommend an intermediate interval of 4-6 weeks with antibiotic therapy. Our results show that within the EndoCert system the trend in the two-stage implant replacement is towards an intermediate interval of 4 to 8 weeks (73.2% in 2020, 61.2% in 2015). A period of nine weeks or more do not seem to be relevant anymore. The distinction between EPZ and EPZmax shows this shift even more clearly. More than 80% of all EPZmax prefer an intermediate interval of 4-8

weeks for a two-stage revision procedure. In the centres with more than 200 revision surgeries per year, more than 90% chose an interval of 4-8 weeks. During the 2018 consensus meeting, delegates were unable to agree on an optimal time interval due to a lack of evidence [26].

The comparison of the two assessed years shows that the use of metal-based spacers with/without reinforcement with antibiotic-containing cement and also the Girdlestone procedure only play a minor role. Here, there was a clear shift towards either individually shaped cement spacers or moulded cement spacers for both, the hip and knee. In the course of the consensus meeting, no guidance was agreed on this issue and no recommendations were made regarding the use of non-articulating or articulating spacers [27].

Compared to one-stage revisions, two-stage revisions follow a new direction with regard to the concept of anchoring. For the reimplantation of a knee endoprosthesis, cemented anchorage has been preferred by more than three-quarters of all centres in recent years. When changing the hip joint, the trend is moving away from a cemented anchorage towards a cementless one. As described above, the consensus meeting was unable to agree on a clear recommendation regarding the type of anchorage, which is due to the lack of randomised studies. Nevertheless, as our results show, there is a trend towards cementless hip joint endoprostheses with good clinical results [25]. In the case of a cemented procedure, no significant differences have been observed in recent years. A small increase with respect to a ready-mixed cement can be seen for both the hip and the knee. In parallel, the usage rate for individual antibiotic admixture to the cement decreases minimally.

Removal of the endoprosthesis

The information provided by the centres on the duration of antibiosis administered varied considerably. Some indicated time periods, others minimum or maximum periods, and still others referred directly to, for example, the procedure published by Trampuz with extended antibiotic medication after reimplantation [12]. For this reason, the evaluation or comparison of the recording years was only possible to a limited extent. Even the working group of the 2018 consensus meeting could not come up with a clear recommendation regarding the optimal duration of antibiotic administration in the context of the two-stage implant replacement. Nevertheless, the group finally agreed that, based on the current literature, support can be given to a duration of 4-6 weeks after removal [29]. Basically, the results of our study show that established standards for the use of postoperative antibiosis are found unchanged in the EPZ. In the current evaluation, we also investigated which time intervals were applied by the majority of centres in order to identify which of the internationally published procedures and recommendations are preferably implemented nationwide. This shows a clear trend towards the concept published by the Trampuz group (42 days after removal and 42 days before reimplantation) [12]. The high number of individual antibiotic administrations is justified by the dependence on the germ and the recommendation of the microbiologist.

Sampling before reimplantation

To assess the eradication of the PJI before reimplantation, there is a clear shift away from preservation of biological material or performance of a puncture. The decrease in the number of punctures performed is also consistent with the recommendations of Mühlhofer et al. [9].

To date, various questions regarding the diagnosis and therapy of PJI remain unanswered. Generally, valid therapeutic approaches cannot be applied to all patients and ultimately the care of these patients often remains an individual decision.

Conclusion

Different definitions of PJI, as well as different treatment options for infections, pose great challenges for both medical staff and patients when dealing with infections. The developments of the last few years are partially reflected in the procedures for handling PJI in the certified EPZ, but differences can be clearly observed depending on the number of revisions per centre. Even if the trend is towards standardised therapeutic procedures, the treatment often remains an individual decision.

Abbreviations

DAIR Debridement, antibiotics, irrigation, and retention of the prosthesis

DDT difficult-to-treat

EBJIS European Bone and Joint Infection Society

EPZ certified endoprosthesis centres

EPZmax certified high volume endoprosthesis centres

ICM International Consensus Meeting

IDSA Infectious Diseases Society of America

MSIS Musculoskeletal Infection Society

PJI periprosthetic joint infection

WAIOT World Association against Infection in Orthopedics and Trauma

Declarations

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None.

Authors' contributions

KOZ, RC, WM: were responsible for data collection, analysis and interpretation of data, design of the work and revision. KOZ, AK, DWC, CHL, HH, BK, WM were responsible for data revision. KOZ, AK, RC, DCW, CHL, HH, BK, WM approved the submitted version and agreed to be personally accountable for the author's own contributions and ensured that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, were appropriately investigated, resolved, and the resolution documented in the literature. KOZ, AK, RC, DCW, CHL, HH, BK, WM have read and approved the final version of the manuscript.

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Availability of data and materials

The consent of EndoCert – an Institution of the German Socitey of Orthopaedics and Orthopaedic Surgery has been granted. The data was collected and evaluated within the scope of the EndoCert certification. The specially designed questionnaire and the data obtained are stored and available at EndoCert. The data that support the findings of this study are available from EndoCert GmbH but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the corresponding author upon reasonable request and with permission of EndoCert GmbH.

Ethics approval and consent to participate

The study was approved by the Ethics Committee at the Medical Faculty of the University Rostock: "Ethikkommission an der Medizinischen Fakultät der Universität Rostock", Address: St.-Georg Str. 108 18055 Rostock, Germany, Votum: A2015–0055. The need for written informed consent was waived off by the Ethics Committee at the Medical Faculty of the University Rostock due to the survey character of the study without patient data or intervention. In addition, the authors and the ethic committee confirm that all methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not Applicable.

Competing interests

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Figures

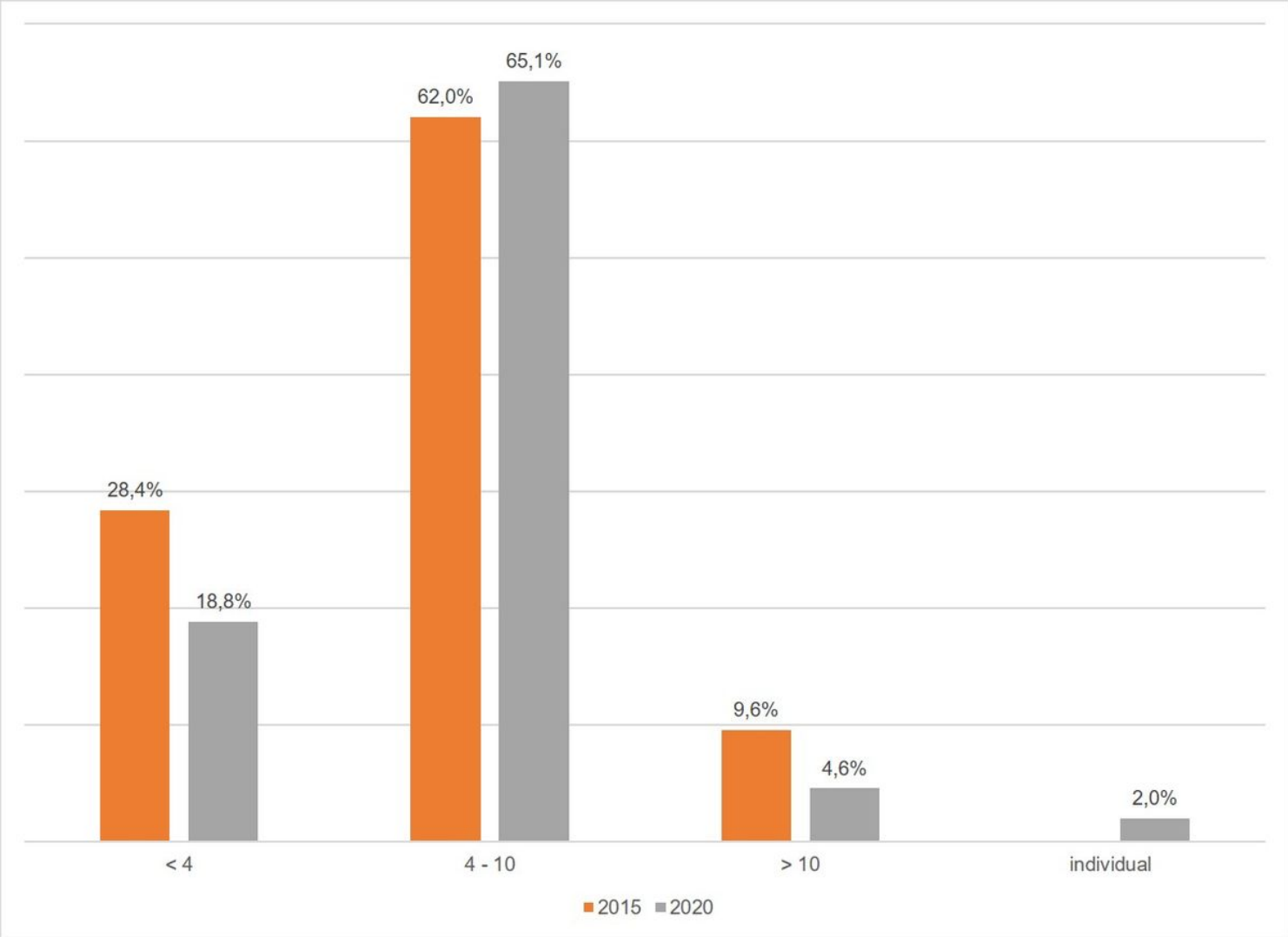

Figure 1

Comparison of the choice of the interval for DAIR

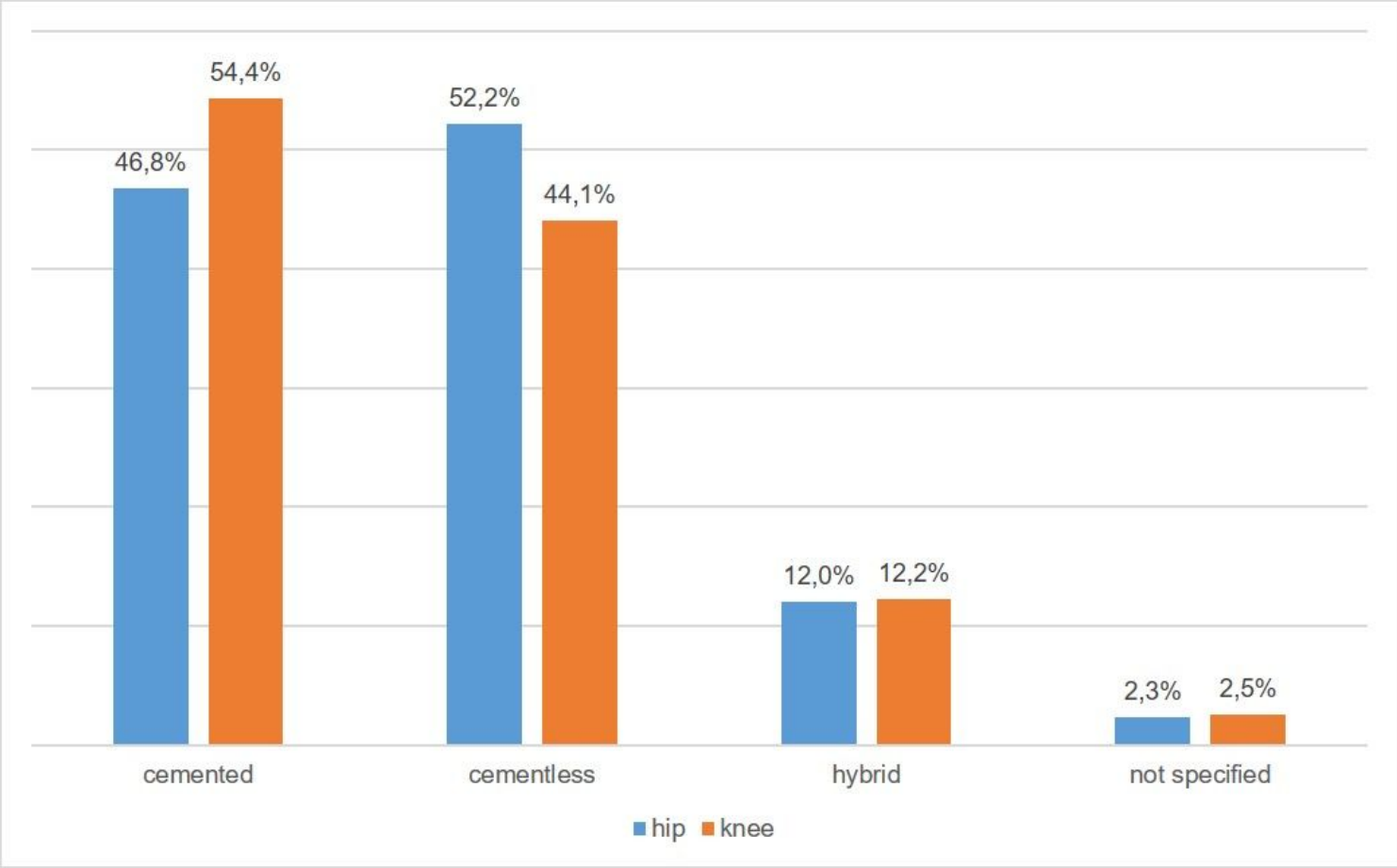

Figure 2

Implant selection for the treatment for the two-stage revision 2015

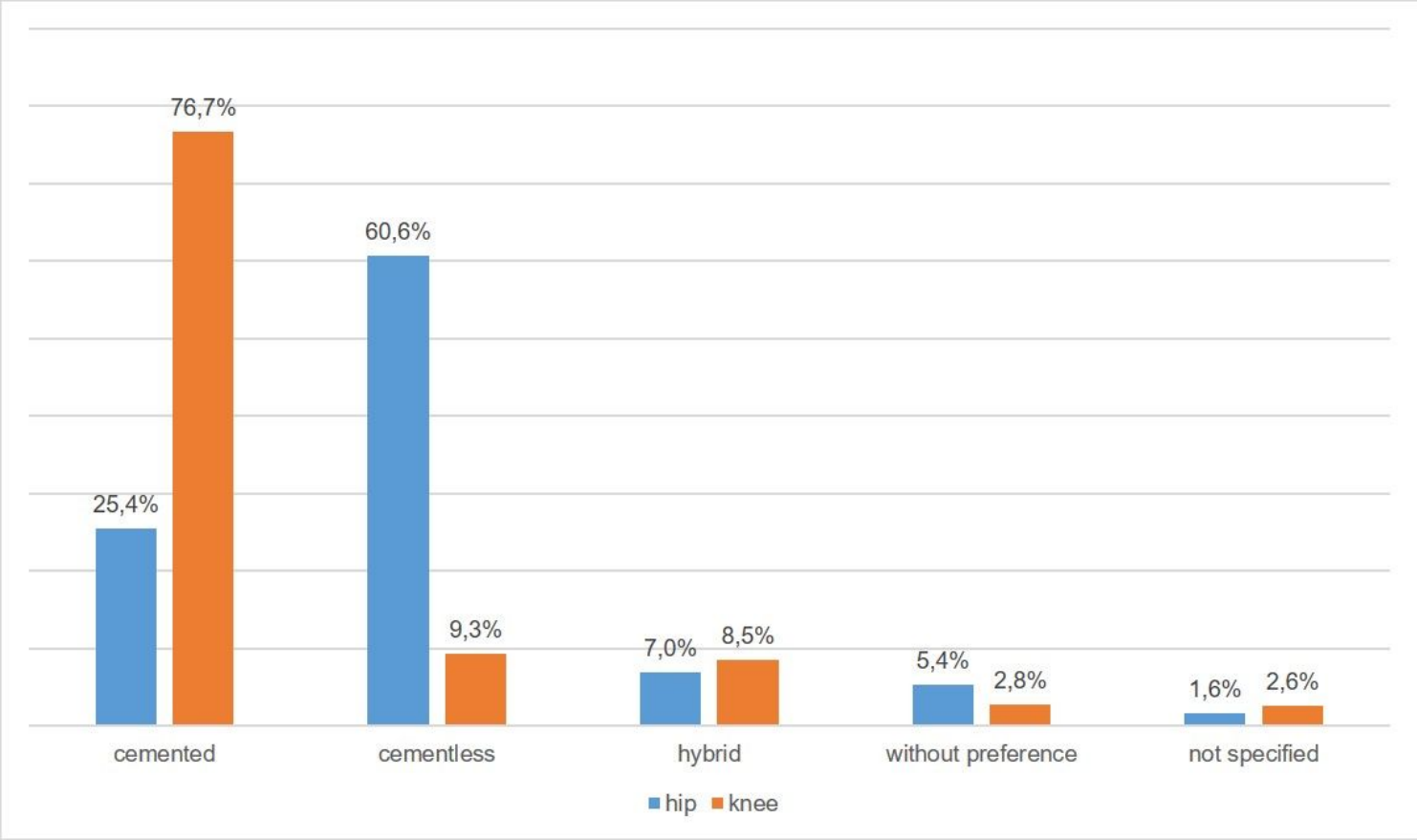

Figure 3

Implant selection for the treatment for the two-stage revision 2020

Figure 4

Procedure for the use of antibiotics after removal and reimplantation 2015

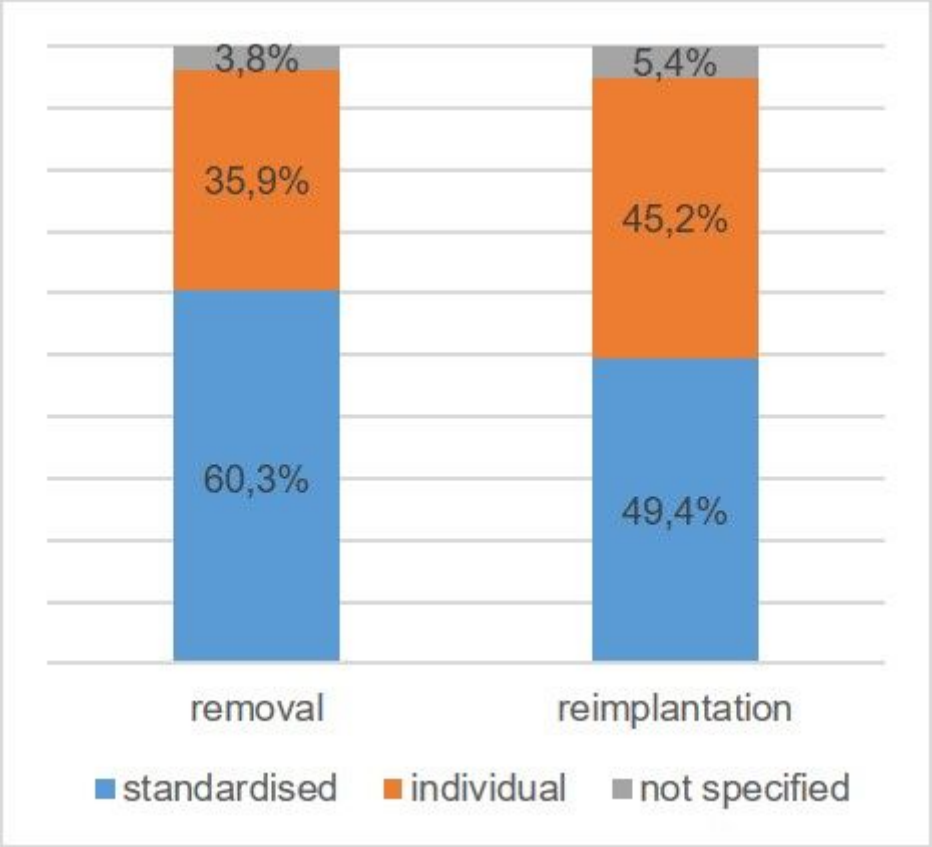

Figure 5

Procedure for the use of antibiotics after removal and reimplantation 2020