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Mandibular reconstruction with vascularised bone flaps: a systematic review over 25 years

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Abstract

A systematic review was undertaken to explore the mandibular reconstruction techniques and outcomes, using composite free flaps.

A total of 9499 mandibular defects were reconstructed with 6178 fibulas, 1380 iliac crests, 1127 composite radials, 709 scapulas, 63 serratus anterior and rib, 32 metatarsals and 10 lateral arm flaps including humerus. The flap failure rate was higher for the iliac crest at 6.2% (66/1059) compared to 3.4% (202/6018) if the fibula, radial or scapula was used ($p<0.001$). Details relating to osteotomy rate, non-union and fistula rates were evaluated. Iliac crest was most often rehabilitated with implant-retained prosthesis (44%, 100/229), compared to 26% (605/2295) ($p<0.001$) if another flap was used. Changing trends over the study period were not apparent, regarding flap choice or related complications.

Although we are able to show some significant differences relating to the type of flap used, it is disappointing to present the underreporting of fundamental outcomes such as the osteotomy rate, non-union and fistula rates. This review demonstrates the need for more comprehensive and consistent outcome reporting, that will allow the comparison of different techniques for similar defects.

Key words: Mandible, reconstruction, free tissue transfer, head and neck, reconstructive microsurgery

Introduction

The focus of this review is the use of vascularised composite or osseous free flaps for segmental mandibular reconstruction. Non-vascularised bone grafts are less reliable for longer defects (1), cannot restore lost soft tissue or withstand postoperative radiotherapy. Since the publication of Mark Urken's review in 1991(2), there has been no comprehensive review of microvascular composite flap reconstruction of mandibular defects. The literature contains opinion-based papers with preferred flap options rather than a detailed analysis of published practice (3,4).

Hidalgo provided an influential contribution with a full description and outcome analysis of the use of vascularised fibula flaps in mandibular reconstruction (5,6), but it could be argued that such an analysis is of less relevance in 2016. While we acknowledge that the fibula flap is the preferred option of many, there are situations when a suitable donor site is unavailable because of vascular disease, unfavourable anatomy, or less favourable dimensions and soft tissue requirements. Even though there may be broad agreement on flap choice, technology is advancing apace. Today, we have access to 3-dimensional (3-D) planning models and computer-aided techniques (7) that are contributing to ever more consistent outcomes. Another advantage of providing a comprehensive analysis of the available case series, is to assess changes in flap usage and opinion over the past 25 years.

Methods

We followed the PRISMA guidance and performed a literature review of English language articles published in Embase and PubMed from 1st January 1990 to July 2015. For the search strategy, keywords were used as thesaurus terms unique to the databases and combined free text terms. The following keywords were used: mandible, oromandibular, reconstruction, classification, free flap, vascularised, microvascular. The searches (Figure 1) were done through Edgehill University library and delivered 3057 referenced abstracts, which were then read by the first author. The inclusion criteria for obtaining full publication were as follows: full length reports of composite or osseous microvascular reconstruction of the mandible. The exclusion criteria were: fewer than ten cases reported, non-free tissue transfer mandibular reconstruction, conference abstracts, and duplicate referenced abstracts. This resulted in the exclusion of 2215 abstracts and 419 papers being obtained and read. Of these, 222 were considered to provide adequate data for the purposes of this review. 197 articles were rejected for the reasons detailed in Table 1, most frequently these publications did not relate to the flap types of interest or reported data was insufficient.

The 222 papers included were read by the first author to obtain the following: Institute, aim of the publication, number of free flaps, inclusion of the condyle, flap type, osteotomy rate, and use of rehabilitation with or without implant assistance. The following complications were recorded: oro-cutaneous fistula rate, non-union/malunion, flap failure (related to the specific flap), and donor site complications. Where only partial inclusion of outcomes was evident, that data that could be ascertained was recorded. Failure to report complications, such as fistula formation, was frequently evident. The four main donor sites (fibula, iliac crest, radius and scapula) were analysed, and although serratus anterior and rib (63 cases) metatarsal (32 cases) and lateral arm (10 cases), were noted these numbers were too small to warrant statistical analysis.

We used Fishers exact test (STATA version 13) for comparisons of categorical variables.

Results

To ensure a clear representation of the time over which reported cases papers were analysed, we have divided the publications by year. As expected, the number of publications increased in each 5-year period, as follows: 23 (8–30) reports for 1990–1995; 32 (31–62), for 1996–2000; 34 (63–96), for 2001–2005; 54 (97–150), for 2006–2010; and 79 (151–229), for 2011–2015. This reflects both the standard level of increased reporting and the evolution of surgical techniques in these complex 3-D reconstructions.

The aims of the publications were analysed, and the trends are presented in Table 2. As expected, the commonest reason for publishing was to report a series demonstrating complete experience with donor sites (12, 45) or with a single flap option (49). In the last 5-year period, more reports appeared with the use of 3-D imaging and plate preparation, with an attempt to show shorter operating times and better outcomes (170). There were an additional 27 aims cited (not shown in Table 2) that included subjects as diverse as distraction versus reconstruction (160) and calcification of the pedicle (172).

Flap options

The four main flap donor sites were the fibula with 6178 flaps (8, 12, 16–18, 20–22, 24, 26–28, 32–55, 57–59, 61–64, 66-, 79, 81–83, 85, 87–89, 93, 94, 96–104, 106, 108–131, 131, 133, 135, 137–141, 143, 145–154, 156, 158–169, 171–175, 179–184, 186–193, 195, 196, 198–200, 202–207, 209, 210, 212–216, 218–223, and 225–229), the iliac crest with 1380 flaps (8, 12–15, 17–20, 26, 29,31, 36, 38, 41, 45, 48, 50, 53, 54, 57–60, 62, 63, 65, 67, 72, 74, 75, 77, 79, 83, 84, 86, 87, 92, 96, 98, 99, 102, 105, 112–115, 121, 132, 149, 151, 152, 155, 157, 158, 161, 168, 170, 171, 173, 174, 177, 178, 181, 183, 186, 201, 211, 212, 216, 219, 227), composite radius with 1127 flaps (8, 10–12, 17, 20, 23, 25, 30, 32, 33, 48, 50, 56, 62, 67, 72, 75, 77, 80, 85, 87, 91, 93, 95, 96, 98, 99, 104, 113, 114, 133, 150, 152 154, 165, 176, 180, 183, 185, 203, 213, and scapula with 709 flaps (8, 9, 12, 14, 17, 26, 32, 45, 46, 48, 50, 53, 58, 59, 63, 67, 70, 74, 77, 85, 87, 90, 93, 96, 99, 113, 114, 134, 136, 142, 144, 151, 156, 169, 172, 189, 191, 194, 196, 197, 203, 208, 217, 224, 226). By contrast, the Serratus anterior and rib accounted for just 63 flaps (8, 67, 90, 107, 108, 113, 128, 107, 149, 108, 226), while the metatarsal accounted for 32 (17) and lateral arm including humerus for just

10 (72, 167). The trend for reporting by donor site is set out in Table 3. All 4 flaps are still being reported regularly over the study period confirming their utility.

Classification

There were 81 papers (16, 24, 29, 30, 31, 33, 38, 47, 49, 53, 55, 57, 63, 65, 66, 69, 71, 73, 75, 76, 81, 84, 89, 91, 95, 97, 99, 100, 103, 104, 107–109, 111–116, 120, 121, 124, 125, 130, 132–134, 137, 140 145–150, 154, 158, 163, 165, 166, 168, 170–173, 180, 184, 185, 188, 194–197, 202, 203, 205, 210, 212, 221, 222, 229) reporting on mandibular reconstruction with no attempt to classify the defect reconstructed. Another 72 papers used their own method to describe defects (8, 9, 19, 20, 26, 34, 35, 41, 44, 46, 48, 50–52, 58, 61, 64, 78–80, 83, 87, 92, 93, 94, 98, 105, 110, 117, 118, 122, 128, 131, 136, 138, 139, 143, 144, 155, 161, 162, 174–177, 181–183, 186, 189, 192, 193, 208, 209, 213, 224, 228) or represent them pictorially (10, 21, 36, 37, 40, 43, 59, 82, 101, 102, 127, 142, 153, 164, 211). The HCL system suggested by Jewer (230) was most commonly cited (11, 12, 17, 23, 25, 27, 32, 42, 54, 56, 67, 68, 70, 72, 74, 86, 90, 106, 123, 129, 135, 141, 156, 157, 159, 160, 167, 169, 178, 179, 187, 191, 200, 204, 206, 216–218, 225), confirming the need for a more universally acceptable method.

Condylar resection and reconstruction

4569 mandibular resections, included sufficient detail to include the resection of the condyle which was performed in 443(9.7%) cases. In some multiple flap series (67), it was not possible to tell which flap had been used for the reconstruction after condylar resection. For those publications clearly indicating the method of reconstruction and condylar resection, it was clear that the fibula was favoured: 8.1% (237/2937) of fibula cases (21, 22, 27, 28, 34–37, 39, 40, 42, 43, 44, 52, 58, 61, 68, 70, 78, 79, 82, 85, 87, 88, 94, 98, 101, 106, 110, 110, 117–119, 122, 123, 126–129, 131, 135, 138, 139, 141, 143, 151, 153, 156, 159–161, 164, 167, 169, 179, 182, 183, 187, 190, 192, 193, 199, 200, 204, 206, 207, 209, 212, 214, 216, 218, 220, 223, 225, 227, 228) also reconstructed the condyle, compared with 1.6% (6/373) for the iliac crest (13, 15, 19, 60, 77, 79, 86, 87, 98, 105, 155, 157, 161, 177, 178, 183, 201, 211, 212, 227), 1.7% (5/291) for the radius (10, 11, 23, 25, 50, 56, 77, 80, 87, 98, 183), and

1.2% (5/406) for the scapula (9, 50, 58, 77, 85, 87, 90, 136, 142, 144, 156, 169, 191, 208, 217, 224). There was no trend for changes in practice for condylar resection and reconstruction over the study period.

Osteotomy rate

81% (188/222) of publications did not include the osteotomy rate, indicating that the data analysed is inevitably limited and may not reflect true practice. Of the data that could be analysed the fibula had a higher osteotomy rate of 1.3 (1082/856) when compared to cases in which the flap type was known combined at 0.56 (304/544) (Table 4). The mean number of osteotomies performed irrespective of flap type was near 1.0 (0.94) for 1773 reconstructions.

Flap failure

The results for those papers reporting the failure rate specific to the flap options are shown in Table 5. The failure rate was not stated in 13% (29/222) of publications (13, 25, 39, 60, 85, 88, 90, 91, 96, 99–101, 108, 115, 121, 132, 135, 138, 146, 148, 151, 159, 169, 180, 199, 200, 209, 213, 214), Table 5. The flap failure rate was higher for the iliac crest at 6.2% (66/1059) compared to 3.4% (202/6018) if the fibula, radial or scapula was used ($p<0.001$).

Fistula rate

Only 23% (50/222) papers contributed to the fistula rate. There did seem to be a trend to higher rates related to the iliac crest (7.8%) and scapula (7.7%) compared to 4.9% and 5.8% respectively for the fibula and radial donor site (Table 6), but the numbers reported are small and so a true trend may not be in evidence. Overall the fistula rate was 5.8% (109/1873).

Non-union

The total non-union rate for the whole cohort was 203/3884 (5.2%) (Table 7), however this may reflect a low estimate of the incidence because this only included 41% (3884/9499) of the reconstructions or 54% (120/222) of publications (Table 7),

which is surprising given the increased morbidity involved with such a complication. On the other hand, there were only five papers (99, 114, 154, 180, 183) in which the type of flap could not be related to non-union.

Rehabilitation

We included all cases rehabilitated with implant retention, even if that was the main reason for publication (146); consequently, the figures for rehabilitation with implants are probably exaggerated to some extent. 35% (3287/9499, Table 8) of reconstructed cases included implant-retained rehabilitation and so this review can only provide limited evidence of the overall rate of implant-retained prosthesis in general use. In terms of the choice of flap, 44% (100/229) and 29% (549/1894) of cases reconstructed with iliac crest and fibula, respectively, had implant-retained prostheses. As expected cases reconstructed with the radial forearm flap (13%; 32/252) and scapula (16%; 24/149) were less likely to have implants placed. The overall rate was, therefore, 27% (884/3287).

Discussion

There have been significant advances since Mark Urken's systematic review of the overall experience of mandibular reconstruction with the fibula in 1991 following the original publication by Hidalgo in 1989 (5). Even after this extensive review it is necessary to accept a paucity of evidence (Oxford IV) in the literature to support current practice in mandibular reconstruction. Although we understand that authors have many and varied reasons for contributing to the literature, we contend that authors should adhere to a basic standard of outcome reporting to ensure reliable comparisons. At the outset it was not our intention to try and set a standard of reporting for reconstruction methods but following this analysis we suggest the minimum requirement that should be included in future publications (Table 9).

Clearly, the fibula remains the preferred free flap option, but the reasons for this preference were not apparent. The method of classification of the mandibular defects was examined to see if this would throw light on the role of flap choice. However, of the 222 included publications, 81 did not classify the defects, while a further 96 (24 Urken, and 72 descriptive or pictorial) simply described the defect without comment on the complexity of the defect or the difficulty in adequate and effective reconstruction. The first author has recently suggested a classification system (231) based on the corners of the mandible. The main advantage of this system is that there is a clear demarcation of the extent and site of the defect with increasing Class representing the increasing morbidity if not reconstructed and increasing complexity of the method if reconstruction is considered the best option.

The only area where we found relevant data contributing to flap choice was in the role of reconstruction options when the condyle was resected. In terms of mandible reconstruction, retention of a condyle with sufficient condylar neck or ramus for plating will ensure a more reliable occlusal result for the dentate patient. By contrast, when the condyle requires greater resection (e.g., when treating osteosarcoma or odontogenic tumours, such as ameloblastomas), then it appears that the fibula remains the preferred flap option. In this review, there was a higher percentage of fibula flaps used when the condyle was resected (237/253; 94%) compared with the iliac crest (6/253; 2.4%) and both the radial and scapula flaps (5/253; 2.0%). This is reflected in our own clinical practice, because less bone is required to fill the condylar region, ramus, and angle, and dental rehabilitation is seldom required.

The fibula is not only by far the most reported flap in the literature but also results in the highest osteotomy rate (Table 4), reflecting the longer span that this donor site can reconstruct, and the more extensive resections associated with this type of resection (231). The radius and scapula flaps, by contrast, had relatively low numbers of osteotomies, but the defect length or site was not shown to influence the osteotomy rate. The most likely reason for this is perhaps the confidence that the surgeon has in their ability to ensure adequate vascularity with the particular flap, but again, evidence to support this proposition was not forthcoming in our review.

Flap failure is always a major complication that at least requires further debridement, even if further flap reconstruction is not possible or desirable for the patient. The reports of failure remained remarkably low throughout the study period, with the overall failure rate of 4.1% (323/7836 Table 5) being as good as in most audits, and should set the standard against which improvement can be sought. When looking at specific flap options, the iliac crest had the poorest survival record (66/1059; 6.2%), probably reflecting the shorter and more delicate vessels of the pedicle and the higher technical skill necessary for the anatomical dissection. It was interesting, therefore, that this flap remains the second most reported flap, and continues to be used despite the extra demands. Some opinion continues to support the iliac crest for the bone quality and donor site tolerance (174. 132). It is also worth noting that the composite radial forearm flap is a good alternative, with poor bone stock but good reliability (2.0% failure rate; 14/708), and with the addition of a prophylactic bone plate to reinforce the donor site, represents an acceptable risk to donor site morbidity (80).

As with most of the complications reported in this review, comparatively few papers reported on the rates of non-union (Table 7). However, there was a higher rate of non-union associated with radius and scapula flaps of 9.1%(79/866) when compared with fibula and iliac crest flaps of 3.9% (103/2632. $p<0.001$ Fisher Exact)., Non-union is sometimes difficult to confirm, and some fibrous unions may be perfectly functional, even when weak by radiographic evidence. One paper (217) reported pseudarthrosis in 46 of 122 patients treated by the scapula flap (118 had mandibular reconstructions, so the potential non-union rate was recorded as 39%). This method included the removal of all hardware at about 6 months, and it was not clear whether the pseudarthrosis was diagnosed at the time of plate removal or by

radiographic analysis. We deliberately excluded the removal of hardware because the need for removal is often unrelated to any significant morbidity or poor outcome. It was hoped that there would be enough data of sufficient quality to estimate the non-union rate to help with flap choice, but the low level of evidence in this retrospective analysis precludes valid conclusions.

A similar argument has to be adopted in the assessment of the results for rehabilitation. In this review, it was decided to include only those cases rehabilitated with implant-retained prosthesis that could be placed into either a native or grafted mandible. It is acknowledged that the facility to place implants relates to the available grafted bone, and the reconstruction quality and the healthcare funding at each institution. In our own practice, we are moving towards the planning and placement of implants at the time of resection and reconstruction, especially since the advent of computer-aided 3-D models and planning.

The low level of evidence in this comprehensive report and the variability of outcomes included will persist unless editors insist on a standard of publication, which we have outlined in Table 9. As clinicians and surgeons, we tend to believe rather than confirm the best techniques scientifically, which is often the result of the high level of specialisation required to deliver complex operations. Cochrane principles and meta-analysis have proved their worth and in such problematic areas of surgical intervention we hope that this suggestion of a minimum of adequate data to be reported may improve our understanding and hence appropriate choice for our patients.

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Conflict of interest

The authors have no conflict of interest to declare

Figure 1: Search results included in the review

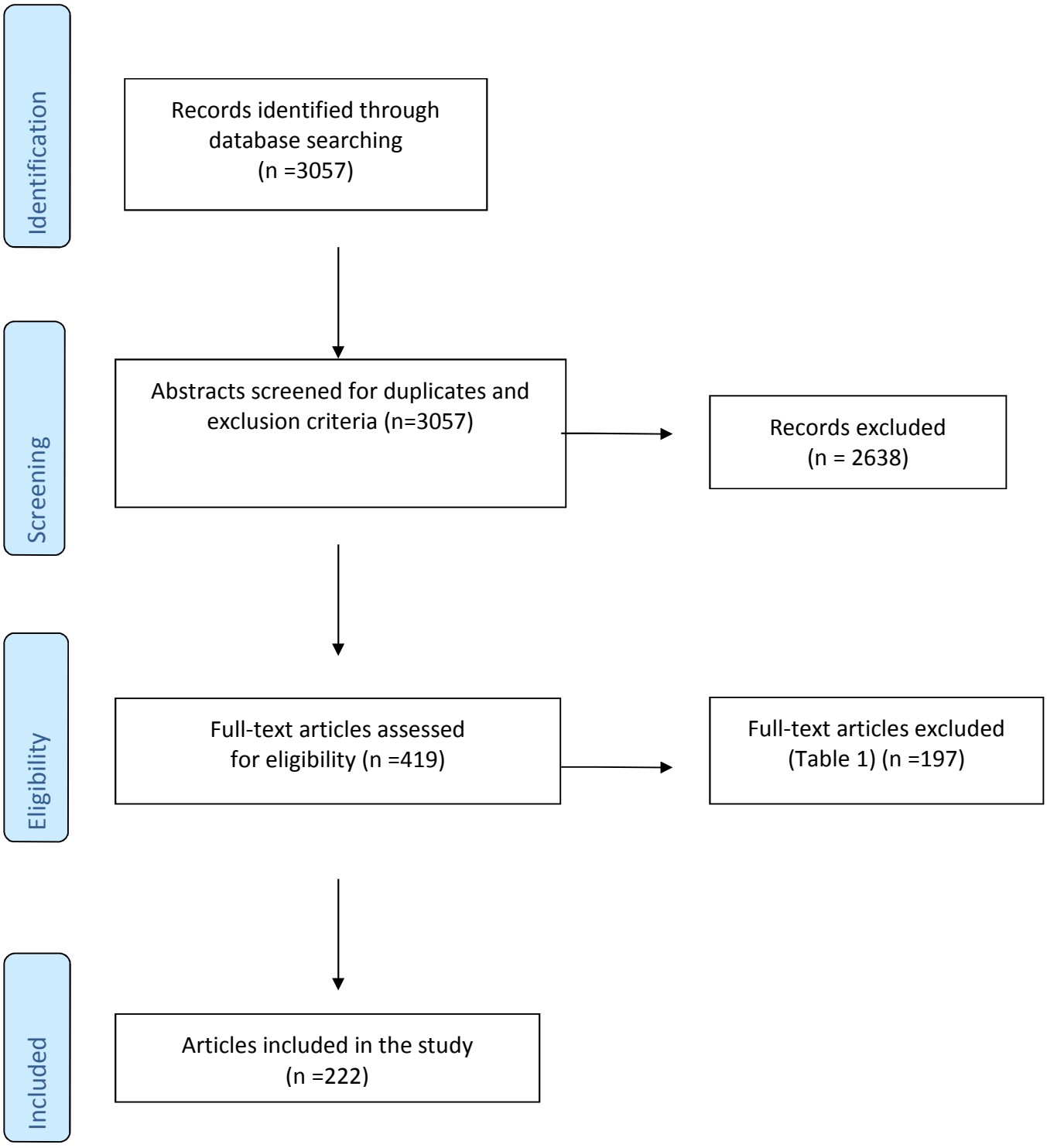

Table 1: Reasons for exclusion

Reason for exclusion	No of papers
Insufficient cases <10	71
Series with insufficient data	30
Review articles	14
Quality of life and functional assessment	12
Technical development	12
Dental rehabilitation	11
Series that repeat data already available	11
Imaging series	9
Donor sites	7
Computer-assisted series	7
Flap survival assessment	4
Plate applications	4
Other more obscure reasons	5
Total	197

*

Table 2

Aims of the publications

Aim of the paper	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Surgical Series	13 (8–10, 12, 14, 17,21,23, 24, 27–30)	9 (34, 37, 45, 48, 49, 55, 56, 61, 62)	13 (65, 66–68, 70, 76, 81, 86, 90–92, 94, 95	17 (103, 106, 107, 109, 119, 123, 126, 129, 130, 136, 139, 140–145)	25 (157, 158, 162, 166, 173, 176–178, 182, 183, 185, 187, 188, 194, 196, 197, 200–202, 205, 207, 208, 217, 223, 224)	77
Comparative analysis of	2 (18, 22)	2 (33, 54)	2 (83, 93)	7 (98, 102,	8 (155, 165,	21

differing free flaps				112, 127, 133, 134, 150)	174, 181, 186, 189, 191, 216)	
Oral Rehabilitation	–	4 (39–41, 60)	3 (82, 88, 96)	4 (97, 113, 122, 146)	5 (153, 164, 190, 215, 218)	16
Osteoradionecrosis	1 (19)	1 (43)	5 (63, 69, 72, 74, 75)	4 (121, 128, 135, 149)	5 (151, 152, 163, 180, 203)	16
Computer-aided planning or technique			1 (7)	1 (101)	11 (156, 161, 167, 169, 170, 179, 192, 206, 210, 211, 219)	13

Table 3

Flap options (%)

Flap type	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	242 (3.9) (8, 12, 16–18, 20–22, 24, 26–28)	910 (15) (32–55, 57–59, 61, 62)	858 (14) (63, 64, 66–79, 81–83, 85, 87–89, 93, 94, 96)	1952 (32) (97–104, 106, 108–131, 133, 135, 137–141, 143, 145–150)	2216 (36) (151–154, 156, 158–169, 171–175, 179–184, 186–193, 195, 196, 198–200, 202–207, 209, 210, 212–216, 218–223, 225–229)	6178 (65)
Iliac crest	252 (18) (8, 12, 13–15, 17–20, 26, 29)	253 (18) (31, 36, 38, 41, 45, 48, 50, 53, 54, 57–60, 62)	164 (12) (63, 65, 67, 72, 74, 75, 77, 79, 83, 84, 86, 87, 92, 96)	165 (12) (98, 99, 102, 105, 112–115, 121, 132, 149)	546 (40) (151, 152, 155, 157, 158, 161, 168, 170, 171, 173, 174, 177, 178, 181, 183, 186, 201, 211,	1380 (15)

					212, 216, 219, 227)	
Radial	157 (14) (8, 10-9, 11, 12, 17, 20, 23, 25, 30)	85 (7.5) (32, 33, 48, 50, 56, 62)	285 (25) (67, 72, 75, 77, 80. 85, 87, 91, 93, 95, 96)	161 (14) (98, 99, 104, 113, 114, 133, 150)	439 (39) (152, 154, 165, 176, 180, 183, 203, 213)	1127 (12)
Scapula	53 (7.5) (8, 9, 12, 14, 17, 26)	59 (8.3) (32, 45, 46, 48, 50, 53, 58, 59)	116 (16) (63, 67, 70, 74, 77, 85, 87, 90, 93, 96)	194 (27) (99, 113, 114, 134, 136, 142, 144)	287 (40) (151, 156, 169, 172, 189, 191, 194, 196, 197, 203, 208, 217, 224, 226)	709 (7.5)
Serratus Anterior and rib	1 (1.7) (8)	0	16 (25) (67, 90)	42 (67) (107, 108, 113, 128, 149)	4 (6.3) (226)	63 (0.7)
Totals	705	1307	1439	2514	3492	9457

Table 4

Osteotomy use per flap (osteotomy rate per flap in brackets)

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	24/16 (1.5) (21)	14/12 (1.2) (43)	88/70 (1.3) (70, 78, 87, 88)	498/387 (1.3) (110, 123, 126, 129, 137, 140, 141)	458/371 (1.2) (156, 161, 189, 192, 198, 206, 207, 210, 215, 225)	1082/856 (1.3)
Iliac	–	–	–	–	84/109 (0.77) (157, 161, 177, 178, 211)	84/109 (0.77)
Radial	34/42 (0.81) (30)	44/60 (0.73) (56)	–	–	–	78/102 (0.76)
Scapula	–	–	–	27/124 (0.22) (142, 144)	115/209 (0.55) (189, 197, 208, 217)	142/333 (0.43)
Not specific to flap	–	–	126/143 (0.88) (87)	–	147/230 (0.64) (156, 213)	273/373 (0.73)
Totals	58/58	58/72	214/213	525/511	804/919	1659/1773

	(1.0)	(0.81)	(1.0)	(1.0)	(0.87)	(0.94)

Table 5: Flap failure rate specific to flap options (%)

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	8/200 (4.0) (8, 16–18, 20–22, 24, 26–29)	28/736 (3.8) (32–35, 37, 40–44, 47–49, 51–55, 57–59, 61, 62)	34/658 (5.2) (63, 64, 66–73, 75–79, 81–83, 89, 93, 94)	53/1315 (4.0) (97, 98, 102–104, 106, 109–113, 116–120, 122–131, 137, 139, 141, 143, 145, 147, 149, 150)	45/1829 (2.5) (153, 154, 156, 158, 160–168, 171, 173–175, 179, 181, 182, 184, 187, 188–193, 195, 196, 198, 202–207, 210, 212, 215, 216, 218–223, 225–229)	168/4738 (3.5)
Iliac crest	17/240 (7.1) (8, 4, 14, 15, 17–20, 26, 29)	6/97 (6.2) (31, 36, 48, 53, 54, 57–59, 62)	12/134 (9.0) (63, 65, 67, 79, 72, 75, 77, 79, 83, 84, 86, 92)	2/66 (3.0) (98, 102, 105, 112, 113, 49)	29/522 (5.6) (155, 157, 158, 161, 168, 170, 171, 173, 174, 177, 178, 181, 201, 211, 212,	66/1059 (6.2)

					216, 219, 227)	
Radial	4/139 (2.9) (8, 10, 11, 17, 20, 23, 30)	1/69 (1.4) (32, 33, 48, 56, 62)	2/167 (1.2) (67, 72, 75, 77, 80 93, 95)	0/26 (0.0) (92, 113)	7/307 (2.3) (154, 165, 176, 185, 203)	14/708 (2.0)
Scapula	4/50 (8.0) (8, 9, 14, 17, 26)	0/26 (0.0) (32, 48, 53, 58, 59)	2/34 (5.9) (63, 67, 70, 77, 93)	6/183 (3.3) (113, 134, 136, 142, 144)	8/279 (2.9) (156, 189, 191, 194, 196, 197, 203, 208, 217, 224, 226)	20/572 (3.5)
Not specified to flap	1/50 (2.0) (12)	10/249 (4.0) (38, 45)	19/158 (12.0) (74, 87)	10/143 (7.0) (114, 133)	15/159 (9.4) 152. 180, 183, 187)	55/759 (7.2)
Totals	34/679 (5.0)	45/1177 (3.8)	69/1151 (6.0)	71/1733 (4.1)	104/3096 (3.4)	323/7836 (4.1)

Table 6: Trends for oro-cutanous fistula rates

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	4/87 (4.6) (22, 27)	10/271 (3.7) (35, 49, 58, 62)	10/159 (6.3) (67–69, 68, 74, 78, 81, 82, 83, 89)	16/307 (5.2) (103, 106, 112, 117, 120, 125, 128, 130, 135, 139, 140, 145, 149)	12/243 (4.9) (160, 164, 165, 198, 204, 212, 215, 227, 228)	52/1067 (4.9)
Iliac crest	–	0/4 (0) (58, 62)	4/93 (4.3) (67, 74, 83, 86)	6/27 (22.2) (112)	8/107 (7.5) (212, 227)	18/231 (7.8)
Radial	2/19 (10.5) (23)	–	9/143 (6.3) (67, 80, 93)	–	6/129 (4.7) (165, 176)	17/291 (5.8)
Scapula	2/30 (6.7) (9)	0/6 (0) (58)	8/52 (15.4) (67, 74)	2/68 (2.9) (136, 144)	–	12/156 (7.7)
Not specific to flap			1/20 (5.0) (70)	–	9/108 (8.3) (182, 226)	10/128 (7.8)
Totals	8/136 (5.9)	10/281 (3.6)	32/467 (6.9)	24/402 (6.0)	35/587 (6.0)	109/1873 (5.8)

Table 7: Trends for the non-union rates per flap

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	4/162 (2.5) (8, 18, 22, 24, 27, 28)	8/226 (3.5) (34, 35, 37, 40, 43–45, 50, 52, 53, 59)	0/336 (0) (63, 70, 74, 75, 81, 82, 89)	28/580 (4.8) (102, 108, 112, 117, 120, 123, 124–126, 128–130, 147, 150	46/682 (6.7) (153, 160, 162, 165, 167, 175, 179, 189, 193, 198, 204, 206, 207, 213, 215, 221, 223, 225, 227, 228)	86/1986 (4.3)
Iliac crest	5/125 (4.0) (8, 17–19)	1/156 (0.64) (45, 53, 59)	4/123 (3.3) (75, 80, 91)	1/61 (1.6) (102, 105,	6/181 (3.3) (155, 157, 170, 177, 178, 204, 227)	17/646 (2.6)
Radial	9/136 (6.6) (8, 10, 11, 17, 23)	4/60 (6.7) (56)	0/4 (63, 70, 74)	1/51 (2.0) (150)	16/240 (6.7) (165, 176, 213)	30/491 (6.1)
Scapula	2/41 (4.9) (8, 9)	0/31 (45, 53)	–	0/130 (107, 108, 142)	47/173 (27.2) (189,	49/375 (13.1)*

					217)	
Not specific to flap				16/261 (6.1) (99, 114)	5/125 (4.0) (154, 180, 183)	21/386 (5.4)
Totals	20/464 (4.3)	13/473 (2.7)	4/463 (0.9)	46/1083 (4.2)	120/1401 (8.6)	203/3884 (5.2)

* See text for clarification

Table 8: Rehabilitation with implants

	1990–1995	1996–2000	2001–2005	2006–2010	2011–2015	Totals
Fibula	9/39 (23) (13, 15, 18)	87/270 (32) (34–36, 39–41, 51, 52, 54, 55)	59/222 (27) (63, 71, 79, 82, 88, 94, 97)	189/567 (33) (106, 109, 117, 119, 123, 126, 135, 141, 143, 146, 150	205/796 (26) (153, 156, 164, 167, 175, 179, 181, 182, 187, 188, 190, 209, 204, 210, 214, 215, 218)	549/1894 (29)
Iliac crest	20/32 (63) (13, 15, 18)	17/78 (22) (36, 41, 54, 60)	11/21 (52) (63, 79, 92)	18/18 (100) (105)	34/80 (43) (155, 177, 178, 181, 201)	100/229 (44)
Radius	3/34 (8.8) (11, 23)	–	–	3/51 (5.9) (150)	26/167 (16) (185)	32/252 (13)
Scapula	–	–	0/2 (0.0) (63)	–	24/147 (16) (156, 194, 217)	24/149 (16)
Not specific to flap	15/71 (21) (14)	112/447 (25) (38, 45, 48, 50)	30/199 (15) (70, 96)	–	22/46 (48) (168, 216)	179/763 (23)

Totals	47/176 (27)	216/795 (27)	100/444 (23)	210/636 (33)	311/1236 (25)	884/3287 (27)

Table 9
Minimum requirement for publications reporting on mandibular reconstruction

Number	Requirement for mandible reconstruction publication
1.	Dental status
2.	Classification / descriptive / pictorial
3.	Length of the defects
4.	Method of reconstruction
5.	Number of osteotomies
6.	<u>Early complications</u> Return to operating environment within 30 days and reason if not flap loss Flap loss Alternative reconstruction / no reconstruction
7	<u>Late complications</u> Late unexpected return to operating environment >30 days and reason Oro-cutaneous fistula Non-union
8	Outcomes Dental rehabilitation achieved Implant-retained dental rehabilitation

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